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Siege Archaeology of the English Civil Wars: Establishing a methodology to unlock the archaeology of attack and defence at early modern siege sites

Richard Jeffrey Leese

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements for the degree of Doctor of Philosophy

The University of Huddersfield in collaboration
with English Heritage

July 2020

Abstract

It is a little over thirty years since modern battlefield studies began the serious investigation of unstratified archaeology for what it could tell us about historic battles. In those three decades the field has grown in breadth of time periods opened to investigation through new methodologies, and in the depth of investigation into the archaeology for what it can tell us about subjects such as weapon development, the historic terrain and evolving methods of warfare. Nevertheless, conflict archaeology for the early modern period has thus far failed to apply the methodological developments made in the study of historic battles to an exploration of siege actions.

This thesis seeks to address this imbalance of focus upon battles, and by developing a methodology for the investigation of siege actions. To achieve this the research has focussed on defining the criteria of action for investigation, and examining existing siege site studies for what aspect of siege evidence are yet to be explored as part of a siege study, specifically the unstratified finds of the siege action, the impact scars on surviving structures, and the remnants of impacted projectiles. An overview and rapid assessment of the extent of the national resource of siege sites available for examination was compiled, selecting several candidates for specific investigation, and one candidate with suitable criteria to serve as a case study survey, Moreton Corbet Castle, Salop. Examination of impact scar evidence required a detailed investigation of scars across a multitude of sites, and the development of a low-cost recording and analytical methodology for these features. Questions arising from scar investigation drove a set of ballistic experiments for impacts against stone targets, identifying further research opportunities for developing understanding of bullet impacts on stone targets. The penultimate chapter focuses on the Moreton Corbet survey, which entailed a combined documentary and archaeological investigation, incorporating examination of impact scar evidence, metal detector survey, and an attempt to develop a methodology for the recovery of impacted bullet fragments. The outcome of the study showed that there are opportunities and benefits to conducting intensive surveys for interpreting small-scale siege locations, even where the contemporary documentary evidence is limited in comparison to battles of the same period. The same study also identifies risks to the archaeology at similar sites owing to the unprotected status of the archaeological scatter, the ignorance towards impact scars as archaeological features, and the difficulty with developing strategies towards management of heritage sites where existing protections of the archaeology prevent new data from being obtained.

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This work is dedicated to Charlotte, Lily and Robyn, with all my love.

1. Introduction

It is a little over thirty years since modern battlefield studies began the serious investigation of the unstratified archaeological evidence of historic battles (Scott et al., 1989). In those three decades the exploration of early modern battlefield archaeology in England has incorporated the first large-scale systematic survey of a battlefield of the Wars of the Three Kingdoms (Foard, 2012), experimental research into contemporary weapon ballistic performance (Eyers, 2006, Miller, 2010) and signature patterns produced through artillery weaponry (Allsop and Foard, 2008), and detailed examination of lead bullets for evidence of firing and impact (Parkman, 2017), and survivability and condition in unstratified contexts (Rowe, 2019). Despite the depth of investigation for battlefield and related conflict archaeological topics, the gains made in the study of historic battles of the early modern period have yet to be translated into an integrated examination of siege actions (Harrington, 2005).

1.1 Aims and objectives of study

This study, supported through a studentship with the Arts and Humanities Research Council in partnership with English Heritage, was undertaken with the aim to develop a methodology for the study of early modern sieges that incorporated methodological advances for the investigation of battles of the same era, and develop new methodologies to tackle small-arms impact scars and impacted bullets that have gone largely unexplored as forms of evidence for siege actions. This would require establishing criteria by which past military actions could be considered for study, an assessment of the suitability of identified siege sites for study, an investigation of the evidence of siege activity at locations through site-visits, and a detailed examination of impact scars as a signature form of evidence to be investigated at siege locations. This would culminate with a case-study to combine documentary research, historic landscape reconstruction, metal detector survey and survey of impact scars and bullet fragments to develop interpretation of the siege action for that site. Arising from the case study, recommendations could then be made for the future archaeological survey of siege actions, and to address risks to the conservation of the archaeology at siege sites.

The scope of the investigative study of sites was limited to locations within England that encountered action during the Wars of the Three Kingdoms between 1642 and 1651. This focus was chosen because of the multitude of contemporary sieges available for study arising from this period, and the availability of existing study of primary and secondary works establishing the extent of the resource (Foard and Morris, 2012), and the availability of support for access to, and digital resources for, these sites to be studied that was provided by English Heritage as a sponsor of the studentship.

1.2 Chapter structure

Chapter Two addresses the concept of siege warfare for the early modern period. It outlines what siege warfare is and how it is fought by the belligerents involved, what should be defined as a siege action for the purposes of comparative archaeological study, and the extent of what is incorporated within and archaeological siege site.

Chapter Three addresses existing studies of siege warfare and siege actions in the early modern period, and research questions that could be explored through examination of the archaeological evidence of sieges together with historiographic approaches. It also explores the elements of the conduct of siege warfare for which methodologies have already been established at siege surveys, and where the evidence of the siege actions has yet to be investigated to its fullest potential.

Chapter Four sets out to establish the extent of the archaeological resource for siege locations in England, with rapid desk-based assessment criteria developed to select exemplar or opportune sites for further investigation. This includes a more detailed examination of three distinct example sites and the opportunities for future study at each of these locations whilst acknowledging their shortcomings for selection as a site-wide case study for this research. These site-studies are followed by a discussion of issues and research questions arising from those for the archaeological investigation of sieges.

Chapter Five investigates impact scar evidence as a largely unexplored resource for interpreting the archaeology of sieges, setting out the ambitions and objectives or their investigation for archaeological interpretation of past actions. This leads to an investigation of scar typology at archaeological sites that examines the scope and variation within scar evidence, followed by a discussion as to what might be achievable in their interpretation through techniques adapted from forensic and experimental ballistic research. To support the surveying of scar evidence, a recording methodology is developed by this study for the distribution of scars across surviving structures, as well as surface scar detail and practical three-dimensional profile recording of impact scars. Arising from this is a short discussion of best practices for presenting impact scar data, and a scar-distribution case study examining scars on the keep ruin at Old Wardour Castle, Wiltshire.

Chapter Six discusses a set of ballistic trials undertaken by this study to explore issues relating to the possibility of archaeological impact scar research using experimental archaeological techniques. This begins with an examination of previous studies that tangentially or directly relate to bullet impacts on stone surfaces and bullet fragmentation processes. This is followed by a discussion of two sets of ballistic trials carried out under this studentship: the first is a pilot trial of bullet impacts against stone blocks carried out prior to the author undertaking this studentship; the second is a limited exploration of multiple impact outcomes using controlled experimental variables to identify how the resulting scars vary under comparable impact circumstances. The results of these trials are discussed for future research opportunities and how this might influence the aspirations of impact scar interpretation.

Chapter Seven presents the case study investigation of the siege site at Moreton Corbet, Shropshire, utilising documentary research and historic terrain reconstruction to establish the character of the site at the time of the siege. This is followed by discussion of the execution and outcomes of an adapted metal-detector survey methodology, and combined with survey of the impact scar evidence using the methodology outlined in Chapter Four. Analysing the results of fieldwork with the prior desk-based research a tentative interpretation of the siege action within the landscape is offered, with recommendations for further archaeological investigation of the site to test hypothesis arising from that interpretation.

Chapter Eight concludes the thesis by outlining the methodological developments by this study, as well as considerations for future research on siege actions, and highlighting issues for heritage management arising from risks to, and restrictions in engaging with, the archaeology at siege sites.

2. What is a Siege?

This chapter will discuss the concept and basic principles of siege warfare for the early modern period, drawing from contemporary texts on military theory, and perceived notions of what a siege is and how they are conducted. This discussion will outline thematic principles regarding attack and defence during a siege action, particularly the methods of attack available to a besieging army in attempting to overcome a defending garrison.

Following from this outline the issue of what historic actions may be considered to be sieges will be examined. This will initially be tackled by identifying a common aspect that links sieges of different characters together as a common type of military action, as well as addressing the difficulties in setting a minimum-threshold for classification regarding the size or scale of an action.

Finally this chapter will address what constitutes a siege site in terms of both the historic action and the archaeology that it produces. This will include an outline of the different components of a siege site based on the description of the zones of archaeology given by Harrington (2005), as well as a critique of the terminology and definitions for each. This will inform the approach to the archaeological exploration of siege sites undertaken as party of this study.

2.1 What are siege actions?

Sieges are most easily described as a military operation against a fortified location. Unlike battles where the landscape is typically more open and fluid, sieges are largely static actions often centred on a collection of structures or fortified position occupied by the defenders, and the attacking force seeks to remove or eliminate the occupiers. The tactical means by which the attackers achieve this, as well as the responses by the defenders can be described as the siege itself, while the landscape and physical area in which the action occurs is the siege site.

This is a simplified definition and the issue of clearly defining what constitutes a siege for the purposes of studying these actions will be addressed further below. The above could be reasonably applied to a military action against an occupied location for almost any period of history, and works as well for describing sieges against medieval castles as it does for those against fortified cities in the nineteenth century. For a better understanding of what a siege looks like in the seventeenth century and particularly during the Wars of the Three Kingdoms, the contemporary military technology and tactical theory need to be discussed in relation to their use against garrisons.

2.1.1 How were sieges fought?

For the period of the seventeenth century, the principal arms of conflict are typically referred to as pike and shot, though this period includes pistol and carbine equipped cavalry, and ordnance. For the purposes of attacking or defending a garrison, black powder weapons hold the key in that the relatively static nature of siege warfare favours the ability to use ranged weapons to harass or engage the enemy, without sacrificing the advantage of protective cover from fortifications. Furthermore ordnance for this period played a key role in the adoption of new fortification styles, as artillery use in sieges during the later fifteenth and sixteenth centuries had transformed fortification from thick, stone-lined walls and medieval castles, into shallow earthen ramparts better able to absorb the energy of artillery impacts (Duffy, 1979). In addition to these weapons also used in battlefield engagements, siege operations might include other forms of gunpowder and ordnance, including mortars for firing explosive of incendiary shells over fortifications, petards that used an explosive charge to breach gates and force entry into a garrisoned site, early hand-grenades used in stormings, and barrels of explosives used to destroy fortifications and buildings when placed in mined tunnels beneath the foundations or walls of a structure.

For an understanding of how these weapons were employed during a siege in attack or defence, there are numerous contemporary military theory manuals that were published or translated into English prior to the outset of the Wars of the Three Kingdoms (Duffy, 1979). Many of these are drawn from examples and developments in warfare during conflicts on the European continent during the late-sixteenth and early-seventeenth century, specifically the Dutch wars against the Spanish known the Eighty Years War (1568-1648), and latterly the much wider and larger Thirty Years War (1618-1648). Examples of these works are largely written as military manuals on how to manage, march and manoeuvre armies, though some also contain details on how to fortify garrisons, and how to carry out attack and defence of a 'fortress' (Du Praissac, 1639, Hexham, 1639, Ward, 1639).

For overall advice to the reader on how to overcome a garrison through attack, 'The Art of Warre' by Du Praissac (1639) helpfully identifies three tactical approaches to attacking a fortified location; by overcoming a garrison through surprise attack (referred to in the text as by petard, surprise or treacherie[sic]), by famine, or by 'siege'. Surprise attack revolves around a sudden assault either by breaching the gates of a fortified location, by overcoming the defenders before an effective defence can be orchestrated, or by subterfuge or support from individuals within the garrison. Famine as described by Du Praissac could be synonymous with blockade or encirclement, requiring that the besieger isolate the garrison from external supplies or support, as well as bombarding the site within the fortifications to bring about surrender through supply shortage (Du Praissac, 1639, pp. 82). The remaining term 'siege' offered by the text refers more specifically to the progressive attack of a fortified location through encirclement and bombardment of the defences, approaching the defences through entrenchment, and the assault of the garrison. Though this approach shares individual tactical elements with the 'famine' approach in the form of encirclement and bombardment, in this instance these activities are for the protection of the besieging force and the battering of fortifications in order to create breaches rather than to bring about capitulation through attrition (Du Praissac, 1639, pp. 63-64).

Curiously enough the term "siege" appears in Ward (1639) only once to prescribe a method of warfare, preferring the term "beleaguer" in reference to the act of attack upon a garrison by an army (Ward, 1639, pp. 62). Ward recommends five options for beleaguering a town or fortification: battery, mine, treason, maladie[sic], and siege. Battery (bombardment) and mining would be considered under siege by Du Praissac and indeed would be hard to achieve without preparing some kind of siegework for protection of the attacking forces to carry out this work. Ward's use of "maladie" is synonymous with surprise attack as per Du Praissac, while treason and "treacherie" are synonymous terms for overcoming the garrison through sympathetic agents within the garrison or through acts of subterfuge. The final term, siege, refers in essence to a circumvallation, bombardment and blockade of the garrison to force capitulation through broken spirit, sickness, famine or attrition, again focussing on an intensive and protracted military action, and advises that a commander seeking to beleaguer a town should ensure before doing so that the army has ample provisions and gunpowder to undertake a siege before committing to the action (Ward, 1639, pp. 79). By contrast to the above examples, Hexham (1639) discusses best practice in digging siegeworks and lines of approach, as well as mines, but doesn't specifically use the term "siege" as a method of warfare, instead preferring to use the adjective form (besieged) to describe garrison that are confined within their defences and the subject of approach or mining.

What is apparent from the contemporary manuals is that there is a logical sequence to the use of siege tactics by a besieging force. This is identified by Bull (2008), who drawing from examples of siege actions in the Civil Wars, sets down a sequence for siege operations from the initial demand for a garrison to surrender by the attackers at the outset, through to the storming of a garrisoned site following breaching of the fortifications (Bull, 2008, pp. 100-113). It is clear however from the examples offered in each step of the sequence, as well as the case studies that follow, that numerous sieges of the conflict did not follow that progression. This would certainly be the case for actions following the 'famine' or 'surprise' approaches for besieging a fortified garrison, but also applies for sieges where supply or circumstance precluded the use of certain tactics in a 'siege' approach.

While each of these approaches differs from each other in overall method, they share between them common elements such as the use of explosive charges, artillery bombardment, digging of siege trenches, and assault through or over the fortifications. To consider only the final approach a siege is therefore missing the common thread that links these types of military action, namely the aim of overcoming the fortified garrison.

2.1.2 Categorising the fighting in a siege

To address how the use of different tactics and tactical approaches may influence the archaeology of a siege, it is worth considering how different sieges could be categorised based on their conduct. There are essentially three ways by which a garrison is compelled to surrender by these approaches, namely through attrition, threat, and force.

2.1.2.1 Attrition

Attrition describes the gradual reduction of the garrison's resolve or an inability to keep fighting either due to loss of life within the garrison force, dwindling food supply, illness, munitions shortage, or a lack of political will to continue the fight. In this regard it is the decision of the defenders themselves to surrender as a result of the effect of the siege on their own condition. This does not necessarily imply a passive or inactive role on the part of either or both sides during the siege, but rather that the outcome is not determined by the progress of the besiegers as much as by the deterioration of the besieged.

2.1.2.2 Threat

Threat centres on the desire to avoid being put at the mercy of the besiegers. It was commonly accepted during the period in question that if a garrison surrendered sooner in the process of a siege, better terms for surrender were usually granted, and that by the time the besiegers had been forced to resort to storming the defences, there should be no expectation of mercy for the occupants of the garrisoned site (Bull, 2008, pp. 111-112). In this regard the defenders elect to capitulate because of the impending threat of assault or attack against the garrison, an accompanying risk of consequences if the attackers are victorious. This surrender is therefore a result of the threat posed by continuing the siege action further, rather than a resolution of the tactical approach used.

2.1.2.3 Force

Force is the most direct method of bringing about the surrender of a garrison. If the siege has progressed through all tactical options to the besiegers and the garrison fails to surrender, then an assault of the defences and taking control of the site through killing or capturing the garrison is the only option that remains for a successful outcome for the attackers. Force should not however be considered the final-step or last-resort for a siege operation however, as a rapid assault of a garrisoned location through surprise or entry into the fortifications by subterfuge could, where possible, conclude a siege much more quickly than by taking time to starve the garrison, or lay down siegeworks and carry out bombardment. In some cases it may have also offered a preferable means of eliminating the garrison rather than carrying out a prolonged siege, as it would prevent the besieging troops from being tied up encircling a garrison and preventing them from contributing to an active field army.

2.1.3 Defence

What has not been discussed as yet is the role of the defenders in the actions during a siege. While the outcome of the action is largely reliant on the garrison's choice of when or whether to surrender, many factors that govern which tactics are able to be used by the besiegers are determined in part before the action commences. The terrain and landscape in which the garrisoned location is set, for instance, will affect whether siegeworks and mines can be dug, or whether artillery can be effectively deployed against the garrison's defences. Furthermore, the type, extent and quality of the fortifications placed around the garrisoned site are all choices and preparations made by the defenders prior to the occurrence of a siege. In this essence, the role of the defending side in setting the 'field' for the engagement ends prior to the commencement of the siege.

This does not mean that every site is necessarily well chosen, and clearly some sites of country manors and castles were garrisoned for political or personal reasons, as well as strategic considerations. Similarly, the quality of the construction and overall formation of the defensive fortifications may not be ideal owing to lack of time, manpower or resources to construct or improve upon existing structures, or a failing in the ability of those in charge of their coordination. Nevertheless, it is the site as it is presented that faces the attacking army upon arrival, and once the garrison take up a defensive posture, their role by definition becomes reactive to the tactics of the besiegers. Though sallies by the defenders stood to be very effective in hampering or halting progress made by the attackers, these activities arguably do not set the character of the siege to the same degree.

2.2 Defining a siege action

What is clear from discussion of the tactical approaches for overcoming a garrison is that sieges vary considerably in the way they are carried out, and the array of tactics that may be used to achieve capitulation. When this is combined with the array of different sites and settlements that were garrisoned, the landscape and terrain setting of fortified positions, the size of garrisons both in terms of men and scale of the garrisoned site, the quality of the fortifications, the size of the besieging army, and the availability of ordnance to both sides, it becomes apparent very quickly that sieges vary considerably from one another to the point where each action is arguably as distinct and specific to its own circumstances as might be said of battlefield engagements between armies. Moreover, in the existing literature regarding sieges, there is no definition that explicitly states what should be considered to constitute a siege action. While this ambiguity may not generally be a problem for the discussion of events that are historically accepted as sieges, it does pose a problem in identifying what should be considered in an archaeological study of siege sites at the extreme ends of the scale regarding the size of action, the manner in which the attack on a garrison was conducted, or the type of garrisoned site that was besieged.

Such a definition already exists for identifying battlefields as archaeological sites as set out in Foard and Morris (2012, pp. 6), using the nature of the belligerents as largely military forces and their use of formalised deployments as the common factor across different landscapes contested by different armies and troop compositions. In order to properly address the archaeology of siege sites of the Civil Wars it is necessary therefore to establish a commonality between these actions for the purpose of categorising them as siege actions, to establish which military engagements may be considered sieges. Using a clear definition and set of criteria for identifying historic military engagements allows us to compare a broad range of sites where the archaeology has been set down under the same set of cultural circumstances, but allows for the variation in their locale, scale, and prosecution.

2.2.1 Building a definition for siege actions

Language definitions for the word siege typically focus on the concept of an occupied location where the attackers attempt to enclose the occupiers and compel them to surrender control of the location (Dictionaries, 2018). Though this certainly occurs in a number of actions against garrisons throughout the Wars of the Three Kingdoms, it is by no means true for all of them and neglects several facets of how attacks against fortified locations are carried out. Returning to Du Praissac's approaches to siegecraft, these definitions would describe the 'famine' approach of blockading a garrison and bringing about surrender through attrition or threat. This clearly neglects the 'siege' and 'surprise' methods, and the use of force to eliminate the defenders.

As identified above, the common factor in each of the approaches and the various tactics used in a siege is the objective of overcoming the garrison within the defended site. This in itself is not quite enough, as an attack on a defended position could potentially also include the defence of a temporary battlefield earthwork, or a skirmish where one force occupied a structure for better defence. The difference between these actions and those of siege is that, typically, the overcoming of the garrisoned force is the purpose of the military action. A temporarily defended structure on a battlefield, while tactically important to occupiers or attackers during a battle, is an incidental part of the terrain of a battlefield rather than the reason for the engagement. Similarly, a building or set of buildings may provide opportune defensive or offensive cover during a skirmish, but the action itself occurs due to a mobile or chance encounter between two military forces, rather than one force converging on the prepared, static location of another

Considering these issues, this study offers the following definition of a siege action:

A siege is a distinct military action against an occupied defensive position where control of the position through displacement, removal or elimination of the garrisoned force, or the destruction *of the position are the main objectives of the attacking force, and where the garrison resist this attack.*

Two points should be made regarding this definition. In contrast to the definition for battlefields, there is no lower limit on the number of soldiers that should be involved for this to constitute a siege action. There are numerous actions that take place in England during the Civil Wars against small garrisons, with the example of the first Royalist garrison at Old Wardour Castle numbering only twenty-five men (Girouard, 2012, pp. 38). There is certainly a threshold at which the number of defenders becomes too few to constitute an effective garrison, though this will be largely dependent on the scale of the defended site, as well as dependent on the period of warfare in which the action takes places as to the capabilities of ever smaller forces when garrisoned. Within the bounds of the Civil Wars a suitable historical example that would help to define this limit for the early modern period has not been identified.

The second point is that the definition also does not discriminate actions based on the character or duration of the siege i.e. the type of structure, the size of the defended site and type of fortifications, the method of attack employed or the time-interval over which the events of the action take place. As discussed above, attacks on fortified garrisons are carried out using the same equipment and tactical methods for small, fortified manor houses as for large settlements, albeit at a different scale of activity. This scale also influences the duration of actions, as the time required to give orders to and prepare an army to storm the defences of a garrisoned city is undoubtedly a much greater logistical and tactically complex process that storming a small rural castle occupied by a hundred soldiers using a single company of musketeers. Yet both require the same tactical knowledge and weaponry to achieve victory, whether or not the process takes two days to prepare in the case of the former (e.g. Bristol, 1643) or less than a couple of hours for the latter (e.g. Moreton Corbet Castle, 1644). Undoubtedly the variation in the character of a siege in turn affects the character of the archaeological evidence of the siege, as well as the methods by which that evidence can be explored, but the underlying formative processes remain the same.

2.2.2 Peripheral examples

Although the definition is clear there are actions that lie on the periphery of being a siege, or actions where the physical evidence may mimic that of a siege site. Obvious examples of the latter group are battles and skirmishes that take place in proximity to settlements or structures. St. Luke's Church in Holmes Chapel, Cheshire, bears numerous small-arms scars on the surviving sandstone tower, as is also the case at churches for a number of small siege sites. However a siege did not occur here as the village is not recorded as a garrison by any contemporary sources, and the scars are believed to derive from a skirmish in the village that coincided with the Battle of Middlewich, 1643 (Foard and Morris, 2012, pp. 129). Perhaps closer to a siege action was the use by Parliamentarians of the church of St. Mary in Canons Ashby, Northamptonshire, which was bears small-arms impact scars from the attack, and was subjected to petard attack of the doors (Foard and Morris, 2012, pp. 127-128). Neither of these are considered sieges as per the definition, however study of their archaeological signatures may compliment investigation of sites with evidence that arises in a similar manner. Moreton Corbet Castle, Shropshire, was stormed in 1644 and the neighbouring church bears numerous impact scars on walls facing the castle (Foard and Morris, 2012, pp. 131-133), suggesting that as with Holmes Chapel, this building was background to fire against a force not occupying a fortified position, although the circumstance of the origin of these shots is different.

A similar occurrence to that at Canons Ashby would be the skirmish at Loppington, Shropshire, where soldiers from outpost of the Parliamentary garrison at Wem were attacked and forced to use the church as temporary refuge (Bracher and Emmett, 2000, pp. 81). It may be that the church at Loppington was already some form of occupied defensive position that prompted its use as a refuge, as the village had been occupied by a substantial number of dragoons from the Wem garrison and the church formed a strong-point during resistance to the attack (Worton, 2016, pp. 205). However as this engagement involved mobile forces of more than a thousand soldiers on each side, it has been argued to fall into the category of a small battle by (Worton, 2016, pp. 205), rather than a skirmish. Loppington is perhaps one of a few actions in the Civil Wars that may have archaeological signatures for a skirmish, siege and battle all within a single location.

The events at Stokesay Castle in 1645 challenge the definition with regards to what constitutes a military action. As is outlined above, the use of threat to force the surrender of a garrison at risk of being stormed can be as effective as direct attack in resolving the siege. At Stokesay however it seems that following the first summons to surrender, as the Parliamentarian forces were preparing to storm the castle due to lack of ordnance for bombardment, the garrison surrendered without any actual fighting having taken place (Summerson, 2009, pp. 32-33). On balance Stokesay should not be considered a siege action for the purposes of the archaeological study of sieges. While the use of threat was key to overcoming the garrison and is a legitimate siege approach, the lack of any form of apparent engagement relegates this to little more than capitulation as a result of the manoeuvres by the besieging force. Archaeological investigation could reveal this not to be the case, however, a later attempt to retake the castle by Royalist forces from Hereford later that year would undoubtedly mask any non-combative signature through the presence of an actual contest (Summerson, 2009, pp. 33-34).

2.3 What is a siege site?

While identifying battlefields often comes with the challenge of correctly locating the site within the modern landscape, identifying the location of identified siege actions is generally much more straightforward, owing to the relatively static nature of sieges compared with battles, and the focus of attack upon an identifiable structure, settlement or fortification. While this is an advantage for investigating archaeological sites of sieges, it has its own set of challenges in relation to the protection and conservation of the archaeology.

Typically, the garrisoned sites of sieges enjoy more statutory protection as archaeological sites than battlefields in England. Castles, churches, ruined buildings and surviving earthworks that generally fall within the defensive circuit of a garrisoned site are largely protected as scheduled monuments or listed buildings. Battlefields by contrast are largely unprotected as they have little or no stratified or upstanding features for statutory protection, with the exception of mass graves where those have been located. While the Register of Historic Battlefields offers some protection against planning and development, the list is not exhaustive and offers no statutory protection against illicit recovery of artefacts through non-archaeological metal-detecting.

Despite this protection of the cores of siege sites, by and large the majority of the siege site itself lies beyond that boundary. With the exceptions again of scheduled siegeworks or listed structures present at the time of the siege, the majority of the active area of the fighting between the position of the besiegers and outer limit of the defences is unprotected from development or non-archaeological metal detecting. Despite the potential archaeology in terms of both unstratified artefact scatter and buried contexts such as siege mines and trenches, there is as yet no form of register for siege locations specifically that parallels the Register of Historic Battlefields in England.

2.3.1 Defining a siege site

Having established what constitutes a siege action, to better address the opportunities and threats regarding siege archaeology it becomes necessary to define the components and extent of what might be considered a siege site. Harrington (2005) identifies three essential components for a siege site, as well as addressing their potential archaeological signatures. The components listed by Harrington are the fortified structure, the location of the besieging forces, and the dead ground or ‘siegefield’ that lies between the two forces. As the term dead ground exists in military vocabulary to refer to an area shielded from view and fire by local topography, the term siegefield will be used hereafter to refer to this aspect.

2.3.1.1 Fortified structure

The garrison is the focus and reason for the occurrence of a siege, and as such the fortified position of the garrison force is the focus of both the siege action and the archaeological site. Harrington sets the limitations of this area as the occupied structures of the garrison, and associated outworks built to fortify and protect the site (Harrington, 2005, pp. 97). The limits of the garrisoned site may be relatively well defined for some sites by the extent of the defensive structures and earthworks, however for many sites the exact limits of the defensive positions are not clear, either through loss of earthworks as a result of their being filled or levelled after the war, or for a lack of specific information about where the garrison were located during the siege. There is also at least one recorded instance from the Civil Wars where a garrison was divided between non-contiguous defensive positions, namely at Tong, Shropshire, where the defending forces were split between the combined site of the church and collegiate in the village, and the castle almost half a kilometre to the south (Worton, 2016, pp. 224).

2.3.1.2 Besieging force

The location of the besieging force would include camp sites as well as lines of circumvallation where used, or other siege works built for the purpose of attacking the garrison. Harrington also identified that it was also common for nearby structures to be occupied and adapted for use as accommodation of the besiegers, or as positions from which to attack the defenders using muskets or ordnance (Harrington, 2005, pp. 98). Generally however the location of the besieging forces within the siege landscape is something poorly understood for a large number of sites, and Harrington acknowledges there is often little evidence by way of surviving siege works, or known camp-locations for the attacking forces (Harrington, 2005, pp. 99).

2.3.1.3 Siegefield

The siegefield is less specific than the other two aspects outlined by Harrington, effectively comprising all of the area and archaeological evidence in between the two positions as well as overlapping them in part (Harrington, 2005, pp. 98-99). This aspect would incorporate lines of approach dug by the besiegers, mining activity beyond the limits of the fortifications, and the unstratified artefacts of exchanges of fire from assaults, sallies, raids and defensive fire. Harrington describes this as the primary zone of deposition and adds to it ditches and moats beyond the defences of the garrison, though these could be argued to be part of the defensive system utilised by the garrison.

2.3.2 Developing a model for siege sites

There are issues with Harrington's definition for the components of siege sites when applied to examples of historic sieges. While the fortified structure component generally works for sieges, the classification itself implies a static zone controlled by the defenders until the siege is concluded. This is certainly not the case for numerous sieges where, over the course of the siege, elements of what would have been part of the fortified site at the outset of the siege were overrun or abandoned as the siege progressed. This certainly applies to Chester in 1645, where the outworks protecting the east suburb were abandoned by the Royalist defenders after Parliament successfully seized control of the Broughton turnpike and forced entry, proceeding thereafter to attack the defended city walls (Ward, 1987, pp. 11-12). At Pontefract the church of All Saints formed an outlier of the garrison and was heavily contested during the second siege, eventually falling to the Parliamentarian besiegers after concerted bombardment of the position by both sides at different stages (Roberts, 2002, pp. 417). In both of these instances the locations in question transition from fortified structure/site to location of besiegers, after seeing fighting that would arguably also make them part of the siegefield evidence.

The component of the besieger's location is also unlikely to manifest itself archaeologically for instances of sieges where the attacking force opted to storm the garrison rather than undertake a protracted siege. This certainly applies to the Shropshire sites of Tong and Moreton Corbet, where both were subjected to storm in 1644 without any siegeworks being produced, though the Royalist besiegers in the former likely at least made a camp site during the two-day interlude between storming the church garrison-outlier, and the surrender of the castle (Worton, 2016, pp. 224). The same also seems to be true of the first siege of Basing House, as the attempted assaults of the defences took place each after a short bombardment of the defences, and during the intervening period between these attempts the Parliamentarian army sheltered in nearby Basingstoke, rather than produce a camp and construct lines of circumvallation (Young and Emberton, 1978, pp. 91-92).

While a useful general description of a siege site, Harrington's assessment does not aid targeting archaeological exploration at siege locations. Although the description of each element offers suggestions to the types of evidence that may be found there, it does not follow that if searching for a particular component of a siege action that a study should target a specific zone. For instance, for archaeologically investigating siegeworks the implication is that a study must focus on the zone of the besieging force. This however overlooks that the key components of attack using siegeworks, such as approaches dug towards fortifications and earthworks thrown up to protect these advances, would occur predominantly within the siegefield zone. This is evident at Pontefract where, as the battle for control of the All Saints' Church developed, the attackers built new earthworks in close proximity to the church in an attempt to gain the upper hand in attempting to take that ground(Roberts, 2002, pp. 417).

What is lacking in Harrington's description of a siege site is the temporal factor. Sieges are not wholly static affairs, and in much the same way as battles develop beyond the initial deployment of soldiers within the landscape, sieges develop as defences are overrun, bombardment and mines damage or demolish buildings, and soldiers contest control of territory. In this regard the evidence of the action can cover all three areas to varying degrees dependent on the specific events during a given siege and the starting conditions with regard to the fortified site and the deployment of the besiegers.

2.3.2.1 Temporal model

Crucially with regard to the siegefield component, Harrington identifies that this has overlap with the other two areas. This would certainly be the case for storming actions through breaches in fortifications or across earthworks for the fortified position component. The same would be true of evidence for sallies by the defenders that leave scatters within the siege-lines of the attacking force, as is likely to be the case for evidence of the second siege at Basing House (Young and Emberton, 1978, pp. 93). Effectively the siegefield is the component that reflects the siege action, rather than the initial extent of the fortified site, or the initial positions taken up by the attackers before advancing during the course of the siege, and thus contains all of the archaeological aspects that are a result of the action at that site. This gives us essentially two components to a siege site.

2.3.2.2 The garrisoned site (pre-siege)

The first is the pre-siege activity of the garrison, particularly in terms of fortification and preparation of the surrounding area, such as burning buildings or felling trees to clear fields of fire. This provides the initial conditions of the fortified site prior to the arrival of the besieging force and the starting point from which the siege action will develop. It will include extant and stratified archaeological contexts for the occupation of the site, construction of the defences and alterations to the fabric of buildings occupied by the garrison. What it will not include however is the evidence of action in the form of unstratified scatters of artefacts, and impact evidence on structures born from attack or defence.

2.3.2.3 The siegefield (siege)

The second component encompasses the entire area within which the siege action was fought. This may seem overly simplistic and too inclusive as it brings all of the elements of a siege site together and incorporates the entire site to the outer limits of its archaeological evidence. Nevertheless dividing a site either based on static concepts or trying to subdivide the site for different archaeological zones overlooks the complexity and variety in siege actions and in the resulting archaeological evidence. The siegefield evidence includes the stratigraphy of offensive earthworks and to a lesser extent defensive works built during the siege, the upstanding remains of earthworks and buildings within the siege area, including the defences of the garrison, and the unstratified scatter of offensive and defensive small-arms fire, ordnance projectiles and impacted bullet fragments adjacent to or within the defended area.

2.3.3 Site specific siege archaeology

For the purposes of defining a siege site, the focus on the garrisoned site and extension out to the limits of the archaeological evidence is simple, though without visible evidence on the ground for the position of the attacking forces, no more straightforward in application than Harrington's model. Rather than attempting to sub-divide the siegefield into defences, siegeworks and middle ground, the siege itself should be considered initially through historic accounts and reconstruction of the historic landscape, including the pre-siege garrisoned site.

We cannot rely on the documentary sources alone to tell us what form the fighting took during a siege action, or where it occurred. As Harrington illustrates from the example of Stirling Castle, the contemporary account highlighted wholly ignores the activity at the main gate of the castle, evidenced archaeologically by the presence of small-arms impact scars (Harrington, 2005, pp. 109-111). However, until a sufficient body of data and interpretative work has been developed for the interpretation of siege archaeology using supporting historical sources, archaeological investigation of the physical evidence alone will provide only a limited understanding of the events of a siege.

2.4 Summary

With a definition of what constitutes a siege action and an understanding of how they are fought, we are able to compare different sieges within the same cultural frame of reference. The variety in approaches and tactics used for siege actions, as well as the different types of sites used for garrisons, produces sieges that will undoubtedly have a variety of archaeological characters. Until a proper base of study exists regarding the evidence for siege action of all forms within a siege site, predicting the archaeology for a site based on the type of action will remain largely speculative.

In order to develop a methodology to allow archaeological investigation to explore and interpret the evidence of siege actions, the existing body of work regarding early modern siege warfare, and particularly archaeological studies that have touched upon the evidence created by the use of specific siege tactics needs to be reviewed.

3. A Review of Existing Siege Studies

Despite the relative ease with which the locations of historic sieges can generally be located, and the quantity of sites that exist for conflicts of the seventeenth century, there remains little archaeological study of the conduct of siege operations for this period that could be considered under the discipline of conflict archaeology. Techniques developed in the pursuit of the archaeological evidence of battle have largely overlooked sieges, despite some inherent advantages that siege sites offer for understanding of conflict for this period and developing the field of battlefield archaeology.

This chapter will present and discuss existing research on seventeenth century siegecraft. This discussion will initially cover the subject from the perspectives of an overview of siege warfare and aspects thereof particularly regarding England during the Wars of the Three Kingdoms, considering both historiographical and archaeological discussion of the subject. Following from an overview of siege warfare the discussion will examine how the archaeology of siege sites has advanced the understanding of individual siege actions and specific aspects of attack and defence. This aspect will cover investigations of post-medieval sieges within the geographical British Isles from the sixteenth century through to the mid-eighteenth century, as while this exceeds the focus on the period of the Civil Wars, the methodologies developed through investigation of these sites will be applicable across the time-period owing to the broadly similar forms of military technology and material culture during the early modern period.

Finally, the gaps in existing understanding of siege operations for the Civil Wars will be highlighted alongside the aspects of the archaeological evidence for which there is yet to be developed a sufficient methodology of investigation. Opportunities for advancing the knowledge of siege activity during the Civil Wars through application of methodological investigation of these aspects will be outlined as the objectives for further targeted study of siege sites in England.

3.1 Overview studies of sieges for the Wars of the Three Kingdoms

How are siege actions fought and how are fortified site defended? These are fundamental questions for understanding the outcome of sieges and the experiences of siege warfare for the Wars of the Three Kingdoms in England. For the most part much of the information from which we presently draw answers for theses are studies based on the contemporary accounts and documentary records, as well as on a growing body of archaeological data from garrisoned site excavations. What is missing from present attempts to answer these questions is an archaeological approach to understanding the processes and experiences of siege actions.

Siege warfare in England and the wider British Isles during the Wars of the Three Kingdoms has been identified as being the characteristic experience of the conflicts (Duffy, 1979, Hutton and Reeves, 1998, Gaunt, 2014). It has been calculated that siege operations account for nearly a quarter of all fatalities in the Civil Wars in England, and nine percent more than those from pitched battles (Carlton, 1992, pp. 155). Two key reasons stand out as to why this was the case. Firstly the conflict was a civil war, and unlike the concurrent international conflict on the continent, generally no side could rely on a contiguous frontier of territory, or the undivided support of the population within controlled areas (Duffy, 1979, pp. 147, Hutton and Reeves, 1998, pp. 199). The second reason is that as the fighting was generally widespread in scope, protecting and controlling local centres of production for war assets such as clothing, food and ordnance, or ports through which supplies and munitions could be imported, was vital for ensuring access to strategic assets once it became apparent that the war would persist after 1642 (Hutton and Reeves, 1998, pp. 199, Gaunt, 2014, pp. 91-93). Garrison warfare for this conflict was therefore as much about exerting control over areas it was a defensive measure against enemy armies. Carlton notes that garrisons spent much of their time providing their own subsistence from local settlements under the guise of tax collecting, often to the increasing ire of the local population (Carlton, 1992, pp. 152-154).

However while many sieges took place at garrisoned urban centres, there are many more that occur at for fortified country houses and rural castles, and in the case of many of these sites the documentary record is extremely limited while the recovered archaeological data is practically non-existent (Harrington, 2005, pp. 111). By contrast however, in rural areas the unstratified artefact scatters and stratified earth-moving evidence of siege actions are generally more likely to have avoided destruction through development. This means that while the majority of siege actions have the least amount of available documentary evidence, they may also have possibly the best surviving archaeology available for study.

3.1.1 The model and application of siege warfare in England

In order to understand how siege actions were conducted in England during the Civil Wars, it is necessary to understand the state of knowledge of siege warfare and fortification as a military science.

Numerous historiographical works provide overviews of both the nature and practice of siege warfare in the English Civil Wars (Duffy, 1979, Hutton and Reeves, 1998, Bull, 2008, Gaunt, 2014). Duffy (1979) in particular puts siege activity and fortification of the Civil Wars in England in the wider context of the development of early modern siege warfare in Europe. Duffy follows the development of permanent artillery fortifications in Italy and France in the sixteenth century through to the Dutch style of fortification during the Eighty Years War, both as a technical response to developing artillery capabilities, but also the strategic demands of fortress building in these regions during the period. Understanding continental developments in siege warfare is important for understanding siege activity during the Civil Wars as with a prolonged period of peace in England since the mid-sixteenth century and the union of crowns in 1603, there had been little requirement for improving or building new fortifications, save for coastal forts and key port settlements under threat from the Spanish Armada in 1588 (Duffy, 1979, pp. 140-141).

The natural consequence of this peace is a lack of domestic expertise and practical familiarity with the practice of siege warfare and fortification. Hutton and Reeves note that the lack of skilled practitioners of siegecraft and fortification in England at the outset of the conflict led both Royalists and Parliament to employ European engineers for siege operations, and to fortification design and construction (Hutton and Reeves, 1998, pp. 208). As a result of this import of expertise, England became largely influenced by the Dutch model of fortification and siegecraft, with contemporary English-language military manuals largely plagiarising Dutch texts (Duffy, 1979, pp. 146). In addition to this Duffy notes key commanders for both sides during the conflict that gained first-hand experience of siegecraft drawn from sieges in the low countries, most notably the Siege of Breda in 1637 (Duffy, 1979, pp. 145).

In addition to a lack of native expertise in fortification and siegecraft, the lack of adequate siege guns in the English theatre is noted as a hindrance for the conduct of siege operations (Hutton and Reeves, 1998, pp. 209). The lack of large calibre guns may not necessarily reflect an inability for English field armies to carry out siege operations during the period, as is noted below, fortifications where typically not as formidable as prepared defences on the continent. As such the tactics and tools necessary to overcome small garrisons, such as at Old Wardour Castle (Wilts.) or Moreton Corbet Castle (Salop.), did not always depend on the success on bombardment. Furthermore the frequency with which small garrisons occupied manor houses as opposed to fortified medieval castles meant that for garrisons such as Grafton House (Northants.) and Compton Wynyates (Warks.), only a saker was required to cause sufficient damage to overcome the garrison (Hutton and Reeves, 1998, pp. 230). There was also a pragmatic need to armies to move quickly through territory in civil conflict where the full support of the local population might not necessarily be trusted, possibly reflected by the choice of King Charles to bring only field guns with his army in 1644 but adding larger guns when required to overcome the defences of Leicester the following year (Hutton and Reeves, 1998). Where armies required larger guns to overcome a difficult garrison, the guns at local friendly garrisons could also be called upon as a loan to that force for the operation, effectively allowing for regional provision of siege guns in place of the need to transport them with an artillery train. At Scarborough (N Yorks.) for instance, the Royalist garrison withdrew to the castle from the surrounding town and required the Parliamentarian besiegers to draw up heavy guns from the garrisons at York and Hull to support the bombardment (Cooke, 2011, pp. 175).

Despite access to knowledge and experience available to both sides, armies with experienced commanders still failed to use proper siege methods for large-scale operations. The Royalist siege of Gloucester and Parliamentarian siege of York both neglected to prepare lines of countervallation during their protracted siege operations, and as such both forces were forced to retreat in the face of relieving forces, precipitating the battles of Newbury (1643) and Marston Moor (1644) respectively (Duffy, 1979, pp. 153-154). This does not necessarily imply superior skill on the part of the fortifications, as Duffy recognises that it is much easier to improvise defence than attack in siege warfare (Duffy, 1979, pp. 152-153), particularly in the context of insufficient supply of ordinance, munitions and gunpowder for intensive bombardment. It was only after the New Model Army had developed an effective siege train of artillery and engineers by 1645 that a field army became reliably competent at garrison conquest and received sufficient supply to do so (Duffy, 1979, pp. 154, Hutton and Reeves, 1998, pp. 209).

The implication of observations regarding Gloucester and York is that it was the lack of expertise and resources for siege operations, rather than of knowledge and experience, that restricted the capability of an army for the conduct of sieges against fortified settlements. Actions on this scale however were not typical for the conflict as the majority of sieges involved smaller defended sites with forces of often a few hundred or less, and rapid bombardment and assault could overcome these with greater ease than with a protracted siege (Gaunt, 2014, pp. 103). Judging the ability of both sides to conduct sieges based on attacks against large garrisons may not be a fair reflection of the capabilities of Civil War armies to carry out siege warfare more widely. For most of the conflict from 1642 to early-1645, siege warfare continued to be practised without widespread access to expert engineers or artillery resources, but nevertheless resulted in numerous successful sieges of both large settlements and small fortified garrisons. A force with sufficient ordinance and engineers for carrying out intensive siege actions against a large urban fortified site only appears in

1645 with the New Model Army, but as the Royalist field army had effectively been destroyed at Naseby in the same year, the effectiveness of the New Model's siege operations could also be a reflection of the freedom of time and movement within England afforded to the Parliamentarians to attack garrisons without the threat of a relief force for the defenders.

If sieges can be concluded successfully for the attacking force without sufficient expertise or resources for a protracted siege, is this a reflection of the manner in which sites are fortified and defended during this period? Are sieges conducted against fortified sites using the best methods available to them despite lack of expert engineers and ordinance, or are besiegers using experience and knowledge in a pragmatic way to take best advantage of weaknesses or opportunities presented by poor garrison defence?

3.1.2 Application of fortification theory to garrisoned sites

Examination of Civil War defences through documentary records and archaeological evidence by Harrington (2004) can provide some answers to these questions. Harrington (2004) provides an overview of the archaeology of the Civil Wars in England and examines the issue of surviving fortification evidence at sites. While stone walls and castle structures were in theory technologically obsolete by this period, these structures still provided an effective defensive obstacle and archaeological evidence shows numerous instances of urban walls being repaired and improved for use during the conflict (Harrington, 2004, pp. 13, 15). Where Harrington goes on to discuss individual examples of urban centres where archaeological work has taken place however, each has revealed some aspect of earthwork defences that complement or replace elements of the stone fortifications, suggesting that over time at least these centres began to utilise modern fortification technology.

While the physical evidence for town defences is largely incomplete due to limited excavation in developed areas, examples of near complete evidence of earthen defensive fortifications at castles and small garrisons offer a glimpse of the adaptive approach to creating earthwork defences. Harrington highlights examples of different approaches at Cambridge and Donnington Castles, the former using earthen bastions to improve the defensiveness of the castle walls as the principle structure, while the defences at the latter wholly surround the medieval structure and form the principle line of defence for the site (Harrington, 2004, pp. 43-44). Archaeological work at the sites of fortified country houses such as High Ercall and Shelford House, and the upstanding earthwork defences at Basing House further underline this adaptive approach to fortification, utilising the existing features of the garrisoned site as the basis for fortification rather than building outworks from scratch (Harrington, 2004, pp. 67-70). This approach to fortification may have been as much a pragmatic use of limited labour and material resources available to these smaller garrisons, as of a lack of expertise in the art of fortification. For a small garrison, it is certain that adapting the existing structure with limited improvements would make better use of the limited defensive labour force than embarking on an ambitious project of earthen defences that could be incomplete at the commencement of a siege.

Even without significant expertise in defensive structures basic improvements to the structure of existing defences could be as effective at withstanding attack as those of better construction and design. Hutton and Reeves (1998) cite the examples of Birmingham and Worcester in this regard. At Birmingham in 1643, professional royalist forces were unable to overcome the basic breastworks constructed by inexperienced troops in the Parliamentary garrison, succeeding only through outflanking the defences (Hutton and Reeves, 1998, pp. 203), suggesting that construction was incomplete at the point of attack. At Worcester, Henry Townshend observed that the structure of the existing stone defences could have been made impenetrable to bombardment simply with the addition of a significant quantity of earth to absorb the shot, though in this instance as Hutton and Reeves point out, the comments were made in lamentation at the lack of adequate earth-shoring of the stone walls due to the willingness of the populace and garrison to opt for the less labour intensive and riskier approach to fortification (Hutton and Reeves, 1998, pp. 203).

In several instances where professional engineers were brought in to improve or implement defensive fortification of garrisons, there is evidence that they too adopted a pragmatic approach to defence. In discussing artillery fortification during the Civil Wars, Bull (2008) indicates that the vast majority of defensive works were locally planned, with similarities in defensive designs the result of common shared knowledge between engineers rather than a centralised planning approach to fortification (Bull, 2008, pp. 98-99). This is further evidenced by a lack of an emergent style for Parliament or Royalist fortification (Bull, 2008, pp. 99), however Bull is here discussing principally artillery-led fortification for the purpose of protecting against or mounting ordnance for siege defence. This overlooks sites of smaller, ‘satellite garrisons’, where the concern of facing large siege guns may have been less immediate, and where ordnance for defending the garrison might be unavailable.

3.1.3 Pragmatism versus inexpertise in attack

If the approach to fortification was pragmatic rather than inexpert, or possibly a combination of the two, how does the prosecution of siege actions by besieging forces compare to the expected approach? With regard to the use of ordnance in siege operations, Bull sets out a structure for what might be considered a stereotypical siege, commencing with a demand for surrender, progressing on to the construction of siegeworks, the bombardment of the enemy defences, and finally the storming of the garrison (Bull, 2008, pp. 100-113). Though several example sieges are set out in limited detail and principally focus on the role and effectiveness of ordnance in each siege (Bull, 2008, pp. 113-136), there is no particular effort to identify how common the use of the above sequence was in the conduct of sieges beyond this overview. Barratt (2009) picks up on the point of lacking ordnance resources directing the ability of siegecraft during the earlier years of the war in England. Though the armies engaged in fighting on the continent used siege trains with a substantial number of guns, the Royalist and Parliamentary armies did not have the resources to field an effective siege train, with both large-calibre guns effective against fortifications and mortars being in short supply (Barratt, 2009, pp. 14-15). Furthermore Barratt identifies that this problem became increasingly more difficult for the Royalists than for Parliament as the war progressed, and for the Royalists other approaches such as direct storming, or using gunpowder charges in siege mining were used to overcome this deficiency (Barratt, 2009, pp. 15-16). This suggests that as with fortification, siege operations were also carried out using a pragmatic approach due to a lack of resources than necessarily knowledge or expertise of siege warfare. Barratt does however cite the examples of individuals such as Sir William Brereton for parliament, and Dr William Chillingworth for the King, who both unsuccessfully adopted the use of medieval-type siege engines for the purposes of besieging the garrisons at Beeston and Gloucester respectively (Barratt, 2009, pp. 16-17).

It is arguable as to whether or not these improvisations reflected a lack of knowledge in military science by the individuals in question, or represent another example of applying knowledge of past-military techniques in an attempt to overcome a lack of resources for the siege. In the latter example it is worth noting that the besieging force also failed to dig lines of circumvallation to enclose the enemy garrison, as was also the case at York by the Parliamentarians (Duffy, 1979, pp. 153-154). This failure to implement a fundamental preparation for besieging a site is unlikely to be the result of error by the commanders, however whether this was a pragmatic decision based on the evident inability to effectively carry out the siege by the attacking army, or one of possible arrogance that they would not be required would require further study to determine.

Historiographies outlining the events of siege actions help outline some of the issues between whether conduct of siege warfare was characterised by pragmatism of poor military practice. In the example of the sieges of Bristol (1643 and 1645), Barratt notes that the initial siege resulted in a pyrrhic victory for the Royalists under Prince Rupert, where, after intensive fighting and losses during the storming action, the defenders were eventually overcome owing to too few defenders to adequately man the defences, poor leadership and a lack of will to continue the struggle amongst the garrison, leading to desertion (Barratt, 2009, pp. 35-36). However by the second siege in 1645, the Royalist garrison of two years had not learned the lessons of the victory in 1643, as the defences were repaired yet largely unaltered to account for previous weaknesses, and the garrison left to control the city was again too small and of insufficient will to continue the fight (Barratt, 2009, pp. 38), though this second siege occurred after the Battle of Naseby at which the Royalist field army was effectively eliminated as a fighting force and arguably the Royalist cause was all but lost by this point in England. The failure to learn the lessons of the previous siege at Bristol is indicative failure of expertise, despite the employment of a professional engineer (de Gomme) to oversee repair of the defences following the storming in 1643 (Barratt, 2009, pp. 38). Other instances of failings in both attacks, such as insufficient ladder lengths for assaulting the defensive works, or difficulties in properly co-ordinating the commencement of the first siege storming action do not necessarily indicate failings of experience in the leadership or professionalism of the soldiers, but are perhaps rather indicative of the difficulties of adequately supplying an army in a civil conflict, where the support of professional craftsmen and industry for a single nation fighting abroad is instead splintered and unreliable.

3.1.4 Destruction at siege sites

Understanding patterns of destruction during pre-siege preparation and during the siege action itself enables a more complete understanding of the evidence created as the result of attack and defence activity. Porter’s study of destruction during the Civil Wars identifies a number of aspects of both the pre-siege defensive preparation of a site, and the siege activity, that would produce destructive activity in relation to buildings (Porter, 1997). Pre-siege activity included the construction and improvement of defences for the physical space that these required, as well as the clearance of areas beyond the defences to ensure these could not be utilised by the enemy as cover or accommodation (Porter, 1997, pp. 15-24), though Porter notes this destruction of suburbs by the occupying garrisons was sometimes not carried out until just before or after the siege had begun, and as a result would likely resort to burning the structures (Porter, 1997, pp. 41-45). While careful early-demolition may not be easily detectable through archaeological means if the land was redeveloped later, razing buildings through burning should leave demolition-related stratigraphy that would contain deposits of burnt material in the areas that fall outside of the fortifications. This in turn could provide archaeological clues as to the extent of fortification at sites where this is known to have occurred but where evidence of the location of fortifications is unclear, though evidence of burnt deposits would need to rule out episodes of fire caused by non-military activity in other near-contemporary periods.

Causes of destruction once a siege had begun are much more varied and could affect areas right across the siegefield dependent on the location of the fighting at any given time, or on which side was the cause. Perhaps the most obvious cause of destruction for the fortified site would be through bombardment, damage typically taking the form of the physical impact of projectiles, though heated cannon balls and exploding mortar grenadoes were capable of greater destruction than impact force, triggering fires that could destroy buildings within the defended area (Porter, 1997, pp. 46-50). Direct evidence for destruction through bombardment is evident on ruined structures that still bear artillery impact scars, though ruins of this kind are typically limited to stone or stone-faced structures, as timber-framed buildings generally do not survive to the present day. Despite the threat of fire damage through bombardment, Porter states that this is relatively uncommon for widespread destruction at sieges, owing in part at besieged settlements to peace-time fire safety measures (Porter, 1997, pp. 51-52), but also to a significant degree on the rate of fire of projectiles during siege actions. Porter shows that for the many sieges the rate of fire of artillery pieces, already identified above and being in relatively short supply for most besieging forces, was considerably constrained by access to sufficient supplies of gunpowder and munitions. With exception of targeted bombardment to breach defences, the rate of fire during sieges was often as low as two to three shots per day (Porter, 1997, pp. 54-55), which in turn allowed the garrison to tackle fires more effectively due to their sporadic occurrence. It is again not until the end of the war and the field-dominance of the New Model Army after Naseby that a besieging force has sufficient supply and manpower to make effective use of artillery for destructive bombardment (Porter, 1997, pp. 54).

One aspect of siege destruction that Porter neglects to address is that caused by mining activity. The scale of destruction caused by mining clearly varied considerably depending on the conditions of the defended site under attack, and the method of ‘springing’ the mine used. Clearly the gunpowder charge used in the second siege of Old Wardour resulted in a considerable degree of damage to the western wall of the keep, which resulted in the permanent ruin of the castle (Girouard, 2012), whereas the use of burnt-prop collapse at Limerick only brought down short sections of the eastern wall and bastion with each collapse (Wiggins, 2001). While mining is not recorded as having been used in many siege actions, and furthermore the mines were not always successfully completed or sprung, these do produce archaeological traces of destruction in the defences of a garrisoned site, albeit for a more targeted area than by indiscriminate bombardment by artillery. The evidence of damage from mining compliments the evidence of destruction wrought by artillery bombardment in trying to overcome defensive structures, and is thus a component in the evidence of how the attacking force conducted their siege.

3.2 Archaeological exploration of attack and defence

While the archaeology of fortified sites has been explored through excavation of occupational deposits and stratigraphy at numerous garrisoned locations from the Civil Wars, the archaeology of attack is far less well represented within the literature. Generally only a few example or pilot studies exist for each of the aspects that could be explored archaeologically, and for many of these there has as yet been no attempt to establish a methodology for detailed investigation of the archaeology that could develop study of siege actions further.

Developments in the exploration of unstratified artefact scatters as achieved through battlefield archaeological studies beginning with the Little Big Horn (Scott et al., 1989) have bypassed sieges as sites of conflict for the seventeenth century. This is illustrated most tellingly by the fact that between Harrington's first overview of siege archaeology of the Civil Wars (Harrington, 1992) and the publication of the research and analysis of the UK Fields of Conflict Database by Foard and Morris (2012), which itself is principally focussed on battlefields, only two detailed studies of siege sites that incorporate the evidence of attack were published (Wiggins, 2001, Foard, 2001), and of these only the Grafton Regis study employed metal detector survey. Both studies are addressed separately below. No doubt the lack of movement in this field over this time frame is the reason why two overview studies exist for the topic that examine the present state of archaeological investigation for attack and defence at sieges (Harrington, 2005, Foard and Morris, 2012), and what potential exists for the archaeological aspects they address. Foard and Morris (2012) offers the most detailed examination of these overviews, as well as some pilot work regarding the archaeology of projectile impact scars and unstratified artefact scatter analysis. This will be addressed further below with regard to areas to be expanded upon elsewhere within this thesis.

3.2.1 Overviews of the potential of small siege sites

Though archaeology has been used as a means to investigate fortification and the application of defence at siege sites, little work has been done to investigate the archaeological evidence of attack. The study by Harrington (2005) outlining the state of 'siegefield' archaeology for the British Civil Wars was published approaching two decades ago, and posed a number of questions about how sieges were fought that could be answered archaeologically through the systematic study of a siege site. Harrington's assessment tries to highlight the advantages of investigating small siege sites for the archaeological signature of siege action that is generally missing from studies of fortified sites and siegefields within urban contexts. Harrington essentially divides siege sites into two categories; sites of large settlements that were garrisoned and besieged, such as Chester, Bristol and Newark, and those of small manor houses and castles that were similarly the centre of siege actions, including Basing House, Grafton Regis and Beeston Castle (Harrington, 2005, pp. 93-95). Harrington's uses of this distinction is not to differentiate the nature of the siege activity but to describe the perceived scale of the siege based on the area of the targeted fortified site, and potential for survival of the archaeology. This is not a useful distinction however as many castle sieges took place wholly or partially within or urban contexts, such as those at Pontefract and Limerick, where the area of the siegefield incorporated the suburbs of the associated settlements. Furthermore a number of sieges that took place in more rural settings at the time of the conflicts are now partially or wholly enveloped by the spread of the neighbouring settlements, such as with Basing House or Wythenshawe Hall, making this distinction largely irrelevant.

Despite identifying that smaller, less developed siege sites offer a wide potential for the study of siege actions, the examples given by Harrington overly focus on aspects of the archaeology recovered through excavation and other approaches for buried contexts. Using the account of Edmund Ludlow, a senior officer in the besieging force at Old Wardour Castle during the first siege and the castle's Parliamentarian garrison commander in the second, Harrington summarises several elements from the sieges that could be identified archaeologically. The key identified elements include siegeworks, approach trenches and the siege mines used to breach the keeps walls (Harrington, 2005, pp. 101-102). Harrington overlooks two points from the quotations given from Ludlow however, namely that the garrison conducted several sallies from the keep prior to the damage to the portcullis, and that one of the forts constructed on the hill above the castle was within a musket-shot of the defenders, both of which could also be investigated archaeologically. The first aspect, the sallies by the defenders, should leave an archaeological trace in the form of fired projectile scatters and dropped artefacts within the landscape close to the location of the attackers, that could be recovered through metal detector survey. The second narrows down the range of search locations for the no-longer extant siegework based on how far could be considered as "within a musket shot". While this is a vague measurement, presumably at this distance the defenders would at least make attempt to fire on the attacker's position, and concentrations of impacted musket balls could be expected to be found close to the former location of the earthworks.

For the defensive activities stated above, metal detector survey is certain to be the only manner in which these activities could be found archaeologically. The projectiles that relate to the defensive fire in question would probably be clustered around the location of the siegeworks built closer to the fortified site, and those against which the sallies were directed. It is likely therefore that any geophysical signature of these works would be accompanied by high quantities of impacted lead projectiles. Other site-specific challenges to locating such features and evidence exist at Old Wardour, however the possibility of using metal detector survey results to inform and guide the search for stratified evidence of other forms of attack and defence should not be dismissed. While the unstratified scatter of battle is a well-recognised form of archaeology in its own right for the seventeenth century (Foard, 2012, Harding, 2012, Schürger, 2015), for sieges it may serve a secondary function of highlighting areas of earthworks that are no-longer extant, or other buried contexts within the siegefield, particularly where defensive fire is used to try to harass besiegers carrying out earth-moving operations such as constructing trenches, saps or siegeworks.

Harrington is correct in that there is still much scope for the investigation of upstanding remains, limited excavation and geophysical survey at sites that would enhance the understanding of individual siege actions further, or allow comparable study with others that have seen more extensive investigation. Nevertheless despite yearning for an expansion in siegefield studies akin to that of battlefields, Harrington effectively disregards the key development of methodology for survey that has arisen from these, that of systematic metal detecting, and as a result offers little suggestion of how it could be applied to sieges, or where the evidence may be best explored through this approach (Harrington, 2005, pp. 111-112).

3.2.2 Siege study of Limerick Castle (Wiggins, 2001)

To date the only example of a detailed siege study that combines both archaeological and written accounts for a siege of the Wars of the Three Kingdoms is the study of the siege of Limerick Castle (1642) by Wiggins (2001). Excavation of the fortified site as part of a tourism and heritage management project in the 1990s revealed the remains of numerous siege-mining galleries and a number of counter-mines, providing in turn the best insight into the archaeology of contemporary siege mining in the British Isles for that period (Wiggins, 2001). The most notable aspect of the discovery however was the survival and quality of the timer-frame evidence of the siege-mined galleries (Wiggins, 2001, pp. 3).

It is clear from the written accounts and archaeological evidence that siege mining was the key method of attack during this siege, chosen because the Irish assailants had neither the ordnance to breach the walls, nor time to bring about surrender through supply-attrition for the risk of the English defenders being relieved of resupplied (Wiggins, 2001). That the principal form of attack and defence during this siege took place in stratified contexts is fortunate for the survival of the siegefield evidence at this largely urban site as surface scatters are typically destroyed by urban development. The quality of the first-hand accounts in terms of providing a chronology of the siege also contributes to the possibilities within this study, as Wiggins is also able to link the excavated mines and counter-mines with specific events during the siege (Wiggins, 2001, pp. 4). This may set the bar particularly high for an archaeological study of a siege action for a site, as the nature of the mining evidence here itself is possibly unique. Though a number of sieges in England are known to have siege mining to attack the garrison (Wiggins, 2003, pp. 33, Harrington, 2005, pp. 111-112), the extent of mining activity combined with the level of artefact and structural survival of the archaeology, and the highly detailed accounts of the action available for this siege is unlikely to be replicated at another site in England or anywhere else within the British isles.

The conclusion Wiggins draws from the mining activity at Limerick is that the Irish besiegers had a lack of experience and expertise within their force for military mining (Wiggins, 2001, pp. 221-222). While the construction evidence of the gallery mines shows that the mining itself was undertaken by skilled miners, the burnt-prop method of collapse employed was closer to medieval approaches of siege mining than contemporary military science (Wiggins, 2001, pp. 220). While the Irish leader, Gerat Barry, had experience of siege mining operations, he lacked engineering knowledge of modern explosive techniques, and the risk posed to the besiegers by using gunpowder charges, if not done properly, would have been sufficient enough to forego their use (Wiggins, 2001, pp. 220-222). This again raises the question of inexpertise versus pragmatism in the case of Limerick. Here the besiegers lacked sufficient artillery to bombard the defences, and the choice was made to undermine the fortifications despite the lack of expertise in modern mining approaches. Arguably however despite the outdated approach, the prop-burning approach which would have been more straightforward to carry out for the inexpert besiegers, was known to be effective against medieval fortifications such as Limerick Castle, suggesting this was as much a pragmatic choice as one forced by inexpertise. Some archaeological evidence of pragmatic approach to the siege mining exists in the timber evidence of the raised floor in one of the galleries. Wiggins notes that the length of at least two planks used in the raised floor of one of the mines precludes the entrance having used a vertical shaft, as the planks would not have fit through the turn from one into the other (Wiggins, 2001, pp. 209). The most likely origin for the gallery was to have been dug horizontally from the cellar of a nearby building, thus avoiding the need to dig vertical shafts, and providing covered shelter for the mine entrance. Finally, there is also a question raised by the outcome of the mining activity regarding the effectiveness of modern fortification. Wiggins notes that, with some irony, the medieval method of mining employed by the attackers proved most effective on the modern bastion-improvement to the castle’s fortifications developments (Wiggins, 2001, pp. 223), and in this aspect the lack of expertise on the part of the defenders had no appreciable impact on the eventual outcome of the siege.

3.2.3 Excavation evidence of defensive siege activity

In addition to the archaeological evidence for the occupation and activity within a garrison site during multiple sieges, excavations at Pontefract Castle have also produced evidence of countermining activity (Roberts, 2002, pp. 425). Though the counter-mine shafts were apparently abandoned without ever being used to intercept offensive mines, and indeed there is no record of siege mining by the besiegers at Pontefract, the additional depth of stratigraphy produced military artefacts that demonstrated the presence of pike-equipped soldiers within the garrison during the siege (Roberts, 2002, pp. 329-330), evidence for which is often scarce in battlefield archaeological scatters as armour and weapon fragments tend to be recovered after battles and sieges, and ferrous objects tend to decay in the plough-zone.

While the study is chiefly focused on a description of the structure and development of the castle’s construction from the evidence of the remains, several aspects relating directly to the Civil War siege activity were identified, including evidence for the conversion of the kitchen into an industrial workshop for producing lead bullets and other equipment (Roberts, 2002, pp. 52-56). Of the siege artefacts recovered, the study discusses in some detail the range of calibres and features of the recovered lead shot from areas within the castle, however it gives only the briefest mention to identification of where the shot came from based on appearance, and disappointingly while referring to impacted rounds that it attributes to attacking fire (Roberts, 2002, pp. 345), makes no relation of where these were discovered in relation to the castle’s defences. Nevertheless the study is a detailed examination of the site where slighting left the archaeological record of the siege largely intact underneath a demolition layer, with the exception of areas where the archaeology was destroyed by later Victorian landscaping (Roberts, 2002, pp. 423).

3.2.4 Bullet scatter surveying at siege sites

Though limited metal detector surveys have been carried out for the purpose of sampling and evaluating the unstratified evidence for siege actions on English sites from the Wars of the Three Kingdoms, such as Basing House (Wilson, 2015) and Newark (Pollard and Oliver, 2002), survey of contiguous siegefield areas using systematic survey and recovery methodologies are still extremely rare.

To date the only published systematic survey of a siege site using metal detectors was at Grafton Regis, Northamptonshire (Foard, 2001). While a key development for siegefield studies as this evidence stands to reveal more about the unstratified evidence of defensive activities and attacking fire, this survey had a number of issues that limit its potential to interpret the siege. The survey methodology employed for the site involved gridded squares for artefact recovery (Foard, 2001, pp. 99), however this methodology is now used less frequently for battlefield sites due to problems in comparing artefact density, owing to not knowing the intensity of survey and overlap by the metal detectorist within each allocated grid (Foard and Morris, 2012, pp. 137). This degree to which the artefact results from each grid reflects a representative sample of the archaeology is therefore unclear, and certainly less clear than for transect-detection methodologies used in more recent systematic surveys of English battlefields, such as at Edgehill (Foard, 2012). The grid survey methodology also proved to be unfeasibly intensive for the volunteer detectorists (Foard and Morris, 2012, pp. 137), and as such coverage was limited to two areas at opposing ends of the village from the past location of the garrisoned manor house.

Despite shortcomings in survey methodology and coverage, the study did reveal significant quantities of bullets that allowed a tentative interpretation of the location of the initial attack, as well as evidence for fighting to take control of the village by the besiegers in order to carry out a bombardment and attack upon the manor (Foard, 2001, pp. 100). Though there is a lack of evidence for the location and layout of the defences at the manor or of and additional garrisoned positions within the village, the distribution of finds has been examined against reconstruction of the historic landscape. This aspect is vital for understanding the movement and deployment of soldiers within the landscape, as together with the location of the defences, this provides the context of the landscape through which the siege was conducted. The Grafton survey work sets an initial bar for further siege site investigations, however until a more complete systematic survey is carried out for a siege site, the interpretation of artefact distribution at Grafton Regis remains untested.

3.2.5 Artillery impact scar investigations

There are limited published studies that attempt to interpret impact scar evidence. To date the only study with elevation diagrams and interpretation of the location and scars themselves is part of a wider study of siege evidence at Chester (Ward, 1987). Artillery scars on Barnaby's Tower on the city walls are presented in elevation showing the positions of each scar, as well as the evidence of repair and reconstruction of different courses of stonework on the face of the tower (Ward, 1987, pp. 30-33). The presentation of the data is limited, as though the scar locations plotted, there is no differentiation between scar sizes, which Ward states vary in diameters from between 22cm to 8cm (Ward, 1987, pp. 32). The variation in size would suggest different calibres of round-shot striking the masonry, and in this regard attempting to categorise the calibres based on scar size might help to identify the calibre and thus type of ordnance pieces being used in this attack. Furthermore there is no examination of the depth profile of scars or examples of any visible attributes that might also help to indicate the size of the projectile that caused the scar as well as provide clues to the angel or direction of impact in the resulting shape. Despite these issues, Ward's assessment of the scars and interpretation as to their probable cause and target is the first such attempt made for this evidence of any archaeological siege site for the Civil Wars.

Though Ward also noted smaller marks being visible on the tower that could correlate to small-arms impacts, these are not investigated further however and the problems with surface weathering deemed too difficult to allow positive identification (Ward, 1987, pp. 32). Ward also suggests that near-miss shots would be likely to have struck the adjacent walls that due to weathering of the stone surface cannot be identified (Ward, 1987, pp. 32), however for the breach in the city wall identified in Roman Gardens Ward neither identifies the presence of similar near-miss marks from the bombardment that led to that breach, nor postulates as to why none are present in this instance where weathering does not seem to have caused similar identification issues (Ward, 1987, pp. 28-30).

Though Ward's study provides the first effort at interpreting artillery scars for their probable reason for their location and the area from which they originated, this has yet to be attempted for similar scars at another site. For small-arms impacts, observations of scars on buildings facing each other in siege settings have been identified as possible locations of exchanges between structures or soldiers between these locations (Harrington, 2005, Foard and Morris, 2012).

3.2.6 Developing a methodology for attack and defence

The assessment of siege sites by Foard and Morris (2012) contrasts the work by Harrington (2005) in two key aspects. Firstly Foard and Morris quantify the number of siege sites in England, identifying 189 siege sites from the database, across which 242 individual siege actions are fought in the UK Fields of Conflict Database (Foard and Morris, 2012, pp. 127). Secondly the study seeks to address the lack of exploration of the unstratified scatter and impact scar evidence at siege sites by undertaking a simple assessment of the nature of these types of evidence and what might be derived from them about attack and defence at siege sites.

For impact scar evidence Foard and Morris identify that, while artillery round-shot scars exist in a handful of locations, it is small-arms impact scars that are dominant in their quantity despite only the former having been recorded by previous siege studies (Foard and Morris, 2012, pp. 129-130). The trial recording of impact scars for the siege site of Moreton Corbet Castle presented in this study was therefore undertaken without an existing methodology for doing so (Foard and Morris, 2012, pp. 130), and is the first published attempt at analysis of this form of evidence in an analytical manner. Though a plan of scar-distribution across the site is shown, accompanying elevation diagrams that were also produced at the same time are not presented with the data (Foard and Morris, 2012, pp. 130), and thus little actual information can be derived from the plan-overview of the site given. Nevertheless, the distribution of scars on the neighbouring church shows that even with this degree of data presentation, it is possible to infer that those scars are the product of defensive fire from the direction of the castle, while that on the castle is attacking fire from the attack on the garrison. A notable omission in the collection of the data is the lack of any individual measurements of the shape and size of scars, though Foard and Morris discuss and provide examples of the different physical appearances of scars on different impacted surfaces at sites, as well as variations in types of scar based on what type of projectile may have created them (Foard and Morris, 2012, pp. 128-134).

Where Foard and Morris address unstratified bullet scatters, the only example study that can be drawn upon for data is that of Grafton Regis, as other extensive assemblages of this type have only been collected either through excavation, where detailed spatial data for individual projectiles is often lost, or in an entirely non-systematic manner through non-archaeological metal detecting (Foard and Morris, 2012, pp. 134-139). Without the spatial context of the located finds, only a calibre graph has been identified as a means of analysing detectorist-collections, though in some instances such as for Boarstall House, detectorists have attempted to record the spatial data in limited fashion (Foard and Morris, 2012, pp. 137-138). Examination of the assemblage of bullets recovered from Beeston Castle shows that even in archaeological excavation contexts, proper identification and recording of bullet finds should not be expected, as from rapid assessment of the collection Foard and Morris identified an additional 163 bullets to the 70 previously recorded (Foard and Morris, 2012, pp. 139). While full spatial data for the bullets recorded at Beeston is identified as existing, Foard and Morris do not undertake a plotting or analysis of the distribution of the bullets from this site. Calibre graphs are presented for both the Grafton bullets and those collected by a metal detectorist from Basing Common that illustrate variation in the evidence collected from different siege sites. However because the assemblage from Basing was not collected in a systematic manner, it is uncertain whether the variance from the Grafton calibre distribution is the result of a genuine difference in the archaeology of these actions, or from a recovery or retention bias in the sample collected non-archaeologically. While more studies similar to Grafton are required, Foard and Morris identify that this needs to be achieved by developing a more sustainable survey approach than that used at Grafton Regis, where the intensity of survey resulted in the fieldwork being terminated before completion (Foard and Morris, 2012, pp. 137).

3.3 What remains to be investigated?

Of the evidence for attack and defence at siege sites, there has as yet been no systematic study of the evidence of artefact scatter survey using controlled-density metal-detector survey. Transect surveys as used at Edgehill (Foard, 2012) allow densities of recovered artefacts to be compared through knowing that the landscape has been surveyed to the same intensity across each area. Utilising transect survey at a siege site would allow for the first time a similar interpretation of the evidence of attack and defence across the siegefield for a site.

Assessment of impact scars on the surviving fabric of ruined structures as well as on extant buildings offers another means of assessing attack at sites. As these impacts represent shots made towards the buildings of garrisons, this evidence is predominantly one of attack, though as noted in the case of the church at Moreton Corbet some instances of scars caused by outgoing defensive fire exist at sites also. Two elements of impact scars addressed very briefly by Foard and Morris (2012) deserve further investigation, in addition to the spatial plotting of the location of impact scars within a site.

The first element is the individual impact scar shape and appearance. As described by Ford and Morris, impact scars comprise of three subcomponents in their appearance: the inner scar, the outer spalling, and the radial fractures. Further investigation of the appearance and variation within each of these features, as well as three-dimensional profile measurements of the scars is needed, not least because of the opportunities applying elements of modern ballistic forensics to this evidence may yield for reconstructing individual shot impacts. The scars themselves are the by-product of a bullet striking a stone surface. Should that surface behave in a largely consistent or predictable manner, variation in bullet impact scars could reflect changing impact variables, including the trajectory, mass, shape and velocity of the bullet prior to impact.

The second element is tied to the first, referring to the impact process that generates both the impact scar and the impacted bullet. As yet there is little information about how the bullet and impact surface transform from their initial states to what we find archaeologically as a result of their interaction, and a multitude of questions present themselves. How are the outer-spalling and radial fractures formed? Is the cup-shaped inner scar formed at part of the impact process, or does this emerge as the impacted location is subjected to weathering? What happens to the bullet as it deforms? Can we determine anything about the initial shape and mass of the bullet based on the resulting shape and features of the impacted bullet? What role does stone type play in the nature of the resulting scar? It is clear that detailed further examination of both archaeological examples and experimental impact data is needed before a full appreciation of what the archaeological evidence might reveal can be understood, and in this regard archaeological recovery of impacted bullets together with an upstanding structure or ruin bearing impact scars would provide a unique comparison of two sets of data formed by the same causal process.

Finally, more work is needed on the topic of impact scar distribution across structures and sites. What variation exists in the distribution of scars vertically at sites needs to be addressed, particularly the frequency of occurrence at other sites of the apparent height-bands of scars as noted at Holmes Chapel (Foard and Morris, 2012, pp. 129). What does the distribution of scars both vertically and on the facings of structure walls reveal in terms of the nature of the target being attacked and the location of that target in relation to the position of the wall on which the scars occur? What does this in turn reveal about the manner of defence at this site, and the method of attack used against that defence?

In order to address these questions through archaeological survey, it is necessary therefore to identify a site for research with probable good survival of the unstratified archaeological scatter, where impact scars can be identified in proximity to areas where unstratified artefacts can be found, and where the impacted bullets and fragments thereof that relate to the impact scars may to a greater extent still be found in situ from their initial point of rest after rebounding from the impacted surface.

4. Establishing the Archaeological Resource in England

The purpose of this chapter is to outline the aims and methodology behind the assessment of the archaeological resource in England for studying siege sites of the Civil Wars. As the preceding chapter has explored, there are numerous facets to siege operations that can be explored in a multitude of different approaches by archaeology, and in this regard the general assessment of the resource potential of English siege sites presented below is undoubtedly limited in scope. Instead the purpose of this overview is to establish the potentials for both investigation of the unstratified scatter of artefacts pertaining to the siege action, and of impact scars created on the fabric of the garrisoned structures attacked during these actions.

The assessment itself is broken down into an overview of the national resource with regards to siege sites conducted using documentary and digital sources, the methodology and outcome of a number of on-site investigations and evaluations, and a set of in-depth explorations of the archaeology at three sites visited as part of the former set of evaluations. These in-depth studies bring together the on-site evaluation methodology with a limited historiography to identify some simple research questions that could be explored archaeologically and identify specific research opportunities presented by observations made at each site.

Following on from the assessment and examination of sites on an individual basis, general issues arising from the findings of these investigations will be explored. These apply across multiple sites and present challenges and problems for approaching archaeological investigation and interpretation of both artefact scatters and impact scars. Though resolving them is not the principle focus of this discussion, identifying the issues is necessary to allow the progression of investigation of sites for the evidence of siege action.

4.1 What is the archaeological resource?

In order to properly assess the potential for the archaeological study of siege actions during the Civil Wars in England, an overview of the quantity and condition of siege sites is needed. This requires an inventory list of sieges and sites together, as identifying sites that were host to multiple siege actions will factor into approaches for exploring the archaeology at these sites. This inventory will then require examination of each site for the current levels of development, survival of contemporary structures, and practical accessibility of the site for survey and examination of the ruins for impact scars. For the purposes of assessing as many siege sites as possible, the UK Fields of Conflict Database (Foard and Morris, 2012) was selected as being the most comprehensive single source of data.

4.1.1 UK Fields of Conflict (UKFoC) database

The UKFoC database of battles, sieges and skirmishes is an extensive collection of identified sites of conflict within the UK. The database is not an exhaustive list of every action that occurred, and research for this has been primarily focussed on battlefields, however it includes a complementary list of sieges for all periods within England including the Civil Wars (Foard and Morris, 2012, pp. 7). Though Foard and Morris also addressed the possibilities for archaeological investigation of impact scars and unstratified evidence across siege sites, their study did not include a systematic assessment of the potential for the survival of these at all of the listed sites.

The study also produced a separate database of recorded garrison locations during the Civil Wars (Foard and Morris, 2012, pp. 127). While no siege action is known to have occurred at these locations, Foard and Morris stipulate that further research of county histories may reveal sieges for these sites also (Foard and Morris, 2012, pp. 128). Further assessment of garrison sites for evidence of unrecorded sieges is not a focus of this study, however where opportunity arose during fieldwork, a number of garrison sites were also subjected to on-site examination for potential impact scars or evidence of attack as a result of siege activity, undocumented raids or skirmishing.

4.1.1.1 Inconsistencies and gaps in the data

The investigation of sites as part of this study is not intended as a critique of this database and is not seeking to make general corrections or additions to this data. Nevertheless there are limitations to the data through error and omission, partly due to the source material used to comprise the dataset. The data itself was collated from secondary historical works, largely from Gaunt (1987) and Rayner (2004), as well as from National Monument Records (NMRs) and local Sites and Monuments Records (SMRs) (Foard and Morris, 2012, pp. 7).

There are errors within the database that transpose directly from these sources, one example of such identified during desk-based assessment was the location of Paynsley Hall, Staffordshire, owing to a grid reference error in the source text by Gaunt (1987, pp. 153). Examples of omission errors within the database include sites where action against garrisons are known to have taken place, such as Farndon, Cheshire, where the village was garrisoned by both sides at different stages during the conflict to control the bridge and passage into Wales, the local church bearing numerous impact scars from contest of this garrison (Gaunt, 1987, pp. 26). Other sites are present on the database, but individual siege actions are absent from the data where the location was besieged multiple times, such with Old Wardour Castle, Wiltshire, which was successfully besieged in 1643 by a Parliamentary force, and attacked in turn by the Royalists in 1644 (Girouard, 2012). The database also contains at least one erroneous entry for a siege at Stanste[a]d House, which is given as two separate physical locations in Surrey and West Sussex. Examination of the reference in Gaunt (1987, pp. 167) identifies only the West Sussex site, and further research of the Surrey site indicates no garrison or siege at that location.

Other limitations of the data are inherent to the nature of the UKFoC database and its intended usage. The database collates information such as the names, dates, and participants of conflict engagements, and gives these details a geospatial entry akin to a pin in a map. This database was intended for use as an analytical catalogue for assessing the archaeological potential and heritage protection concerns of battlefields, and as such was not designed to provide detailed spatial data more than for a general location of sites (Foard and Morris, 2012, pp. 7-8). For the examination of sieges, more specific spatial information is needed for the extent of the fortified site within the landscape in order to identify both the focal point of the action, and also make better informed judgement of the potential extent of the archaeological evidence of the siegefield radiating outward.

While enhancing the UKFoC database in relation to sieges of this period would be useful in providing more accurate statistical breakdown of sites for a general overview, the existing data provides a firm basis for assessing sites generally for likely of survival of unstratified archaeology, and moreover as a basis for identifying suitable candidate siege sites for developing a methodology to investigate siegefield archaeology through pilot study. Where sites with multiple sieges are listed only once this did not affect their desk-based assessment using aerial imagery, as a single list-entry was sufficient for these to be examined. Where the spatial data contains errors in the site location, these were identified and accounted for during further research to identify the presence of buildings contemporary with the siege and the potential survival of impact scars. Carrying out a more detailed individual assessment of each site would undoubtedly allow for refining the existing dataset further, though this is not the principle aim of this study, or of the investigation process discussed here.

4.1.2 Quantity of sites

Using the UKFoC database, a total of 245 actions that have been identified as sieges or possible sieges for the period of the Civil Wars in England (1642-1649) were collated into a single list for assessment. Once locations with multiple entries are taken into account, this gave a total of 194 individual siege sites for further assessment.

4.1.2.1 How many are sieges?

Identifying which sites within this data set do or do not constitute siege actions based on the definition set out in this study is difficult to do from the information available within the database. The definition was not available at the time the data was compiled and further limited research of some of the actions listed provides contradictory details about the number of sieges and the extent of the siege activity for some sites.

For the purposes of a general overview of siege archaeology, the accuracy of the database’s categorisation of actions as sieges is not necessarily a problem, as most actions that are traditionally considered as sieges would still be defined as such under the definition. It is smaller-scale stormings or attacks against garrisons that are likely to go unrecorded rather than previous designations being rejected. Though there are errors and gaps in the data set, the UKFoC database provides a useful basis for further assessment work without the need to compile a new database from scratch using the same source pool of documents and gazetteers.

4.2 Assessing the siege data set

The assessment of sites undertaken here was based on a simple categorisation of the present-day conditions of the site, and the potential for the survival of impact scars on contemporary structures, the impacted round fragments adjacent to the impacted surfaces, and the unstratified scatters from the siege action in the topsoil surrounding the garrison location. As well as the present-day level of development, the practical aspect of this assessment to find sites for further study also required that the ownership of the land and structures pertaining to the siege site were publicly accessible, or at least could be visited and inspected with appropriate permissions to do so.

To make this process comparable for the sites selected, a set of categories and grades were drawn up for each site to be assessed against. The first of these categories is the present-day nature of the siege site, and includes urban, rural and coastal classifications. Urban sites are those where the surrounding landscape has been predominantly urbanised and does not necessarily reflect the character of the siege action itself. Rural sites are categorised as those with significant undeveloped landscape surrounding either the known location of the garrison, or where the location of the garrison is not apparent or not marked by the database entry, the area surrounding the village church as a structure most likely to be contemporary to the siege, and therefore carry impact scar evidence. The final group of coastal sites are categorised as those site with an area of water that covers more than approximately one third of the surrounding landscape, or for those where the key garrison site is located on the banks of a major estuary, or on the sea shore This does not mean the archaeological survival is necessarily likely to be worse than for rural or urban sites, but that potential siege area around the garrison is much more limited in possible scope, and thus might require a different approach to investigation.

Following from this each site was to be given a ranked score for the level of land development surrounding the garrison location, the potential for metal detector survey of the surrounding landscape, and the presence and quality of structures contemporary to the siege. This gave each site an individual score in those categories, from three to zero, and thus a total ranking score to identify the sites with the best overall potential for survey.

4.2.1 Google Earth assessment

In order to assess each site for the categories described above, the georeferenced entries from the UKFoC database were uploaded into Google Earth for investigation. This allowed each site to be examined using an aerial overview to establish the site type and level of development, as well as identifying potential areas of ground for metal detector survey. This imagery could also be examined through the historical image mode to examine recent developmental changes and changing land use. To supplement this activity, each site was briefly subjected to a Google search to establish present ownership and accessibility, and also identify possible contemporary buildings in or around the siege site for potential impact scar locations.

4.2.1.1 Scoring process

Each scoring category was given a range of values from three to zero for the purpose of quantifying the potential of each site, the criteria for which are given in full in Table 1. The overall 'Development Level' score was based on the quantity of land surrounding the besieged location, or probable location for sites with uncertain garrison-limits. With regards to the need to recover artefacts from the topsoil using metal-detector survey, this included any are where buildings, landscaping or surface removal might have occurred, such as golf courses, housing estates, sports pitches, but not necessarily farmland or woodland areas. In this regard a score of three reflected a less than ten percent degree of land development surrounding the site, while a score of zero reflected anything more than ninety percent. For 'Contemporary Structures', a full score would reflect the key garrisoned structures being still largely in their original condition at the site, while each reduced value reflects an increasing degree of structural loss down to no obviously identifiable contemporary structures relating to the siege action. Finally, for 'Surveyable Area' a score of three was given where more than fifty percent of the surrounding landscape could be practically surveyed using metal detectors, taking into account the difficulties of detecting in wooded areas, or on steep inclined surfaces surrounding some castles, for instance. Low scores reflected a near impossibility for the recovery of artefact scatters in the area of the siege action, with only small patches of land being accessible or practicable, with a score of zero reflecting only developed or likely disturbed land being an option to carry out metal detecting.

Development Level		Contemporary Structures		Potential Surveyable Area	
Score		Score		Score	
3	Less than 10% development of the land surrounding the garrison site	3	Contemporary structures still mostly intact or well preserved	3	More than 50% of the surrounding landscape is practically surveyable
2	Between 10% and 50% land development	2	Some structures mostly intact, others largely ruined, redeveloped or rebuilt	2	Between 50% and 10% of the surrounding landscape is practically surveyable
1	Between 50% and 90% land development	1	All structures ruined, redeveloped or rebuilt	1	Surveyable are is limited to less than 10% of the surrounding landscape
0	Greater than 90% land development	0	No contemporary structures or ruins survive	0	No surveyable area, or only partial area of redeveloped land available to survey

Table 1: Scoring categories used to assess sites in Google Earth

4.2.1.2 Assessment results

The data presented below in Table 2 shows the statistical breakdown of the scores of sites in each character type for each category of assessment. The combined score for each site through all three categories were added together to give a total assessment score based on this process, the distribution of sites in each score bracket is shown in Table 3. Finally, the fourteen top-scoring siege sites by total assessment score are listed in Table 4. Complete ranking scores for all 194 listed sites can be found in Appendix A.

Present Site Character	Total Number	Development Level Score				Contemporary Structures Score				Potential Survey-able Area Score			
		3	2	1	0	3	2	1	0	3	2	1	0
Coastal	23	1	4	7	11	3	4	9	7	3	1	5	14
Rural	94	53	29	12			41	46	7	52	29	12	1
Urban	77		3	37	37	1	48	18	10		6	29	42
Total	**194**	**54**	**36**	**56**	**48**	**4**	**93**	**73**	**24**	**55**	**36**	**46**	**57**
Percentage of sites	**100**	**27.8**	**18.6**	**28.9**	**24.7**	**2.1**	**47.9**	**37.6**	**12.4**	**28.4**	**18.6**	**23.7**	**29.4**

Table 2: Assessment scores by site type for siege sites in England

Present Site Character	Total Number	Total Assessment Score								
		8	7	6	5	4	3	2	1	0
Coastal	23		2	3		2	3	4	3	6
Rural	94	14	33	24	9	11	1	2		
Urban	77		1		5	21	13	18	10	9
Total	**194**	**14**	**36**	**27**	**14**	**34**	**17**	**24**	**13**	**15**
Percentage of sites	**100**	**7.2**	**18.6**	**13.9**	**7.2**	**17.5**	**8.8**	**12.4**	**6.7**	**7.7**

Table 3: Number of sites scoring each Total Assessment Score value for each type category

Site Name	No. Sieges Listed	Development Score	Upstanding Structures Score	Surveyable Area Score	Total Score
Albright Hussey	1	3	2	3	8
Barthomley church	1	3	2	3	8
Beverstone	1	3	2	3	8
Bewcastle	1	3	2	3	8
Boarstall House	2	3	2	3	8
Canon Frome	1	3	2	3	8
Castle Bolton	1	3	2	3	8
Grafton Regis	1	3	2	3	8
High Ercall	3	3	2	3	8
Hillesden	1	3	2	3	8
Moreton Corbet	1	3	2	3	8
Pembridge Castle	1	3	2	3	8
Wormleighton	1	3	2	3	8
Yate Court	1	3	2	3	8

Table 4: Top ranked sites based on total assessment score

The best scoring sites are unsurprisingly all rural in character, and score highly largely as a result of their generally better surveyable-area potential and lack of surrounding development. It is also perhaps unsurprising that the sites with the best structural preservation are also those where garrisons utilised a single structure or a small group of buildings such as at Albright Hussey, Wythenshawe Hall, or Walmer Castle. Despite scoring highly for contemporary structures however, this does not necessarily reflect the likelihood of the presence of impact scars on the structure, and as such on-site inspections were required to ascertain the prevalence of this type of evidence.

4.3 Site inspection visits

Following from the overall assessment, individual sites that scored highly were targeted for on-site visits to inspect for impact scar evidence, and assess the sites for survey potential for recovering impacted rounds from the adjacent ground. While some sites scored very highly in terms of survey potential, the target aim of finding a case-study site with this potential, surviving impact scars and the opportunity to archaeologically recover the impacted rounds was the target goal of this stage of the site assessments.

For each set of visits a group of key sites were identified for investigation based on their total assessment score. These were then supplemented by middle-scoring sites where the survival of contemporary structures was good, or those known to have impact scars present on surviving structures or ruins. Finally, a number of low-scoring sites and garrison locations with no known siege action were included to test the validity of the assessment scoring process. In total fifty-four siege locations from the Fields of Conflict Database were visited during the course of the study, along with six sites where garrisons were located but no siege action is listed in the database.

4.3.1 Site inspection results

Of the sites visited, impact scars were positively identified at 24, with a further 9 showing only possible impact scars in quantities fewer than five. Where impact scars were identified, these were photographically recorded and the surrounding land adjacent to the structure was assessed for the potential of round recovery. Of the 24 sites that present impact scar evidence, fully half of these included scarring on churches or other structures in consecrated ground, and of those in six instances the only identified or observed scars were located on these buildings. Although not necessarily a preclusion to archaeological recovery of the bullet fragments, the issue of obtaining permission to dig in churchyards, coupled with the likelihood of ground disturbance as a result of post-period burial and grounds-keeping activity, effectively ruled out carrying out impacted round recovery at these sites.

Of the 18 sites that showed signs of impact scarring not on religious buildings or within consecrated ground, only 4 showed little or no sign of subsequent land disturbance that would have prevented or significantly obstructed the recovery of the impacted round fragments. Of these, the site at Moreton Corbet in Shropshire provided the best survival of a significant quantity of impact scars, coupled with the possibility of recovering impacted bullets, and surveying the surrounding landscape for the unstratified evidence of the siege action.

4.3.2 Prevalence of impact scars

The low rate of scar identification from the sites visited is not an unexpected outcome. The majority of sites visited were either already known to have impact scars present, or there had been sufficient destruction or remodelling/restoration of the contemporary structures that the evidence might not be expected to survive at all. For many sites accessibility was also a problem, as while church buildings are generally unobstructed on their sides, and publicly accessible, many castle and manor house ruins or remains lie within private land, or have restricted access. As such it is possible that a number of scars were missed due to time-constraints on visits and limited access to contemporary structures. The aim of this assessment was to select sites for detailed study and not to build a comprehensive assessment of siege sites in England, and a full and detailed assessment of every siege site across the country was simply not within the resources or limits of this study to achieve. Nevertheless it is clear that such an assessment would be beneficial in establishing the full extent of surviving impact scar evidence, and has significant potential to expand the list of known sites with examples of scarring if full access to identified siege sites could be obtained.

4.4 Detailed Site Investigations

The sites presented below are examples of sites that after initial assessment were selected for on-site investigation of potential impact scar evidence, as well as an exploration of what potential each of the sites offers to archaeological research of artefact scatters, impact scar evidence and impacted-round fragment recovery. The results of these investigations also raise a number of questions about what influence modern site treatment and historic activity on these sites after the period of the Civil Wars has had on their respective archaeology.

4.4.1 Old Wardour Castle, Wiltshire

Old Wardour Castle, Wiltshire, was besieged twice during the Civil Wars firstly as a Royalist garrison in 1643, and latterly as Parliamentarian garrison in late-1643 to early-1644. The site was twice overcome through the use of gunpowder-charges placed in mines beneath the main keep, the second occasion of which brought down a significant section of the outer wall of the keep, leading to its abandonment as an inhabited structure and its present status as a ruin.

4.4.1.1 Historical overview of the sieges

The first siege from 2nd-8th May 1643 and saw a Royalist garrison of 25 soldiers, supplemented by household staff, besieged by a force of 1,300 Parliamentary soldiers equipped with only two small cannon (Girouard, 2012, pp. 38). The ineffectiveness of these guns against the fabric of the castle led to the Parliamentary commander deploying gunpowder charges in the latrine vaults under the castle, the detonation of which prompted the surrender of the garrison (Girouard, 2012, pp. 38-39). The second siege from December 1643 to March 1644 saw a larger Parliamentary garrison defending against a besieging Royalist force, equipped with larger artillery pieces than the previous attacking force (Girouard, 2012, pp. 39). Nevertheless the siege of the castle was again settled through the use of gunpowder charges, with the detonation of a sap dug by miners resulting in the collapse of much of the western wall of the keep. Fighting continued through the breach until the threat of a second sap charge forced the defenders to surrender (Girouard, 2012, pp. 39). The castle keep was not re-occupied following the second siege, and was incorporated into the gardens of Old Wardour House between 1660 and 1694, and then subsequently into the grounds of the new Wardour Castle, built in the 1770s (Girouard, 2012, pp. 40-41).

4.4.1.2 Overview of the present site

The present site of Old Wardour Castle has been altered significantly since the period of the siege. The development of Old Wardour House to the south marks the beginning of the transformation of the castle from a residence into a feature of the subsequent gardens of the contemporary residence of the site, beginning at least in the early eighteenth century (Girouard, 2012, pp. 42-43). Although the present bailey is largely contiguous with the extent of the original, the walls have been largely rebuilt on the north-west side, and the ground level has been raised as a result of landscaping activity in the sixteenth or seventeenth centuries (Historic England, List Entry 1013398, 1183429).

The ground beyond the castle has also undergone some degree of landscaping, including the eighteenth century extension of the present swan pond from the original rectangular feature (Girouard, 2012, pp. 45). Based on survey plans from the late eighteenth century, the level of tree coverage on the surrounding slopes has also increased, and moved closer to the bailey walls, surpassing them in the north-eastern part (Girouard, 2012, pp. 45). Alteration to the fabric of the keep itself castle is not clear from inspection and not mentioned in monument listings, however it is clear that the site has been cleared of ivy and other foliage in the twentieth century (Girouard, 2012, pp. 47-48).

The castle keep and bailey are set within a valley within the park land of the nearby New Wardour Castle. The valley sides are wooded and comparison of Google Earth aerial images from the 1940s and 2000s indicates that the majority of this land has been subjected to felling and replanting throughout the twentieth century. Immediately to the south of the bailey are the grounds of Old Wardour House, built after the war to replace the castle as a site of accommodation, and almost a kilometre away to the north-west by New Wardour Castle. Other post-1640s developments include the banqueting house built into the south-western face of the bailey wall, the modern visitor centre to the north and the grotto to the north-east both within the bailey walls, a farmyard and associated buildings to the north-west, and the swan pond expanded from an existing pond in late eighteenth century. Historic aerial images in Google Earth show the land beyond the valley has all been under arable crop at least as recently as 2002, though some fields in the south are now used to graze cattle.

4.4.1.3 Impact scar evidence

The walls of the outer bailey show no obvious signs of impact scars from small-arms fire or artillery shot. This was not unsurprising as the majority of this part of the site consists of rough-faced limestone, which serves to both obscure impact scars through surface irregularity, and to impede the formation of easily identifiable scars as the bullets are more likely to hit a non-orthogonal surface and fragment without forming a regular-shaped scar. A complete examination of the bailey wall was not possible due to the presence of the privately owned Old Wardour House, and some parts of the surface remain covered in foliage on the northern side, however it is unlikely that impact evidence will be identified on these surfaces due to the challenges described above.

The keep itself shows numerous impact scars on a number of different facings of its surviving outer wall, with the majority occurring on the north-eastern (front) face of the gatehouse. The scars visible on this facing and others are predominantly small-arms scars, typically of only a few centimetres in diameter, and appear to be largely focussed around windows openings on the gatehouse towers (Figure 1: Photograph of impact scarring in proximity to a window on Old Wardour Castle, Wiltshire). Though scars occur in the vicinity of windows at other sites such as at the churches at Tong and Loppington, both in Shropshire, no other visited or known site with impact scars displays the quantity of focussed fire on an opening in the walls as is presented at Old Wardour Castle.

Figure 1: Photograph of impact scarring in proximity to a window on Old Wardour Castle, Wiltshire

On the gatehouse wall there is present of a much larger impact scar just to the left of the main doorway. The scar is approximately 7cm in diameter within the inner-scar and 13cm overall across the width of the spalling (Figure 2), and is significantly larger than observed small-arms scars. A short distance to the right on the flanking doorway pillar there is the trace of a second, possibly similar scar, though this appears to have resulted in the destruction of part of the curved stonework on that feature and as a result no clear scar remains to be compared.

Figure 2: Photograph of a suspected artillery impact scar at Old Wardour Castle, Wiltshire

Finally there is a single, possible impact scar identified above a doorway on a southern-facing section of the internal walls on the destroyed western side of the keep, however positive identification of the mark as a scar could not be achieved as its location was inaccessible at the time of the investigation.

4.4.1.4 Opportunities for scar study

Measurement of the vast majority of the scars on this site is not practically feasible within this study. The height at which most identifiable impacts occur is too great to achieve a depth-profile measurement of the scars using any of the techniques discussed below in chapter five. This site does present several opportunities for distribution analysis of scars however, particularly in relation to the visible clustering of scars around window openings. If the window openings are taken to be the target of the shots that struck the walls surrounding them, this could be confirmed by taking a section of the wall, giving each scar a set of co-ordinates in terms of x and y on an elevation plot, and calculating the average centre point for the distribution both horizontally and vertically. Furthermore, using data taken from Miller's ballistics experiments for the accuracy and deviation of musket shot for seventeenth century firearms (Miller, 2010), it may be possible using a plot of the scars to make an approximation of the distance from which shots were fired based on the observed limits of bullet deviation, assuming a common targeting point centred on each window opening. These issues are also explored further in chapter five.

The single large and clearly formed scar adjacent to the doorway also presents an opportunity to examine the location of the origin of fire for this particular impact. As it occurs on a recess into the front of the gatehouse between the towers and close to a protruding pillar, there is a limited range of angles from which this scar could have been fired. Its size, shape and internal surface also offer clues to the possible calibre of the gun that created it, and the material of the projectile fired.

4.4.1.5 Impacted round recovery

The post-period uses and management of the site within the grounds of the bailey at Old Wardour make surveying for the fragments of impacted bullets an unappealing prospect. While it is possible that the raising of the ground level within the walls may have stratified some of the fragments in their original resting locations in relation to the keep, successive centuries of garden development and presentation of the site discussed in Girouard (2012, pp. 40-45) will undoubtedly have produced disturbance of the topsoil in the areas of interest beneath the gatehouse windows, as the engravings and survey plans presented show significant garden activity immediately in front of the keep. The degree to which the distribution of rebounding bullet fragments will have been affected is hard to predict, and without a dataset from a site with minimal or no disturbance for comparison, would be impossible to assess based on a recovered distribution from the present site.

The influence of the height of the impact scars on the distribution of fragments would also cause difficulty in the assessment of soil movement, as the spread of impacted bullets is likely to be much greater than for sites where impact scars occur closer to ground level, owing to the increased distance a rebounding bullet fragment would be able to travel before encountering the ground. It may be impossible to assess whether fragments found at distance from the keep were the result of this rebound action from the height of impact, or due to soil disturbance by subsequent garden activity.

The area immediately outside the bailey walls is similarly unsuitable for a pilot study of this material. Though some sections of the ground outside the wall are hampered by the presence of present-day paths and roads, the eighteenth-century banqueting house and the grounds of Old Wardour House, there are sections to the south-east and north of the keep that may be relatively undisturbed and from which bullet fragments may be able to be recovered. However without being able to locate or positively identify bullet impact scars along these sections of the wall, any such attempt at recovery would be without a known source of impacted bullets for targeted excavation.

4.4.1.6 Metal detector survey potential

There has undoubtedly been loss to the archaeology in the post-siege development of Old Wardour House, the expansion of the swan pond, and the farm site to the north-east. Furthermore, it is clear that there will have been significant ground disturbance in the wooded areas surrounding the valley as a result of tree felling and replanting. While metal-detecting in woodland is not impossible and has been successfully utilised in survey at Orovais battlefield in Finland (Foard, 2015), the removal and replanting of trees will have displaced the unstratified artefacts in such a manner that they may not be easily detectable or retrieved within this area.

There are still however several opportunities for research of the unstratified artefact scatter at Old Wardour. While there has undoubtedly been loss to the archaeology in the post-period development of Old Wardour House, the expansion of the swan pond, and the farm site to the north-east, a large area of land beyond the bailey to the south and east is presently under pasture. While a widespread survey of the land extending away from the impacted wall facings is not possible due to scheduling and tree coverage beyond the bailey grounds, the land to the south of the bailey presents an opportunity to test effective fire ranges. The slope climbs with distance from the bailey wall up to the valley edge, and as such any shots by the defenders towards this direction are likely to have undergone a reduced degree of ‘bounce and roll’ after contact with the ground. It may be possible from distribution data on this area to determine the probable location of the targets, assuming that missed shots hit the slope behind and travel very little after ground impact, and based on the angle to ground from the keep and the bailey wall, assess probabilities for the location of the firers.

The presence of two sieges at this location has implications for study of the artefact scatter patterns. Though the first siege was a particularly small-scale action in terms of soldiers and probably also the area of engagement, the second siege featured a much larger attacking force, and overlapping of the area of fighting is very likely, especially as the focus of both actions featured the same structures and access points. It may also prove that the route of access for the mining operations used in both sieges occurred in a similar location, though these and the castle vault locations have not been positively through excavation despite geophysical survey of the area of the bailey (Harrington, 2005, pp. 103).

4.4.1.7 Site summary

The challenges of ground disturbance and expanded tree coverage preclude Old Wardour from being an ideal case-study site for investigating the unstratified scatter and impacted round evidence from the siege actions. Furthermore the height of the majority of scars on the surviving structure makes a study of scar shape and detail more challenging without some form of enhanced access.

Nevertheless Old Wardour offers an unparalleled opportunity to examine a series of impact scars on a structure where the inferable target is an opening on the structure facing itself. For the majority of sites examined for small-arms impact scar evidence, no obvious structural target has been identified, and as such the distribution of scars on the gatehouse wall surrounding the window openings is without an identified parallel for a besieged Civil War structure in England. For this reason and the opportunities discussed above in relation to predicting range based on scar deviation, Old Wardour is addressed further below in chapter five as a case-study site for scar distribution.

4.4.2 Pontefract Castle, West Yorkshire

In contrast to many of the sites visited during the study, Pontefract Castle scores low in every category. The castle, a Royalist garrison besieged three times during the 1640s, has been ruined and redeveloped or repurposed numerous times since the castle itself was demolished after the Civil Wars by act of Parliament. The neighbouring All Saints' Church also stands in a state of ruin as a result of the siege action, though a partially restored church structure stands within the shell of the original. The surrounding landscape which lay within the outskirts of Pontefract at the time of the Civil Wars is now wholly enveloped by the modern settlement and flanked to the north and south by railway embankments and cuttings as well as industrial and commercial developments. This site was chosen for on-site assessment in part to test the validity of the assessment scores, but also to determine what might be achievable for sites in this score range, which include the majority of urban-context sites.

4.4.2.1 Historical overview of the sieges

The first siege of Pontefract Castle between December 1644 and March 1645 was characterised by artillery exchanges between the Parliamentarian besiegers and the Royalist garrison, resulting in the destruction of the Piper Tower of the castle (Roberts, 2002, pp. 414). The first siege ended with the Battle of Chequerfield (1645), which saw a Royalist force drive off the Parliamentarians, relieving the garrison until the second siege commenced on 21st March 1645. During the second siege the Parliamentary army put down siege lines, apparently circumvallating the castle with the aim of bombarding and starving the garrison into submission. The desperation and urgency with which the garrison sought supplies resulted in several sallies from the defences to harass the attackers and to acquire food stocks. However after the capture of All Saints' Church by the besiegers cut off the remaining supply routes, the garrison ultimately surrendered on 21st July 1645 (Roberts, 2002, pp. 415-416).

The final siege from September 1648 to March 1649 was initially a less thorough encirclement than that of the previous siege, until the arrival of Oliver Cromwell in November, and the subsequent requisition of artillery pieces suitable for bombardment. Nevertheless the garrison held out until the effective end of the Royalist cause after the execution of the king, coupled with a desperate supply situation (Roberts, 2002, pp. 419-421). Following the surrender of what was at the time the last Royalist garrison in England, Parliament ordered the castle be demolished to prevent its use in any further conflict. Since demolition the castle site has been used as land for liquorice cultivation, been redeveloped and excavated to form a Victorian pleasure park and an open-air museum (Roberts, 2002, pp. 46-48), but now exists as a heritage site under the management of Wakefield Metropolitan District Council.

4.4.2.2 Overview of the present site

The castle itself is a ruin as a result of the post-conflict slighting, and no section of the walls or remains of the towers stand higher than a few metres. The ground inside and outside of the Inner Bailey have invariably been altered and landscaped as part of post-period uses, including the Victorian pleasure gardens at the end of the nineteenth century. While the foundations of most of the walls and towers remain within the site, almost half of the foundations of the Swillington Tower on the northern edge of the castle lies under the road constructed in 1800 (Roberts, 2002, pp. 56-57). The Outer bailey is similarly ruined with little trace of the walls surviving above ground, and the location of the barbican serves as the foundations for a prison building constructed sometime after the demolition of the castle (Roberts, 2002, pp. 130-133).

Surrounding the majority of the castle is the modern development of Pontefract, and as such little or nothing survives of the area across which the siege lines were constructed, and which the majority of the action took place. The only land that remains undeveloped is that of St John's priory, which survives as scheduled parkland, and of the All Saints' Church, which was heavily contested during the sieges and ruined as a result of that damage. The church ruins contain within their core a later, reconstructed site of worship, though the outer, heavily weathered ruins still bear numerous impact scars.

4.4.2.3 Impact Scars

Despite the apparent lack of upstanding remains of the castle as a result of its demolition, much of the surviving external facings of the walls and towers indicate that the castle was largely faced in dressed-stone, which provides an ideal surface for the identification of impact scars. Despite this, very few small-arms scars could be positively identified on the surviving wall sections (Figure 3). It is difficult to predict what may have been lost as a result of slighting in this regard, though as numerous scars are still visible on the neighbouring All Saints' Church, despite ruin and weathering influences. It is also worth noting that, while much of the inner bailey and keep site of the castle has weathered well, the stone facing of the barbican walls has survived considerably less well, and scars may have been lost here as a result.

Figure 3: Photograph of an impact scar on a surviving castle wall section at Pontefract Castle, West Yorkshire

The neighbouring All Saints' church by contrast bears multiple small-arms impacts. Identification of impact scars on the church stonework was made difficult owing to the degree of weathering and decay of the surviving stonework, and many of the identified scars occur away from the edges of stone blocks, where weathering has generally had a more significant influence on surface loss. The majority of scars identified across the structure occur between one and three metres in height, on both internal and externally facing walls, and no scar groupings could be identified as having been targeted at openings or doorways specifically.

4.4.2.4 Opportunities for impact scar study

The lack of small-arms impacts on the castle fits with the accounts of the action described in Roberts (2002, pp. 414-421). For much of the each of the three sieges, the principal exchange of fire to and from the castle was through artillery, where supplies would allow. While the few scars on the castle offer little value for detailed study, the distribution of scars on the church may be another matter. While the scars themselves are too heavily weathered for a detailed study of scar profiles, their distribution about the structure and height band limits indicate a wholly different approach to fighting than that discussed for Old Wardour. The distribution of the scars against featureless walls, as well as on buttresses and other projecting parts of the masonry suggest that rather than being the target of this fire, the church is acting as a backdrop for engagements nearby and incidentally intercepts the missed shots. Perhaps a study of the distributions of these, and the wall facings on which they occur may indicate from which direction the shots were fired, and possibly whether these were from the defenders of the attackers, given the implied direction of attack for each based on the location of siege lines.

4.4.2.5 Impacted rounds recovery and metal detector survey potential

Only All Saints church offers a reasonable opportunity for impacted rounds study at Pontefract. It has the highest concentration of impact scars across the site and a significant quantity that recovery of bullet fragments might be possible. Being consecrated ground means that there might be an expected degree of ground disturbance through burial, however the ruined state of the church after the siege may have precluded the continued use of the church grounds for wide scale burial activity. The lack of a modern graveyard surrounding the site may be evidence of this, though there are a few gravestones located about the site dated from the nineteenth century onwards. While some clearance of fabric from the ruined building has obviously occurred, this does not necessarily indicate that ground disturbance with regards to the impacted bullet fragments.

The majority of locations for any kind of metal detector survey of unstratified archaeology around the castle or church sites are impractical and likely unproductive. The grassed areas adjacent to the castle is promisingly located in an area of active fighting for control of the church, however it is improbable that this land has not been altered or landscaped since the sieges. The scheduled area of the priory offers possible scope for detector survey if permissions could be obtained for the monument, however it is unclear from scheduling details what the extent of the remains of the priory were at the time of the siege, and how much this site has been cleared or tidied since that period. In the translation of siegeworks presented in Roberts (2002, pp. 416, 419), the map suggests that these lines run close to if not through the area of the priory. If this is indeed correct, these have also been reduced within the grounds of the scheduled area prior to the modern period. For the purposes of a case study site, these areas are also impracticable.

4.4.2.6 Site summary

Pontefract has limited options for study of impact scars, impacted bullets and unstratified evidence of the sieges, largely as a result of the extensive development of the siege area. While the church offers opportunity to examine scar distribution across a structure seemingly caught in the crossfire of heavy fighting for control of the location, the difficulties of obtaining permission for excavation within the church grounds eliminated this site from consideration for a pilot study to recover impacted round fragments. Similarly the only areas potentially suitable for local metal detector survey are limited to those that are either highly-probably a product of post-period landscaping disturbance, or those under scheduled monument protection, and where systematic transect survey is unlikely to be granted permission.

While the assessment outcomes for Pontefract are essentially negative, Pontefract Castle has however provided a huge wealth of material culture for the period associated with the domestic arrangements and activities of the garrison during the Civil Wars. The more recent excavations outlined in Roberts (2002) also discuss evidence for garrison activities including the digging of counter-mining shafts, and metal working within the site, and evidence for the Parliamentary prisoners held in the castle vaults in the form of contemporary graffiti. While further study would undoubtedly enhance the archaeological story of the garrison and siege at this site, the conditions here are not ideal for developing a methodology for understanding the archaeology of a siege action.

4.4.3 Basing House, Hampshire

The fortified house at Basing was a Royalist garrison besieged three times during the conflict, though the first siege could be argued to be two separate attempts to storm the garrison, as the besieging army retired into neighbouring Basingstoke for almost five days between these assaults during November 1643, effectively lifting the siege in between. The storming during the final siege in 1645 resulted in a fire that partially destroyed the house, with the old and new houses both being demolished after the Civil Wars.

4.4.3.1 Historical Overview of the Sieges

This first siege by Parliament in November 1643 consisted of a short artillery bombardment of the site from the north, followed by two, non-consecutive storming actions separated by poor weather consisted of a short barrage of artillery from the North on 7th November 1643, followed by an extensive assault from the same direction spanning from the Grange to the nearby church that same day. This only came to a halt when a rainstorm in the afternoon rendered the powder and match of the attacking forces inoperable, forcing Waller to retire to Basingstoke to take shelter (Young and Emberton, 1978, pp. 91-92). After the failing of the second attempt at storming, the Parliamentary army withdrew after nine days.

The second siege by contrast lasted just over four months from July to November 1644, as the besieging army chose to circumvallate the house with siege lines. This time the besiegers relied on a prolonged bombardment using mortars and cannon, and encroaching the siege lines towards the garrisoned house, with the defenders launching repeated sally attacks against the Parliamentarian lines (Young and Emberton, 1978, pp. 93-94). Despite the efforts of both sides the siege was eventually lifted after the Royalist victory at the second Battle of Newbury led to a relief detachment from the victorious army relieving the garrison force, causing the besiegers to withdraw (Young and Emberton, 1978, pp. 95).

The final siege from June to October 1645 took place under much different strategic circumstances to the preceding attempts. Parliament had formed the New Model Army with its own guns and engineers for siege actions, and by now the Royalist field army had been effectively destroyed at the Battle of Naseby, meaning no hope of relief for the garrison. This final siege was arguably more professional those prior, having a skilled engineer (Col. John Dalbier) plan and systematically bombard the defences prior to the arrival of Cromwell's force from the siege of Winchester in early-October. At this point the besiegers had sufficient number of soldiers and ordnance to mount a full assault, and within six days the defences had been breached and successfully stormed, ending the siege and the garrison (Young and Emberton, 1978, pp. 96-97).

4.4.3.2 Overview of the present site

Nothing remains of the outer fabric of the structures of the houses themselves at Basing. Much of the earthwork defences surrounding the garrison are gone, though the section immediately adjacent to the ruins of the old house, as well as the earthen banks and moat surrounding the old house itself are both still extant. To the north upstanding structures from the period of the siege include the garden walls, and across the intersecting road, the Grange Barn, which bears a number of small-arms impact scars.

Much of the surrounding landscape has been developed by the expansion of Old Basing as a suburb of Basingstoke, however to the south and east of the site of Basing House, Basing Common occupies a significant are of the former siege landscape and has been subjected to at least two archaeological explorations of the unstratified scatter relating to the sieges. Examination of the listing entries held by Historic England identify several other contemporary structures within the village of Old Basing, including the church and a number of timber-framed private residences, and additionally several buildings that were constructed out of recycled material from the demolished house.

4.4.3.3 Impact scars

The ruined state of Basing House means that no impact scars are present for the garrisoned area adjacent to areas suitable for survey of outgoing fire. Several impact scars have been identified for both artillery and small-arms impacts on the barn building of The Grange, which formed part of the outer defences on the northern side of the garrison. Very few impact scars have been positively identified on brick structures of the period, partly due to the difficulty of identifying these (see Chapter 5), but also likely due to the tendency for these building to be at greater risk of demolition and redevelopment in the post-siege period than those of constructed of stone. Despite this, the easily identifiable scars are few in number and their irregular form means that depth-profile measurement is much harder for these examples than those much more commonly found on faced-stone surfaces.

The garden walls south of the grange also show a number of impacts from artillery, with sections of brick having been pulverised or dislodged in a number of holes of approximately 15-20cm diameter. Inspection of these walls and the intersecting octagonal dovecotes for small-arms impacts failed to identify obvious impact scars. Several locations were identified where bricks in that location were missing a significant section of their surface had been broken or was missing, however this type of fragmentation is also common in weathered bricks from structures not associated with siege actions, and as such these could not be reasonably identified even as possible impact scars.

Basing Church was inspected for evidence of impact scars, as were the publicly visible facings of private timber-framed residences within the village. No impact scars on these buildings were identified during the site visit.

4.4.3.4 Impacted round recovery

The potential for impacted round recovery at Basing is less hampered by the difficulty with identifying impact scars on brickwork. At the grange several scars can be identified, however the ground beneath the walls is the location of a modern path, and as such the level of disturbance of the topsoil is unclear. The surrounding area is under scheduled monument protection, so potentially the ground remains relatively undisturbed, but targeting a limited excavation for the fragments of impacts is difficult here without a clear concentration of scars.

The garden wall locations with numerous potential impacts would offer a more promising location for limited excavation to test the hypothesis that these surface-broken bricks are a result of small-arms impacts, and the concentrations on the ‘towers’ would offer a reasonable starting point, however the level ground beyond the banks beneath the walls form the filled remains of the Basingstoke Canal built in the eighteenth century. It is unclear what level of disturbance the banked area immediately beneath the brickwork was subjected to, however the height of the scars and the potential rebound distances mean that a significant portion of the distribution of fragments will undoubtedly have been lost due to this previous earth movement.

4.4.3.5 Metal detector survey potential

The siege site areas suitable for metal detector survey are limited due to the expansion and development of Old Basing towards the A30 on the East side of Basing House, and by the river and woodlands to the North and North-west. The house itself is a scheduled ancient monument, as is the ground surrounding and adjacent to the grange buildings to the north. The area of ground immediately outside of the walled garden is however not scheduled, and an opportunity there to search for impacted rounds and evidence of attack against this wall may be possible in that area.

The key area of interest for survey is the common land itself. This is presently under pasture and accessible to the public, however as least part of the land area had been ploughed as recently at the mid-Twentieth Century according to historic aerial photography (Wilson, 2010). This is actually a beneficial set of circumstances for archaeological survey. While pasture fields tend to produce lower recovery rates for finds as artefacts sink deeper into the soil over time, ploughing in the relatively recent past means the archaeology will have been brought closer to the surface as is observed in arable field surveys. There is also the added bonus for survey practicality in that as the land is no longer under crop rotation, the survey season is not limited to windows in the harvest cycle as for arable farmland.

4.4.3.6 Non-archaeological Metal Detecting

The drawback to the potential of the common as an area for survey, and its focus as an area of siege activity in at least two of the sieges, is that it has been an area of interest for non-archaeological metal detecting for a number of decades. The degree to which the archaeological record has been altered by this form of artefact removal will be unclear without systematic survey efforts. A large quantity of lead shot and other metal artefacts are known to have been removed by detectorists over the last half a century, including one such collection examined for calibre distribution by Foard (2012, pp. 70-71). All of these finds are sadly without geospatial context, save for a general indication of the area of the common in which they were recovered(Foard, 2012).

Non-archaeological detecting remains an active problem for the area of Basing Common. During participation on a metal detector survey of the common with the University of Southampton in 2014, the author experienced first-hand not only a sample of material collected over previous years by a local detectorist (despite admitting to numerous requests from the local council to desist), but also a sample of objects removed from the common by the same detectorist during the evening between days of the survey.

4.4.3.7 2014 Detector Survey

Despite the loss of siege archaeology to the above practices, the common itself still contains large quantities of scattered metal artefacts. An archaeological metal-detector survey in 2014 sampled five areas of the common searching for archaeological trace of the siege action, and to assess the extent of the survival of archaeological remains after years of non-archaeological detecting (Wilson, 2015). What the survey found was that, contrary to anecdotal evidence, the common had not been ‘picked clean’ by past detecting, and that systematic transect survey was still capable of recover of large quantities of lead shot, as well as other non-military finds contemporary to the period of the siege (Wilson, 2015). Perhaps the most intriguing find during the survey was of two musket balls that had apparently collided and fused in mid-air during an exchange of fire, either the product of an extremely low-probability occurrence, or testament to the intensity of small-arms fire during one of the sieges, and to the probable quantities of bullets deposited by that action.

4.4.3.8 Site summary

The greatest potential for Basing House is also probably the aspect of the site most at risk. The archaeological deposits within Basing Common reflect potentially the highest concentration unstratified Civil War siege archaeology in England, and possibly therefore the greatest concentration of Civil War artefacts relating to military engagement that is not the site of a battle. However the unprotected nature of the land, and the high concentration of finds has made this site a target for decades of non-archaeological metal detecting, and as such the impact of the loss of material should not be overlooked. Individual fragments of canister shot used by artillery against infantry were identified during the 2014 survey which is fully plotted could indicate the direction of fire accurately enough to identify where on the defences the responsible artillery pieces were positioned. However the loss of sufficient pieces of this from any given scatter may render such interpretation impossible. There is sufficient case for either a ban on the use of metal detectors on the common, or an intensive survey to recover a large sample of the surviving archaeology as possible to reduce the risk of data loss to further removal.

4.5 General Discussion of Site Issues

A number of issues pertaining to the archaeological study of attack and defence in siege actions can be identified both from the assessment of the archaeological resource in England, and from the individual investigations presented above. While the specifics of these issues will vary based on the individual circumstances of each site and the historical siege actions that took place there, these require addressing for siege sites more generally.

4.5.1 Multiple sieges

Sites where garrisons were besieged more than once pose challenges to understanding the archaeology. The initial problem that would be expected is how to make sense of overlapping evidence from multiple actions, both in the form of impact scars and unstratified artefact scatters. This issue is highlighted above in the cases of Old Wardour Castle and Basing House with regards to impact scars and artefact scatters respectively, but is in no way unique to these sites. The UKFoC database shows that of the total 194 siege sites, at least 25 of these were subjected to multiple siege actions. This means that for the apparent majority of sites, the evidence should be limited to the single siege action that took place there, and as such this issue applies only to a limited number of sites.

4.5.1.1 Overlapping evidence within siege sites

While interpretation of a single action at a site with evidence from multiple sieges may not be possible in its entirety, this does not invalidate the archaeology as useful to understanding the sieges that took place at a garrison. Even for the site of a single siege, scatter evidence of sallies by the defenders, for example, would overlap evidence of raiding attacks by the besiegers, or storming actions taken over the course of the siege. In early-1644 at Hopton Castle, Shropshire, Royalist forces attempted to storm the castle on at least four occasions over the space of almost a month

(Barratt, 2009, pp. 145). Given the relatively confined space of the garrison, the rectangular-based keep being no larger than sixteen metre along its longest edge, there is likely to be considerable overlap in the artefact scatter surrounding the site, as well as numerous bullets fired by the defenders. No impact scars have been positively identified on the keep, though impact scars have been found on bricks during excavation of the demolished or destroyed buildings that surround the keep (Reavill, 2015).

The goal of examining the artefact scatter then is to identify patterns within the distribution that identify activities during a siege, rather than an individual siege. For instance recovered case shot projectiles from Basing Common likely relates to the use of the garrison's artillery against advancing soldiers during one of the storming actions in the 1643 and 1645. Though in a battlefield context sufficient recovery of these projectiles and analysis of their distribution may indicate the deployed locations of the garrison's guns, efforts at this kind of analysis at Basing is problematic. Given the extensive detecting carried out across this site since the mid-late twentieth century, much of the archaeology is likely to be incomplete, although clearly significant amounts of material still remain (Wilson, 2015).

Indeed by taking the complete data set for a battlefield and interpreting the distribution, it becomes possible to pick out details of the action, such as the areas of cavalry engagement and the attack on the baggage train at Edgehill (Foard, 2012). Though siege sites are often more confined than battlefields, and the deposition of artefacts may take place over several months of engagement in some cases, the same processes by which the archaeological record is formed for battles are in action at siege sites also, and only a study of a siege site using systematic metal detector survey will allow us to begin to examine the evidence of sieges beyond the upstanding remains of sites and investigation of stratigraphy within the fortified location.

4.5.1.2 Skirmish encounters at garrisons

One consideration that should be made for all sites, particularly small garrisons, is the possibility for the presence of scatters and impact scars as a result of undocumented skirmish actions that occurred during the occupation of the site. It is feasible that smaller, outlier garrisons would have been more susceptible to being harassed by small groups of enemy forces, or more likely to encounter hostile soldiers using roads passing in close proximity to the garrison. If these events were at all considered too inconsequential or common place to be worthy of note, it is possible that such encounters and short exchanges of fire might be undocumented by contemporary accounts.

In the case of Stokesay Castle in Shropshire, such a skirmish may be the only evidence at all of conflict at this site. The Royalist garrison in the castle surrendered to the Parliamentary force before the latter began an attempt at storming (Bracher and Emmett, 2000, pp. 87). References exist to a possible skirmish between the castle's new Parliamentary garrison and a party of Royalist horse using the neighbouring church as shelter in February 1646, apparently resulting in extensive damage to the structure of the latter (Summerson, 2009, pp. 34). In any case the church was almost entirely rebuilt during the period between the wars, and no impact scars have been found on the castle to show evidence of fire from the Royalists, though this is possibly due to the difficulty of identifying impacts on the rough-faced stone that dresses the castle walls. The signature of this skirmish might be identified through an archaeological detector survey in the field to the north of the church, where one would expect to find bullets fired from the garrison towards the church, particularly if these were aimed at an elevation sufficient to hit mounted soldiers. The recovery of potential bullets fired from the attackers towards the garrison may also be possible, though it is likely that where these missed their intended target they will have struck the castle and only be recoverable as partial fragments.

It might be expected that skirmishes close to defended sites would leave both artefact scatter and impact scars at a siege site that could be mistaken for the archaeological signature of sallying and probing attacks carried out during sieges, as well to some extent as those of storming actions in much lower density. Further study of garrison skirmishes may be required before it become possible to identify with any certainty the pattern of these actions at siege sites.

4.5.2 Recovery of impacted bullets

The investigation of Old Wardour raised potential problems for the recovery of impacted projectiles at that site, though these highlight general issues that will apply to other sites. While recovery of bullets relating to impact scars should be possible, the challenge of finding these using the impact scars as a reference point may be hampered by the issue of bullet rebound, and movement of the topsoil as a result of landscaping/gardening.

4.5.2.1 Rebounding bullets

A difficulty that exists for identifying the likely location of bullets that formed impact scars is that the degree to which soft lead bullets fragment or rebound from stone surfaces is not discussed in the literature. Observations from experiments suggest that the rebounding bullet cores can easily rebound more than 5m on an indoor range where blocks have been positioned at ground level. The majority of the fragmenting bullet towards the edges of the flattening disc appears to eject at angles close to perpendicular to the direction of travel i.e. almost parallel to the wall surface for orthogonal impacts, and is likely to be distributed much closer to the point immediately below the location of impact scars. Until further data can be collected regarding the rebound and dispersal of lead bullet fragments impacting stone targets, predictive modelling for the location of these objects using scar locations, and a meaningful interpretation of archaeological assemblages of these fragments is not feasible.

This matter is further complicated by the height of the impacts as they occur on the structures, as those at greater height would be expected rebound a greater horizontal distance before reaching the ground. For Old Wardour where the curtain wall stands some distance from the keep, this will leave impacted bullets and fragments well within the bounds of the scheduled area. However for sites such as Lilleshall Abbey in Shropshire, the rebounding bullets may have carried beyond the grounds of the scheduling, as the impact scars identified there occur on a wall only 12m from the site boundary. This issue is a matter not only for the recovery of these artefacts, but also a consideration for their conservation and protection. Where this evidence lies beyond existing areas of statutory protection, it is at risk of loss from non-archaeological metal detecting or other land-use activity that could result in topsoil removal.

4.5.2.2 Ground movement

Compounding the issue of unknown position of rest for rebounded projectiles is the issue of whether the ground in which they reside has been altered since the time of the siege. At Old Wardour the grounds immediately outside the castle were subjected to a number of stages of gardening in the period after the Civil Wars, particularly the eighteenth century (Girouard, 2012, pp.

40). The extent to which the bullet fragments were moved from their original positions is unknown, though it seems likely that heavy soil disturbance may have scattered these both vertically and laterally within the grounds of the keep.

Despite the likely disturbance, recovery of these fragments and impacted may still be valuable. Identifying individual scar and projectile pairing is not a feasible archaeological aim, but what could be achieved however is an overall assessment of the remains of impacted and rebounded projectiles within an area that can be reasonably related to a building facing, or a particular set of impact scars. Unless later landscaping has physically moved or removed both soil and artefacts well beyond their original positions, it should still be possible to study bullet fragments in relation to their scars for a broad section of surviving structures, particularly for observing the discrepancy between the number of scars identified, and the number of distinct fragmented bullets found in the corresponding area of ground.

4.5.3 Relationship of churches to fortified sites

The relationship between churches close to the garrison and their role in the defended site is something that is circumstantial to each site. Certainly churches close to a garrisoned castle or manor house are often good candidates for impact scars given their proximity to the fighting, and for sieges of towns or villages, the church may be the only contemporary structure surviving that might yield impact evidence. There are other factors that make churches a productive target for impact scar assessment, as they are often lined or faced wholly with dressed stone external walls, and they generally survive at least in part up to the present. Nevertheless the reason why different churches carry impact scars is dependent on their role in the siege.

All Saints' Church in Pontefract initially formed part of the defensive circuit of the castle garrison, given its close proximity to the latter (Roberts, 2002). As the fighting during the second siege progressed, the site of the church became an active zone of engagement, and was eventually overcome by the attackers. Although now ruinous and significantly weathered, it is likely the majority of surviving scars on this structure relate to the proximity of this contest for control over the grounds. St. Bartholomew's Church at Tong, Shropshire, was also incorporated as part of the garrison at Tong, together with neighbouring collegiate, and the Castle over half a kilometre to the south, the latter two of which are no longer extant. At Tong there is a significant bias in the impact scar evidence as, because only the church survives, it is impossible to say if the scars here represent the core of the attack during the siege, or if this is a fragment of the complete action. While recovery of impacted projectiles might allow comparison of the intensity of attack where the walls do not survive to a height to show impact scars, at Tong this is not possible owing to the castle site having been lost to the development of the M54 motorway in the twentieth century. At other sites where the church was not incorporated into the defended site, this caused problems for the garrison in due course. The use of the church as cover during the skirmish at Stokesay is discussed above, and here the presence of the church allowed the attackers to use it as cover from the defences. It is possible that neighbouring church was also used to screen the approach of attacking soldiers at Moreton Corbet, as the church here shows impact scars only on walls facing towards the garrisoned castle.

The use of the church for different sites seems largely to be connected to the strength of the garrison to incorporate it within the perimeter. The fact that churches close to garrisons become backdrop for exchanges of fire is fortuitous in that churches are often good candidates for the formation and survival of scars, producing an undoubtable survival bias in the data. What is apparent from observing churches used in both attack and defence at garrisons is that for the majority the structures themselves do not appear to have been used as defensive positions. While a number of churches bear evidence of attack in the form of scars, only the church at Tong has clear evidence of impact scars on window frames, though even here the majority of scars occur lower down and are distributed more evenly across the impacted face of the building than for those surrounding the windows at Old Wardour Castle.

4.5.4 Modern treatment of sites

In addition to considerations about the archaeological biases and research issues posed by on site evidence, the modern management of, and public interaction with, siege sites in the twentieth and twenty-first centuries have implications for the survival and survey of the archaeology. In particular the elements most at risk from the factors identified are the unstratified scatters within the siegefield, bullet-fragment scatters from impacts against structures, and impact scars on buildings that have undergone conservation and restoration work.

4.5.4.1 Non-archaeological metal detecting

The threat to the archaeology of attack and defence posed by non-archaeological metal detecting is as significant if not more so than for battlefields. While battlefields tend to be more remote and harder to locate, sieges are by contract usually close to settlements and easy to find for the purpose of recovering material culture from the conflict. Several sites are known to have been subjected to detecting without recording of spatial data and the damage to the archaeological record through the loss of this material compounds over time.

While these collections of finds are by no means without worth for study, their usefulness is limited without the spatial context of their discovery. For instance numerous finds donated by detectorists from Basing Common have been analysed by Glenn Foard to produce calibre distribution graphs for comparison with those produced for sites such as Edgehill (Foard, 2012, pp. 70-71). However the lack of systematic recovery masks any recovery bias in the area or manner of collecting or retention of finds, and the lack of spatial data impedes on the ability of subsequent archaeological study to properly assess patterns in the distribution of finds.

4.5.4.2 Litter noise

In addition to their visibility as sites for detecting, siege sites are also frequently historic structures open to the public. The presence and interaction of the public typically produces significant amounts of rubbish and lost objects that reduce the efficiency of surveying through repeated recovery of modern metallic finds, from foil-lined wrappers and ring-pulls, to the percussion caps of discarded shotgun cartridges. While this becomes less of a problem for the recovery of objects in fields and ground beyond the public site, it is in the area closest to the fortified site where impacted rounds and evidence of assault actions are likely to be located, and as such if the topsoil has become sufficiently contaminated by modern rubbish practical survey of the fragments may not be possible.

4.5.4.3 Ministry of Works site clearances

What is also clear from examination of a number of sites under state stewardship is that there has been work to make these sites both presentable and accessible to the public, and in some instances to restore aspects of the masonry. This began as early at the nineteenth century, and often involved the clearing of the topsoil layer at sites until reaching the first solid level with little effort to record the context of spatial position of recovered artefacts (Harrington, 2004, pp. 47). This evidently continued into the twentieth century, and comparison of contemporary and present-day photographs of Moreton Corbet Castle shows how part of the Elizabethan façade has been 'restored' after it entered state guardianship. If such clearance can be expected at all sites in present state custodianship, now under English Heritage, it may be that the unstratified evidence of impacted bullet fragments and siege action within the boundaries of these sites is already lost as a result of historic heritage management policies. General assessment of this may not be possible, but specific research of individual records from the Ministry of Works and later successor organisations activity may help to answer these questions for specific sites.

4.5.4.4 Conservation and stonework restoration

The restoration of stonework at sites also poses a problem for study of the impact scars. As stone-faced buildings are subjected to weathering and loss of surface, impact scarring can be lost by this process alone. However as impact scars typically penetrate the stone surface by several centimetres, loss of the dressed surface may not eliminate all of the evidence for the scar. At Ashby Castle, numerous impact scars cover part of the lower wall of the keep tower, though the stonework here has clearly suffered as a result of weathering loss. Despite this, the large quantity of surrounding scars makes identifying possible scars more likely, as it is clear this is an area of dense coverage.

For other sites with very few scars the problem of identifying scars lost to weathering becomes much more difficult. At Chester the church of St. John the Baptist outside the city walls bears only a single impact scar identified during this study, on a south-facing wall at the base of the ruined west tower. Immediately adjacent to this is a surface-weathered stone that bears a mark suggesting the base of an impact scar where the outer features have been lost (Figure 4). Although it was not possible to confirm this hypothesis, if it is indeed the case that this is the remains of a lost scar, then the scar is still effectively present as a visible mark on the stone despite the loss of the identifying features. While this is impractical as a means of identifying scars at sites to simply count up all of the colour variation on the stone surface of the structure without the nearby presence of identifiable scars, it does indicate that were simple replacement of apparently un-impacted stone undertaken without sufficient recording, the presence and location of these lost scars could be removed without any awareness of their existence. At Chester Cathedral, several scars have been recorded on a wall facing where significant stonework restoration/replacement has already occurred. The step-difference in the stone surface in (Figure 5) indicates the implied depth of the surface lost due to weathering.

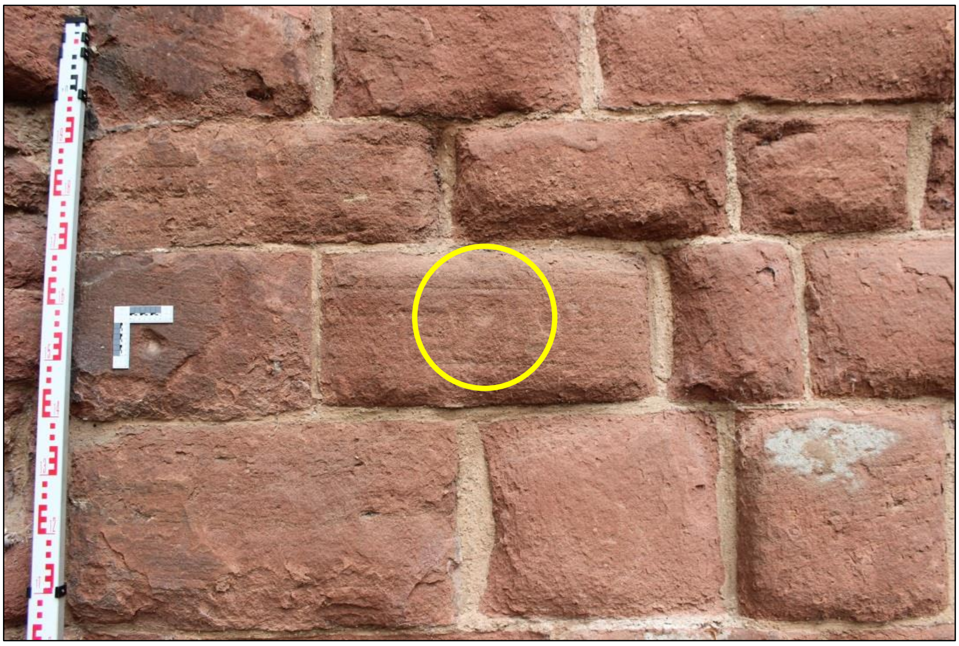

Figure 4: Photograph of a possible impact scar remnant at Chester, Cheshire. The remnant is located in the centre of the circled area

Figure 5: Photograph of stone replacement adjacent to an impact scar at Chester Cathedral

4.6 Summary

While not ubiquitous, impact scars on structures at siege sites offer additional potential for reconstructing the events of historic sieges. Examples at Pontefract and Old Wardour provide opportunities to explore ways of interpreting the data for their lateral distribution around a structure, as well as vertical and horizontal distribution on specific facings of buildings, while other sites with limited concentrations may still reveal details about the point of origin of the impacts and the size of the bullet that caused the scar. For this to be determined further investigation of the impact behaviour of bullets and impacted surfaces will be required.

Perhaps the best potential based on both the assessment statistics and observations from sites is for the recovery of the artefact scatter of the siegefield of sieges in rural areas where the process of settlement-creep into the surrounding landscape has been limited. The data that can be drawn from this evidence is possibly the most at-risk due to the activity of non-archaeological metal detecting. Unrecorded or unidentified instances of non-archaeological artefact removal will change the data drawn from the distribution of objects in ways that may not be apparent, while even recorded instances or volunteered objects lose their ability to contribute to the interpretation of a site without spatial data, and assessment of distribution density it much more difficult where artefacts have been recovered in a non-systematic manner.

5. Impact Scars

5.1 Introduction

A bullet impact scar is formed when a ballistic projectile strikes a stone surface, resulting in the loss of surface material from the stone, and the deformation or disintegration of the projectile. For scars to be present at archaeological sites of conflict, a shot must have been fired in the past that struck the surface of a structure at that site.

Other elements factor into the formation of a scar besides a bullet impact. The impacted surface type must be one that will produce a scar when impacted, and the bullet must have enough kinetic energy to overcome the failure point of the material i.e. the point at which the material fragments rather than resists the impact, leading to the creation of a scar. For the resulting impact scar to be identifiable in the present-day the impacted surface must also have survived the loss through weathering, and the destruction, removal or restoration of the structure upon which it is located. Identifying scars in practice is also influenced by the surface type and material, as variations in the surface appearance, hardness and surface geometry will affect the form and observability of the scars produced, and the degree of difficulty entailed in identifying them. What remains when a scar is formed however is a direct physical trace from a shot fired in the past, as while the shooter, target and conflict have all departed, the impact scar remains in the location in which it was created as a witness to that shot.

To fully explore the archaeology of attack and defence at siege sites, bullet impact scars on stone-faced surfaces must be better understood as a form of evidence of siege actions. Impact scars have never before been investigated in detail for what survives across a broad number of sites, or what examination of these scars might tell us about the associated siege actions (Foard and Morris, 2012, pp. 128). Though impact scars are not unique to siege sites, sieges offer an almost ideal opportunity for their creation as many garrisoned sites utilised large masonry structures as part of the defended position, such as a castle, manor house or church. Furthermore these structures are typically those more likely to survive to the present day from most siege settings, as unless they were deliberately demolished after the conflict, they are less prone to demolition or replacement in urban locations than timber or brick structures, and in some cases survive despite significant destruction as heritage-protected ruins. Buildings of these types are frequently a feature of the terrain of siege actions due to the need for a defensible garrison location; however some instances of scars on structures at sites relating to both battles and skirmishes have been identified (Foard and Morris, 2012, pp. 128-129). The presence of impact scars in varying quantities at numerous siege sites identifies them as a signature form of evidence for these military actions. It is important therefore to establish what impact evidence can tell us about past conflict.

This chapter will explore the subject of impact scars as a form of archaeological evidence at siege sites from the Civil Wars in England. A typology of scars will be presented to outline what features exist and can be identified in archaeological examples, how scar features vary between different archaeological sites and surfaces, and the influence of weathering upon surviving scar evidence. This will be followed by an evaluation of examining individual impact scars with an aim towards shot reconstruction, and a discussion of applicable forensic studies that could allow scar details to be suitably analysed to this end. After identifying the features of archaeological scars and discussing potential methods for an investigation of the details of archaeological scar features, a methodology for recording data from impacts in order to begin answering questions about the three-dimensional profile of scars as undertaken by this study will be introduced, comparing different methods of measurement and recording, as well as presenting the results of profile recording and analysis in identifying relationships between scar features. Finally this chapter will discuss how examining the spatial location of scars can contribute to understanding siege sites more generally, and specifically in a case study of Old Wardour Castle.

5.2 Shot-reconstruction from impact evidence

The ideal outcome for investigation of an individual impact scar would be the ability to reconstruct the specific variable of the shot fired in the past that led to its formation. This would allow the deduction of the position of the shooter, the calibre of the bullet and the probable type of firearm used to deliver it, and the range of probable target positions at which the shot was aimed, all of which in turn would reveal information about the siege action itself.

For seventeenth century ballistics this level of specificity is simply not possible to achieve. At a fundamental level the inconsistency in the performance of smooth-bore, black powder muskets firing near-spherical lead bullets is too great across a range of variables to make an exact statement about the origins of a shot. Even if the impact conditions upon which that statement would be based could be identified with certainty from an impact scar, ballistic performance experiments for seventeenth century muskets have shown that even with a consistent set of starting conditions for repeated firings, the flight characteristics, bullet trajectory and velocity of the bullet differ between each shot (Miller, 2010). This variation in turn makes it effectively impossible to recreate a precise shot-origin from values for the impact variables alone.

There is nevertheless merit to adopting reconstruction as a goal for investigating impact scars. Though precision reconstruction is not possible, the circumstances for the creation of an impact scar are still limited to a finite range of possibilities. Ballistic research studies have made considerable advances in the understanding of the ranges in performance and behaviour of seventeenth century weapons systems, identifying the best comparably performing modern propellants (Parkman, 2017), the identifying the influence on muzzle velocity of issues such as windage and use of a wad (Eyers, 2006), and the flight performance variability of spherical bullets under controlled firing (Miller, 2010). If the impact variables that led to the formation of a scar can be determined from the archaeological evidence, combining this with current understanding of the ballistic behaviour for seventeenth century firearms would make it possible to begin determining a limited range of values for variables associated with the shot to produce a ‘cone of probable origin’. Taking this approach, reconstruction becomes a matter of assessing the range of probable values for variables from the impact evidence, using a combination of further archaeological evidence, contemporary sources and landscape reconstruction to derive a reasonable interpretation for the origin of the shot.

5.2.1 Identifying the key variables for shot-reconstruction

In order to determine the broad location from which a shot was fired, the final flight characteristics of the bullet must be determined from the impact evidence. The variable values within these characteristics that would allow a reconstruction of origin to begin to be determined are the angle and direction of impact, and the final velocity of the bullet. These values are related respectively to the direction from which the shot was fired, and the distance over which the bullet travelled before impact Both variables are necessary to extrapolate the possible origins of the shot.

This relationship is not straightforward however, as a number of factors influence the flight characteristics of the bullet and the starting conditions of the shot. The initial (muzzle) velocity is influenced by the internal ballistics of the firearm including the quality and grain size of the propellant, the in-bore motion of the bullet and friction against the barrel, the windage between the bullet and the barrel, and the barrel length of the firearm (Parkman, 2017, pp. 91-99). If the rate of deceleration of the bullet in flight between the muzzle and impact could be known, without a muzzle velocity it would be difficult to identify with certainty the point along the flight at which the bullet began its journey. This itself is an over-simplification of the problem, as the influence of external ballistics variables upon the bullet flight, predominantly the influence of drag on decelerating the bullet, is affected by conditions such as the shape and deformation of the bullet, the atmospheric and weather conditions at the time of the shot (Parkman, 2017, pp. 99-105). Finally the flight behaviour of the bullet itself is not straightforward, as spherical bullets have shown a tendency to curl or corkscrew through the air when fired from a smoothbore firearm (such as a musket) (Miller, 2010), and can become unstable in flight when crossing the threshold between supersonic and subsonic speed in flight (Parkman, 2017, pp. 105).

In addition to challenges in reconstruction of a bullet's flight, there are separate factors that influence the formation and present-day appearance of impact scars, from which the impact data would be being sought, that must be understood or overcome. In limited ballistic studies the relative hardness of the stone surface has been identified as being influential in the overall size and form of an impact scar, with softer stone types producing generally larger scars (Green, 2010). The resistance of different surface types to weathering is also an important factor, as surface loss due to erosion will undoubtedly reduce the degree of detail that can be gleaned from measurement of an impact scar. It is unclear at this stage to what degree impact scars are formed, enhanced, or deteriorated through weathering processes over time. If scars are largely uninfluenced by weathering, then their characteristics should relate closely to impact variables, whereas if the scars are predominantly formed through weathering processes, a more detailed understanding of how an impact develops into a scar would be needed before analysis of the features could be related to impact processes. While a deep investigation of this issue is beyond the purview of this study, a key task for identifying whether impact variables might be able to be drawn from scars is establishing whether there is significant variance in the physical form of impact scars across sites. Where a surface typically of a single stone-source has been subjected to the same weathering environment, variation between the profiles of individual scars would indicate differences in the starting conditions for the formation of those scars, either due to the impact process itself, or the properties of the impacted stone surface that is then exposed to weathering processes.

Before any of these challenges can be tackled however, it is necessary to address which impact characteristics are being sought from scars, and how these relate to the reconstruction of a shot fired in the past.

5.2.1.1 Impact angle and direction

Identifying the angle and direction of an impacting shot would provide a bearing back from the fixed position of the scar towards the historic location from which the shot was fired. This is necessary for reconstruction as it limits the shot origins to an arc of possible angles in relation to the impacted surface.

While the relationship between origin and angle of impact are closely linked, variation between the position of the shot and the angle of impact will occur as a result of factors that cause deviation in the flight path of the bullet. Causes of deviation could be a result of drag influence on the bullet, rotation of the bullet in flight causing its flight path to curve or curl between origin and impact, and to an extent the influence of weather and atmospheric conditions (Parkman, 2017, pp. 99-105, Miller, 2010).

5.2.1.2 Impact velocity

The final velocity of the bullet upon contact with the impact point is necessary for to attempt a calculation of the distance from which the shot originated. Impact velocity is a product of the initial velocity of the bullet from the muzzle of the firearm, its rate of deceleration, and the time spent decelerating (in flight) from shot to impact. If the rate of deceleration can be determined and the impact velocity is identified, then the velocity of the bullet at any given point along its flight can be calculated. If in turn the muzzle velocity is known or can be reasonably estimated, the distance over which the bullet has travelled can be calculated, providing a set of equidistant points from which the shot must have occurred.

Variation in the muzzle velocity will influence the final velocity of the bullet, such as the quality and quantity of gunpowder used in the charge, the presence of wadding that increases the peak pressure generated before acceleration of the bullet down the barrel, and the barrel length of the firearm in question (Parkman, 2017, pp. 91-99). The deceleration of the bullet due to drag will be influenced by atmospheric conditions and the shape of the bullet, though drag caused by small surface variation of the bullet shape, caused through firing deformation, has been shown to have the least influence on the drag coefficient of the bullet compared with its overall spherical shape (Miller, 2010, pp. 45).

5.2.2 Limiting uncertainty in variables

The challenge facing reconstruction is that not all of the influencing variables can be known with any certainty. An example of this is the issue of atmospheric conditions at the time of the engagement. If the siege took place over a period of months across multiple seasons, it could be expected that changes in weather, humidity, air pressure and wind speed and direction would all occur, yet determining these from the impact evidence is certainly impossible. Even those elements that could be purposely reproduced and subjected to experimentation cannot be relied upon for repeatable results. For instance, a bullet with a protruding mould seam would be more greatly affected by aerodynamic drag in flight than one without, however in firing this seam may rotate away from or towards the airstream, or may be largely deformed as a result of contact between the bullet and the barrel, resulting in bullet-banding. There is therefore a random element to almost every variable that cannot be entirely controlled or predicted.

Despite this it is important to establish that the aim of reconstruction here is not a precise recreation of all variables, but rather an attempt to create a set of possible solutions for an impact. Although for historic sieges these variables cannot be known for certain, similar problems exist to a limited degree for the reconstruction of crime-scene shooting incidents. While the range of possible values for variables is large, it is not without limits and through experimentation, detailed scientific modelling and contemporary source investigation, the influence of variation within each of these variables can begin to be defined.

An example of this approach has been utilised for the issue of muzzle velocity. The muzzle velocity of a smoothbore musket is influenced by factors including propellant quality, barrel length, windage, etc. However while each of these variables affects the muzzle velocity of the bullet, these would all vary within the historical period itself due to pre-industrial inconsistencies in manufacture of gunpowder, bullets and gun barrels. What is needed for creating a relatable model for shot-reconstruction therefore is a mean value for muzzle velocity based on data drawn from contemporary sources for firearm performance and experimental firing. Experimental firing carried out by Parkman (2017) has utilised historic sources for seventeenth century musket performance to identify a modern gunpowder type to best replicate this performance, and establish a mean value for muzzle velocity that can be used as a bench mark for further ballistics experiments, and potentially for shot-reconstruction if impact velocity can be determined for an impacting bullet.

While further research and experimentation may be necessary to identify the limitations of influence for each specific variable upon flight characteristics and performance for bullets of varying calibres fired from a range of seventeenth century firearm types before a complete catalogue of ballistic data could be drawn upon understanding can be achieved, even limited data can be utilised to begin attempting interpretation of impact scar evidence through reconstruction. For this to be possible however, it is necessary to first establish what detailed investigation of impact scars might reveal about the impact variables identified above as being necessary to shot-reconstruction.

5.3 Typology of Archaeological Impact Scars

Examination and recording of impact scarring during this study has identified two categories of scars, both of which can be subdivided into types based on surface medium and/or the features of the scar. The most prevalent category of scarring by far is that of small-arms impacts, i.e. bullets fired by hand-held firearms such as pistols, carbines, muskets, etc. The second category is that of artillery impacts, i.e. from shots fired by artillery pieces, siege guns and mortars. Examples of both artillery and small-arms scars have previously been noted and recorded at several locations of conflict in England (Ward, 1987, Foard and Morris, 2012), and for the latter have also been investigated for their influence on long-term decay of stone surfaces and heritage conservation (Mol and Gomez-Heras, 2018). Despite the awareness of their existence as evidence of past conflict however, they are yet to be explored in detail for what information can be discerned about past military engagements from their specific form or features.

Although this section principally focuses on bullet impact scars, not all surfaces will produce a scar as the result of a bullet impacts. If a bullet strikes a yielding material such as a wooden frame or door, the resulting impact typically produces a perforation, or will penetrate and come to a stop within the material (Haag, 2005, pp. 83). Where a bullet strikes an unyielding surface, or does not deliver enough impact force to overcome the failure point for a frangible surface, the projectile rebounds or ricochets from the surface, leaving a surface transfer of bullet material (lead for seventeenth century small-arms bullets), and deforming or fragmenting the bullet itself (Haag, 2005, pp. 83, 128). Neither of these impact types produces impact scars, though of perforating impacts have been identified at several sites of sieges from the Civil Wars and are addressed below for opportunities of study in conjunction with impact scars.

5.3.1 Anatomy of impact scars

For scars caused by impact from small-arms fire and some artillery projectiles, common aspects of appearance can be identified. These aspects can be labelled as three distinct but related features: The 'inner scar' is the central, primary feature of a scar and must typically be present in order for an impact to be identified as such; the 'outer spalling' is an area of surface material loss that surrounds the circumference of the inner scar; 'radial fractures' emanate from the impact site and move outward into the material, visible at the surface typically as narrow channels but occasionally as deeper fissures. An illustrative diagram of these features is presented in Figure 6. The shape, size and form of each of these individual features varies between surface stone/material types, and is likely to be directly tied to the properties of the surface as well as the impact variables of shot that produced the scar.

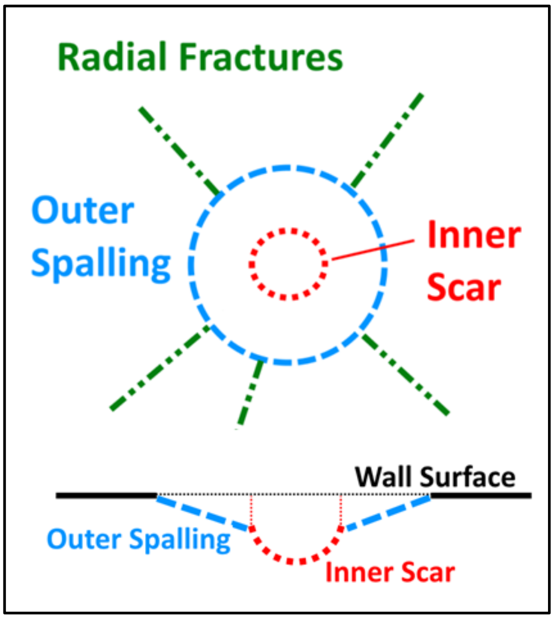

Figure 6: Simplified diagram of the characteristic features of an impact scar in profile (above) and cross-section (below)

The overall appearance and visibility of scars upon surfaces is also dependent on the surface type that has been struck. For the majority of small-arms scars observed by this study, only those occurring on worked stone surfaces of sedimentary stone types could be readily discerned. Though examples of rebounding impacts have been observed on other surface types, they are rarely identified for a variety of reasons discussed below in relation to specific examples.

Impacts from artillery-type projectiles are often more visible due to the high-energy of the impact causing a greater level of damage to the structure, however these seldom leave a neat scar as described above. Impacts upon stone or brick surfaces caused by ordnance typically leave irregular holes where masonry or brickwork has been fragmented and dislodged. Though ordinance impacts that do produce a readily measurable scar have been observed at several sites, these are too few in quantity across multiple sites for a meaningful investigation to be attempted by this study. Nevertheless some artillery scars that have been observed are examined below for how they compare to small-arms scars and what might be concluded from their form and appearance in relation to other examples of impact scars.

5.3.2 Small-arms impact scars

Small-arms impact scars are by far the most frequently encountered form of impact evidence at sites of sieges across England for the Civil Wars. Their occurrence at sites ranges from a few scattered individual scars on a single surviving building, such as at All Saints Church in Hillesden, Buckinghamshire, to over a hundred scars identified across multiple contemporary structures within and surrounding a garrisoned site, as at Ashby de la Zouche, Leicestershire. Archaeological examples of small-arms scars generally adhere to the pattern of appearance discussed for worked stone surfaces and to a lesser extent for occurrences on fired-clay brickwork. Scars vary significantly in diameter, depth and visibility between different surface types, but also across the same surface at a number of sites with multiple impacts. This implies that variation may be as much a reflection of impact characteristics of each shot as it is of the behaviour of the impacted material.

5.3.2.1 Inner Scars

The principal feature of an archaeological impact scar is that of the inner scar. This feature above all others is necessary for the positive identification of a mark on a surface as being an impact scar caused by a projectile. Where a complete impact scar is present on a worked stone surface, the inner scar takes the form of an ellipse when viewed perpendicular to the impacted surface, with a smoothed interior if examined in cross-sectional (Figure 7). In instances where a bullet has struck on the edge of a block or a shaped surface such as a window mullion, the ellipse of the inner scar may only be partially complete due to fracturing of the stone block between the impact point and the edge-surface. The remnant of the scar on the remaining surface frequently retain some of the scar shape and associated features, enabling identification and frequently some degree of measurement to be undertaken.

Figure 7: Photography of an impact scar showing characteristic cup shape of the inner scar, in addition to spalling and radial fracturing

Inner scars measure typically between 15mm and 40mm in diameter for a coherent scar, and where able to be measured in profile, between 5mm and 25mm in depth from the mean surface level. With the exception of instances where the scar has become covered in lichen or pollution, the inner scar often appears a different shade or hue to the surface wall colour, possibly as a result of weathering differentiation where the outer layer of the stone has weathered more consistently over a longer period of time, while the inner scar has been partly sheltered due to its recessive shape. In some observed instances the inner scar surface also appears to be blistering, which may also be due to weathering effects on the surface of the stone within the scar. Erosion due to weathering also has the dual ability to either reduce or increase the apparent depth of a scar. At Bridgnorth Castle, Shropshire, the outer surface of the stone has weathered drastically that the shallow outline of the inner scar is all that remains on the surface to indicate the presence of an impact (Figure 8), whereas at Taunton Castle, Devon, scars on a surviving buttress have been deepened due to the influence of weathering on the bedding planes in the 'Hamstone' sandstone surface.

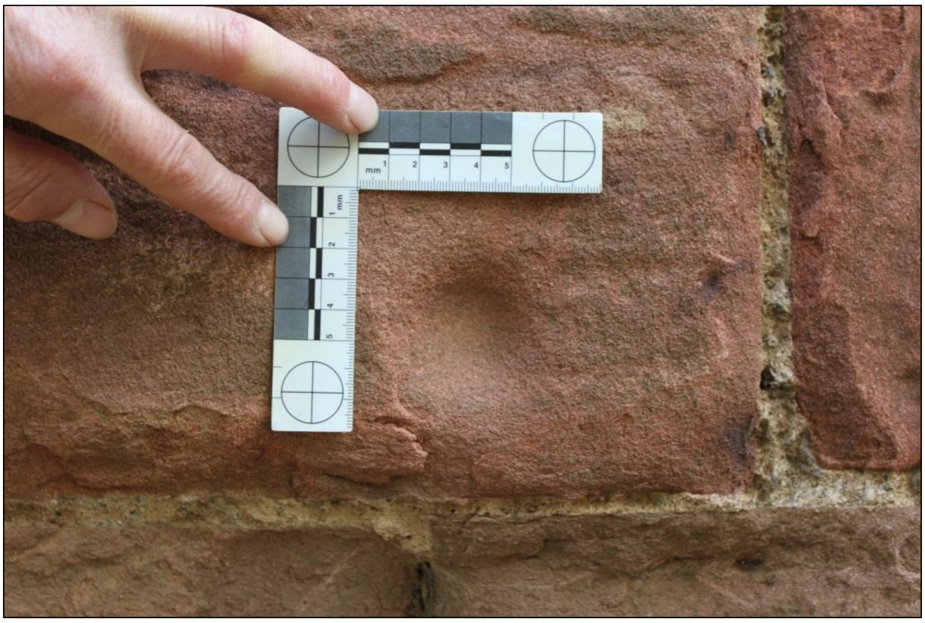

Figure 8: Photograph of a weathered impact scar from Bridgnorth, Shropshire

The hardness of the stone from which a structure is built is likely to influence whether or not it is susceptible to the formation of an inner scar from small-arms impacts. Though no granite-built castles were visited during the course of this study, an example of a granite structure bearing small-arms impact marks is known to the author at Bomarshund in the Åland Islands, Finland. Here the artillery impacts from cast iron projectiles have made obvious impact scars, whereas the softer lead projectiles of small-arms fire have left only a surface mark from the lead transferred during impact (Foard, Pers. comm). Though this has not been observed in Civil Wars siege contexts, it could be expected that for particularly hard stone types scars may not form beyond a surface lead transfer.

Indeed it is not wholly clear whether the inner scar is predominantly a direct product of the pulverisation of the stone surface upon impact, or a secondary formation as a result of the weakened surface under the impact point allowing greater moisture ingress and rapid weathering of the damaged material to form the cup shape of the scar. Experimental impacts on stone targets, discussed further in subsequent chapters, have thus far been unable to produce a scar that directly resembles an archaeological impact scar, indicating the latter is a more likely probability.

5.3.2.2 Outer spalling

Immediately adjacent to and surrounding the outer circumference of the inner scar is outer spalling. As with the inner scar the process of formation of this feature is not entirely clear. The outer spalling may represent the impact deformation of the bullet removing a largely circular layer of material through abrasion of the bullet lead as it flattens and fragments radially, or the displacement of material from the block surface as the deforming lead expands outwards from within the space of the inner scar. Spalling may also be a partially a result of the loss of edge surface material around the impact scar that has been cracked or weakened as a result of the impact and gradually been removed by weathering processes. High speed footage taken from experimental firing seems to suggest the displacement of the adjacent surface stone by the expanding bullet (dependent on the degree of penetration of the bullet) is the most significant cause, however archaeologically observed examples display evidence of spalling loss expanding close to faults or edges of the stone blocks, indicating fracturing travelling towards weaknesses in the structure of the stone.

Figure 9: Photograph of scars showing prominent outer spalling at Ashby Castle, Leicestershire

What is certainly true is that outer spalling is not always evident in the appearance of a scar. This may be due to softening of the distinction between the inner scar and the outer spalling due to weathering effects, or in some instances the loss of the spalling feature altogether due to surface loss of the stone. The width of the spalling varies between scars, ranging from only a couple of millimetres in some cases, to more than half the total diameter of the scar in others. There is also no clear correlation between the diameter of the inner scar feature and the radius of the spalling extent for scars across the same surface at individual siege sites, suggesting that the formation of these features may be tied to different variables of the bullet impact.

Identifying spalling through visual examination alone is much harder where weathering has served to soften or obscure the transition between the feature and the inner scar. Identifying the surface variation relating to spalling in photography is made easier where direct light is being shone across the scar at an angle, revealing the subtle variations in depth that outer spalling generally presents.

5.3.2.3 Radial fracturing

Radial fractures are cracks visible at the surface of the impacted material that radiate outward from the location of the impact. While these fractures typically radiate directly outward in one or more directions, in some instances they can be observed to follow lines of apparent weakness in the surface material, such as bedding planes in sedimentary stone types, or travel towards the edge of a stone block where an impact has occurred close to a joint in the wall surface. The fractures also appear to continue inwards into the surface material in a plane perpendicular to that of the impacted surface. This can be seen in examples where the stone has fractured away from the impact site close to the edge of stone blocks along the course of the radial fracturing, or one observed instance where the sub-surface fractures emerge from adjacent facing of the same block on a wall corner (Figure 10).

Figure 10: Photograph of an impact scar from Hillesden church, Buckinghamshire, showing a radial fracture emerging from an adjacent surface of the impacted block

Radial fractures are less frequently observed as a feature of archaeological scars than the outer spalling or the inner scar. There are number of possible explanations for this apparent rarity. A reason for this may be that not all fractures that are formed in the stone in this manner emerge at the surface, and would thus not be evident without bisecting the stone. In addition to this a visual assessment of radial fracturing in non-edge impacts suggests that it is erosion through weathering processes that deepening and widening the cracks at the surface, making them visible. If the surface stone is thus resistant to weathering, these cracks may not be visible despite being present. Surface fracturing of masonry may also be limited to impacts with a certain energy threshold to break the surface material in this manner, as example impacts on individual stone blocks under experimental conditions show that fracturing of this nature tends to occur more frequently with increased impact velocity (and thus higher impact energy), or where bullets strike close to the edge of a block and require less energy to fracture to the edge through a path of least resistance.

There is no obvious relationship between the size and depth of a scar and the quantity or severity of the radial fracturing present. This may be an indication that it is the properties of the stone that has a more significant influence on the visibility of radial fractures. Indeed for sites selected for investigation of scar cross-sectional profile, the presence and severity of fracturing was apparently more likely to occur for scar across a single site, than even distributed between multiple sites. If this is the underlying cause, then the radial fractures may not prove to be of any additional use to scar investigation save for perhaps clues toward the susceptibility of the surface to softening or enhancement of feature due to weathering.

5.3.3 Marks that are not early modern scars

It is worth considering some of the difficulties in positively identifying marks and feature that are the result of impacts and those that are ‘red herrings’. Each of the principal features of impact scars can be mimicked, and as such the key to correctly dismissing these marks comes in recognising either their actual cause, their variation from true scar features, or the lack of further supporting evidence.

Inner scars are for instance typically circular in appearance and shape, although some degree of elongation is often present. Although weathering and the encroachment of lichens can disguise this feature, the circular aspect is typically still visible where the scar is complete (i.e. not an edge-impact). Stone is also prone to forming cracks under impact or fracturing, it is also relatively common for marks near the edges of blocks of masonry, or those cause by an impact, such as driving a spike or nail into a hole, to give the impression of radial fracturing. Figure 11 taken from Moreton Corbet Castle shows an impact scar with radial fracturing close to the lower edge of a block, and close to the location of a metal pin that has been inserted between blocks of stonework, also creating a radial fracture pattern. Numerous other holes on this surface are likely to be the result of weathering of weak faults in the stonework which are also visible elsewhere on the castle. This image also shows a number of shallow pits, approximately one centimetre in diameter, that have been observed at this site and numerous other locations with or without known siege activity, and are speculated to be the by-product of shotgun pellet impacts from recreational shooting.

Figure 11: Photography of an impact scar surrounded by numerous features that mimic aspects of early modern small-arms impacts

5.3.3.1 Modern projectile scars

While no modern projectile impacts have been identified at sites investigated over the course of this study, the subject of archaeological impact scarring from later conflicts and modern small-arms is discussed by authors elsewhere (Shiels, 2006, Mol and Gomez-Heras, 2018). Images of impact scars present on structures from military training sites in England from the Second World War show scars that are proportionally deeper within the inner scar and broadly more conical in appearance to those created by seventeenth century small-arms. This could be due to difference in both the shape and material of modern bullets from early modern lead bullets, and typically higher projectile velocities of modern firearms, however as these scars have only endured weathering for roughly a fifth of the timescale of those from the Civil Wars, it remains to be seen whether they would grow to more closely resemble early modern impact scars over a similar timescale.

As modern impact scars do not typically appear on siege sites of the Civil Wars in England, it has not been within the capacity of this study to pursue a detailed comparative assessment of the variation in form and shape between modern ballistic impact scars, and those recorded at seventeenth century siege sites. This issue might have greater importance in the examination of siege sites in continental Europe, where frequently sites of engagements from early modern sieges overlap with those of later civil and international conflicts arising in the twentieth century. In this regard a comparative study of the geometry of modern impacts may prove useful in identifying overlapping sets of scars on surviving contemporary structures at these sites, and a distinction to be made between modern and early modern archaeological scars within scar clusters should that be necessary.

5.3.4 Other small-arms impacts

In addition to small-arms impacts on stone surface, two other surface types on structures at siege sites have been identified as having been struck by bullets, specifically brick and timber. While it is highly probable that there would have been numerous structures built from these materials present at the majority of siege sites, the survival of contemporary timber-framed and brick structures is relatively low. Considering the risk of destruction by physical-battery and fire as a result of artillery bombardment or during an infantry assault, as well as the relative ease with which these structures can be completely demolished and rebuilt in comparison to stone castles and churches, it becomes all the more remarkable that evidence of these types survives at all for the Civil Wars.

5.3.4.1 Impacts on fired clay bricks

To date only a single site of brick-based impact scaring has been identified by the author at the siege site of Basing House, Wiltshire, on the associated garden walls and the adjacent Basing Grange barn. Though other examples may exist nationally, brick impacts are difficult to identify with certainty due to a combination of both the non-uniform appearance of individual bricks, and the irregular shape of impacts on brickwork.

For stone surfaces, the inner scar is a crucial feature to the positive identification of a mark as being an impact scar. Examples of clear inner scars on brickwork are less frequently observed, partially due to the smaller size of bricks in comparison to masonry blocks increasing the probability of fired bullets striking the mortar or the edge of a brick, rather than the centre. Those examples that do occur fully within a single brick retain the ellipse shape to the inner scar, though the internal base of the scar is more irregular and less smoothed than on worked stone examples (Figure 12). This may be a result of the properties of the impacted material, and the Basing examples at least partly match the scar texture of those observed at Carter House in Franklin, Tennessee (Foard and Morris, 2012, pp. 130). The other aspects to scars that might be identified, namely the spalling and radial fracturing, are much harder to identify on brick. If they are formed at all, identifying these where a scar has been located is problematic due both to the irregular surface of the medium, and the presence of naturally formed fracture-like cracks on that surface. Assessing impacts that occur on the edge or join of bricks is additionally difficult because of the transition of surface material running across the scar, but also because of the tendency for weak brick-edges to dislodge due to natural weathering processes. In this regard, it become impossible to be certain if a missing brick-face is a result of natural decay, or damage through bullet impacts.

Figure 12: Photography of an impact scar on a brick wall at Basing House, Wiltshire

An opportunity to positively identify brick impact sites may come in the form of X-ray Fluorescence scanning (XRF, discussed below) for surviving lead trace from the bullet fragmentation. While the surfaces of bricks are also susceptible to weathering, the irregular surface texture and greater resistance to loss of surface sediment as for most stone types used in English castle and churches may provide a refuge for small traces of the lead residue that is lost from stone impacts. Use of the transfer method for testing the presence of lead with Sodium Rhodizonate is less likely to work well in brick-based settings as any recesses that harbour lead residue are also likely to be difficult to contact with the transfer paper. If a study were able to identify lead trace on brickwork as a result of small-arms impacts, this would allow both a better identification of what brick-damage from small-arms fire looks like, but also provide a means of investigation for other contemporary brick structures at siege locations where bullet impacts have never been previously considered or identified.

5.3.4.2 Timber perforation impacts

The only other surface type observed to have been impacted by small-arms projectiles during this study was timber, predominantly church doors. Impacts observed on timber surfaces are penetrative rather than rebounding impacts, and do not follow the above form of scar formation. Rather these typically result in a hole on the outward-facing surface and, if the bullet penetrates the reverse side of the timber, produce splintered-spalling of the surface surrounding the exit hole. Though only a few examples have been observed at sites of Civil Wars sieges, some examples of timber penetration impacts are discussed below for how they might also add to the understanding past sieges.

Impacts on timber surfaces are infrequently observed at archaeological sites for a number of reasons. As identified above, there is a survival bias against timber-framed structures up to the present day, but further to this is that timber fittings, such as doors and door frames, are more easily and frequently replaces than surface stonework or bricks. For ruined structures, or those where extensive repair was undertaken after the conflict ended, the timber fittings are even less likely to survive than those in structures in a good state of repair. Nevertheless contemporary timber impacts have been identified at a number of siege sites.

Examples of timber bullet holes exist in the church doors of Hillesden Church, Buckinghamshire (Foard and Morris, 2012, pp. 131) and St. Mary's Church in Berkeley, Gloucestershire, as well as a number of small arms impact scars across the stone facings on both buildings. On the west-facing door at the latter site, the internal face of the door shows evidence of splintering where some of the bullets have passed through the internal face of the door, as well as the evidence for patched repair of a number of musket loops. Other sites known to feature bullet impacts in timber include the 'Siege House' in Colchester, Essex, where the surviving building bears numerous bullet impacts in the timber framework, presumably with the original bullets still embedded in the timber.

Despite their infrequent observation, the presence of bullet holes on associated timber at siege sites may prove particularly useful for investigating issues of angle and direction of impact for scars. The resistance of timber to weathering processes makes it an ideal candidate for XRF examination of the lead-wipe from the bullet passing through the material. Furthermore the nature of these impact as being partially or whole perforating should provide an impact hole that is measurable for angle and direction of impact using the trigonometric relationship between the width and length of the resulting hole (Ellipsis method, discussed below), and could potentially provide a greater amount of detail regarding the location from which impacting shots were fired than for impacts occurring on stone structures. While a detailed investigation of this form of evidence is beyond the scope of this study, further study of these bullet holes may prove incredibly fruitful for study of the siege actions for these specific sites.

5.3.5 Artillery Impact Scars

Though artillery impacts have been observed in limited frequency at a number of sites during this study, they are far less homogenous in appearance than those of small-arms scars. This is undoubtedly due to greater variation in the calibre of guns being used against garrisons of differing scales of significance, as well as variation in the types of bullet being fired by these weapons. In addition to the variability of scar appearances and sizes for artillery scars, the majority of impacts observed at sites occur at elevations beyond ease of access for detailed measurement or good quality imaging.

Of those scars that have been imaged, two types of projectile have been identified, loosely categorised as round shot impacts and hail shot impacts. Only a single potential instance of the latter has been examined on the eastern external wall of the church of St. John the Baptist in Devizes, Wiltshire, and is addressed directly below. For the former numerous individual and grouped examples or have been observed across sites in England of varying detail and quality, however the degree to which the variation between these is down to the surface properties of the stone is difficult to isolate. Observed instances occur in significantly different geographical locations where the building stone used is different between them, but the behaviour of stone surfaces under artillery impact is even less well understood than for small-arms impacts of the seventeenth century, and is unlikely to be developed further in the foreseeable future owing to the prohibitive risk and expense of rigorously testing ordinance against stone targets under experimental conditions.

One further point of consideration in artillery projectiles used in siege engagements of the early modern period is that of mortar rounds. Mortars were used in a number of siege engagements during the period, including Goodrich Castle where the only surviving example of a mortar made during the Civil Wars, specifically for the besieging of that castle, stands on display (Ashbee, 2005, pp. 43). During the examination of a number of sites, including Goodrich Castle, no artillery impacts were identified on surviving structures that could be attributed specifically to mortar fire, or not attributed to projectiles from other forms of ordnance. Further research and examination of sites with the known use of mortars against masonry targets may yield examples of artillery impact distinct in appearance or measured characteristics that indicate they were fired from a mortar rather than a gun, however this was beyond the capacity of this study to investigate in further detail. To avoid any assumption of the delivery method of large ordnance projectile scars observed at siege sites, these impacts are categorised together as single large projectile impact scars, or ‘round shot’ impacts.

5.3.5.1 Single large projectile impacts (round shot)

Impacts caused by a singular, large projectile were observed at nine sites visited during this study. These include a range of site sizes in terms of both area and garrison scale, such as the large city garrison at Chester, and the smaller castle garrison at Old Wardour Castle, Wiltshire. For the majority of impacts observed, there is no coherent scar as formed for small-arms impacts, and instead the impact site presents an area of broken or dislodged stone in the surrounding surface facing. This is most likely a reflection of the higher kinetic energy of artillery projectiles transferring enough impact force into the surface to fragment or cause failure of the wall structure at a larger scale. This is particularly notable on the surviving keep structure at Donnington Castle, Berkshire (Figure 13), on the ruins of Goodrich Castle, Herefordshire, and for the only identified artillery impacts on brickwork at the Grange building adjacent to Basing House, Hampshire (Figure 14). A difficulty with identifying these forms of impact is that is in not always clear where loss of surface masonry may be due to ordnance impacts, or may simply be a side effect of weathering and decay on ruined structures, and as such it would be difficult to identify artillery impacts of this nature without first knowing that artillery was indeed used offensively against a particular garrisoned site. An alternative confirmation of the damage as being the result of artillery might come in the recovery of projectiles or fragments from the siege action, however this in of itself does not necessarily prove a hole in a wall was the result of artillery.

Figure 13: Photograph of artillery damage at Donington Castle, Berkshire

Figure 14: Photograph of artillery impact on brickwork at Basing House, Wiltshire

Some artillery impacts form partial scars that bear some of the hallmarks of an impact, yet also result in loss of much of the impacted surface and the area immediately behind the impact point due to the destructive force of the projectile. Scars observed at the privately-owned ruins of Biddulph Old Hall, Staffordshire, show signs of radial fracturing and some signs of edge spalling, while on the attached residence on the northern side several impacts have been partially repaired in the centre of the resulting impact scar. One of these repairs involved the extraction of an embedded projectile currently held at the Congleton Museum, which together with recovered projectile fragments from the private gardens indicates that these impacts were caused by solid-iron round shot. The sole artillery impact on the church of St. Bartholomew in Tong, Shropshire (Figure 15), is largely similar in appearance to those at Biddulph, although the scar is mostly complete and presents all the key elements identified for small-arms impact as described above. A key characteristic difference between this impact and those of the small-arms scars is the rough fracturing at the back of the scar, suggesting that the formation process of the inner-scar was one of fracturing and dislodging of the material, rather than pulverisation or weathering of the struck surface. It is likely that his reflects the difference between iron and lead projectiles, as where lead easily distorts and deforms on impact, iron would appear to be more resilient upon impact with stone. The only artillery round shot impact identified that is unlikely to be iron due to both its size and form is located on the gatehouse-face of the keep at Old Wardour Castle. Here again the impact scar bears all of the features of a small-arms impact, however unlike the impact at Tong, this scar has a smooth interior of the inner-scar, which suggests the formation process for this scar is largely similar to that for entirely lead projectiles.

Figure 15: Photograph of an artillery round shot impact at Tong church, Shropshire

It may be possible for impacts from round shot to yield clues as to the calibre of the impacting projectile. For these types of scars where the majority of the inner scar or spalling is visible, a simple measurement of the diameter of the impact provides at the very least an upper limit for the size of the projectile. Using calibre values for ordinance given by Bull (2008, pp. 173-174), the upper gun calibre for the Tong impact would likely be a culverin or smaller (scar diameter of approx. 13cm (5in)), while the Old Wardour impact implies a smaller gun of falcon or falconet calibre (scar diameter of approx. 6-7cm (2.5in)). An example of an embedded projectile from Biddulph might allow for the relationship between scar size and projectile calibre for iron round shot, however as the ball and part of the scar were removed from the context of the wall, it would be difficult to identify this relationship without being able to identify the exact location from which this was removed. Measurements of the curvature of another round shot fragment recovered during gardening at the same site produced a projectile diameter of at least 9cm (3.5in), suggesting that an ordnance piece of at least saker calibre was in use during one of the sieges of that garrison (Bull, 2008). However in order to use this information in an interpretation of the impacts on the surviving wall surfaces at Biddulph, a greater understanding of the relationship between projectile calibre and scar size for artillery projectiles would be necessary.

5.3.5.2 Multiple-projectile impacts (hail shot)

Artillery hail shot projectile impacts on structures are by their nature unlikely to have occurred often, as this type of ordinance was typically deployed in defensive context on battlefields or by garrisons against an approaching target of massed infantry or cavalry (Allsop and Foard, 2008, pp. 111). The only example of impact scarring that has been attributed to artillery hail shot on a structure is from St John the Baptist’s Church in Devizes, Wiltshire (Foard and Morris, 2012, pp. 133). In this particular instance a group of twenty-four impact scars and a further four probable-impacts have been identified on a section of wall with a maximum horizontal spread of nearly 2m and vertical spread of 1.3m (Figure 16).

Figure 16: Photograph of possible hail shot impacts on St. John's church, Devizes, Wiltshire

As hail shot typically comprised of a wooden canister or canvas bag of lead musket balls fired from an ordinance piece, the expectation for impact scars formed by these would be principally the same as for those from small-arms impacts. The scars observed at Devizes largely match this expectation, with the exceptions that they appear to penetrate deeper into the surface stone than scars identified elsewhere on the structure, as well as showing more prominent spalling and a greater frequency of radial fractures. This may indicate a greater impact energy in the instances of these scars from other impacts identified at this site, however this is not necessarily indicative fire from an artillery piece over the possibility of muskets fired from short range. Unfortunately no reliable data source for muzzle velocity of hail shot projectiles for seventeenth century artillery has been identified from which to base an assumption of greater impact energy for these bullets, or to determine whether there is a cross-over between the probable range of impact energies for musket projectiles as for hail shot (Allsop and Foard, 2008, pp. 121).

The low quantity and spread of the impacts is inconclusive in identifying these as hail shot impacts. Within the grouping there are only twenty-four discernible impacts, a lower quantity than might be expected of an artillery piece discharging hail shot. It is possible that the low frequency may reflect impacts against the intended target, effectively intercepting the bullet before it can create an impact scar. Given the urban context the chance that part of the discharge was received by another structure that is no longer extant also should be considered. Furthermore it is likely that a number of impacts from hail shot would occur as fused bullets, where the lead bullets effectively weld together as a result of the heat and pressure discharging of the gun. These have been found archaeologically in battlefield contexts, and observed as a result of experimental firing (Foard, 2012, pp. 90), though the influence on the scar shape as a result of being impacts by fused hail shot bullets is unknown.

It is unlikely that the low frequency of observed impact scars could be due to bullets striking the surface but leaving no scar as the scars in question are easily discernible and largely uniform in appearance, suggesting that there is little relative variation in the impact energies of those impacts that did form scars, and there is no reason to suspect the range of muzzle velocities for these projectiles would include individuals with sufficiently low kinetic energy to strike the surface without causing scarring. The height of the centre of the spread at approximately 2.2m above ground level, with the lowest 'possible scar' at 1.3m above ground gives reason to presume that few, if any of the bullets deflected so far as to strike the ground first or to miss the structure entirely. The total horizontal spread of 2m is particularly tight, as figures quoted for nineteenth century experiments indicate that even at as little as 35m down range from the muzzle, the maximum horizontal spread reaches out up to 4m (Allsop and Foard, 2008, pp. 123), though this data is not necessarily representative of all ordinance calibres. If the scars do reflect the full spread of shot for an artillery piece this would place the gun well within the present-day grounds of the church from the main road and in a precarious position for either defence or attack given the proximity to the fortified site, yet apparently being fired towards the same.

The evidence to attribute these impacts as hail shot scars is limited based on the assessment above and is dependent largely on the enhanced appearance of the scar. As study of scar-formation processes develops, the evidence may indicate that these are indeed hail shot scars rather than small-arms impacts. However present understanding is insufficient to take that conclusion based on the form of the scars alone, and the supporting evidence of spread and density is not distinct from scar distributions observed at other locations where they are almost certainly the result of small-arms fire.

5.4 Forensic approaches to impact scar investigation

There are a number of similarities between attempting to study bullet impact scars for shot-reconstruction, and the investigation of bullet marks at crime scenes for forensic reconstruction of shooting incidents. Both approaches are attempting to use physical evidence to make a statement about events that took place in the past, and decipher the variables of the shot that created an impact mark, such as the location from which the shot was fired, the bullet size or firearm type, the intended target and target location in relation to the impacted surface, and the final resting position of the bullet or resulting fragments.

The obvious difference between both instances of investigation is the issue of timescale. Forensic investigation generally takes place within hours or days of an incident and relies on much of the evidence of the shooting being in situ at the location. By contrast impact scars from the Civil Wars in England are over three and a half centuries in age, and as such the degree of change in the surrounding landscape and to impacted surface is typically much greater than that for a crime scene. The practical problems of the time interval between the fired shot and study of the impact location at archaeological sites are the cumulative effect of weathering on the impacted surface, corrosion or decay of the bullet fragments, changes to the surrounding land use, and the loss of data to removal of material through past excavations, or in some instances looting of artefacts from archaeological sites.

In translating forensic ballistics to archaeological examples there is an additional hurdle to overcome in the firearm technology itself. While forensic investigation can rely to varying degrees on standardisation of weapons and ammunition for mass production when reconstruction of a shooting incident, those used in the seventeenth century as discussed above are less consistent in manufacturing tolerances and processes. This results in variable performance for elements such as muzzle velocity and the ballistic performance of the bullet, elements that would be vital in any attempt at an accurate reconstruction. The practical upshot of this is that forensic literature for understanding the ballistic behaviour of bullets focuses on modern firearms and projectiles, particularly those available in the domestic market in the USA. Forensic science studies of impact processes are also largely limited to those surfaces expected to be found in a typical crime scene in North America, such as plasterboard, glass, sheet metal and concrete, which are all significantly different to stone in composition and material properties. Datasets for smoothbore black-powder weapons firing near-spherical lead bullets against stone targets are therefore lacking in quantity due to their limited practical forensic application. An examination of existing forensic literature relating to bullet impacts is necessary therefore to establish to what extent the underlying principles of investigation can be applied directly to archaeological impact scars, or can be drawn upon to identify alternative approaches to this analysis.

5.4.1 Identifying variables from impact evidence

As outlined above, the key impact variables for identifying the origin of a shot are the impact velocity and angle of impact of the bullet. In addition to these, a third variable is also likely to influence the formation of a scar, namely the size of the bullet. The mass of the bullet relates directly to the volume of the projectile and the density of the material from which it is made (predominantly lead). The kinetic energy of the impacting bullet is proportional to the velocity and mass of the bullet, therefore in order to determine impact velocity from a scar, the energy released and the size of the bullet need to be determined.

Examining the impact angle and direction of a bullet forming an impact scar has a number of potential approaches derived from forensic investigation of non-orthogonal impacts, and these are presented below. For the question of impact energy or bullet size there are insufficient studies or data sets available for impacts on stone targets, or for the relationship between impact mark features and the impact characteristics of the bullet, to allow attempts at analysis of these variables. This issue will therefore need to be approached by developing a thorough understanding the impact processes for a bullet striking a frangible stone surface to identify which features are most likely to be significantly determined by impact energy or bullet size variables.

5.4.2 Determining direction and angle of impact

There are two methods of approach to determining the direction of travel for a bullet impact that could be used for archaeological impact scars. The first of these is by means of a physical measurement of the 3D profile of an impact scar relating to its depth and elongation. The second is by means of trace analysis of the result lead-splash in the direction of travel of the bullet as a result of deformation and fragmentation upon impact.

The issue of angle of impact for a rebounding impact has no directly relatable study for assessment in relation to stone or other frangible surfaces. In lieu of a suitable approach the methodology for examining angle of impact in perforating impacts, i.e. bullet holes passing through sheet materials such as aluminium or plaster board, will be examined below with an aim to adapting these principles for the scar shape as a result of impact angle.

5.4.2.1 Direction of impact – scar geometry

Where an homogenous, frangible surface (such as sandstone block) is struck by a bullet it will behave in one of two ways: it will ricochet, or it will penetrate (Haag, 2005, pp. 119).This behaviour is dependent on whether or not the failure point of the impacted surface material has been reached (Haag, 2005, pp. 128). If this point has not been reached, the surface will behave as an unyielding material and the bullet will ricochet without breaking the surface. If this point is reached or exceeded, the surface will pulverise in relation to the direction of the bullet and angle of incidence. The failure point is dependent on both a number of factors such as the type and hardness of the stone, the material from which the bullet is made and the shape of the projectile. The bullet itself will only ricochet or rebound if impacting at an angle below the 'critical angle' for a given impact. If the impact angle is above this value i.e. closer to perpendicular than the critical angle, it will either fragment, or penetrate the impacted material (Haag, 2005, pp. 119).

The deepest point of pulverisation on impact occurs immediately below the surface point of impact of the bullet. The progression of the bullet beyond initial contact will pulverise surface material in the direction of travel away from the point of impact, with perpendicular impacts therefore creating a symmetrical impact scar (Haag, 2005, pp. 128). The offset relationship between the deepest point of the scar's penetration into the surface material and its overall centre directly reflects the direction of travel of the projectile. This means that through careful measurement of the depth of a scar across numerous axes, it might be possible to determine the general direction from which the round was fired.

The accuracy of identifying this through measurement is dependent on the influence of weathering on the surface in question between the time of the impact and the present day. If weathering has acted in a directional manner due to prevailing wind direction or stone weakness for example, it is possible that the geometry of the scar will have been altered sufficiently to make directional assessment more problematic. Nevertheless as the difference between the centre and deepest point are not being compared for a proportional relationship in this approach, unless weathering acts to significantly alter the asymmetry of a scar, this should not impact the ability to determine overall direction.

5.4.2.2 Direction of impact – lead trace

An alternative approach for establishing direction of impact is in testing for the presence of lead transfer onto the impacted surface. As a lead bullet deforms on impact with a solid object, lead is transferred from the surface of the bullet to the target at the point of impact. In addition to this surface transfer, droplets of molten surface lead are 'splashed' across the surface of the impacted object down-range of the impact site (Haag, 2005, pp. 137). The presence of lead is used in crime scene investigation to assess whether a mark or hole has been caused by a bullet, and can be tested for using either chemical tests or X-ray fluorescence.

Chemical testing for the presence of lead involves the use of Sodium Rhodizonate, which leaves a purple-blue residue upon contact with lead (Haag, 2005, pp. 54-57). The test involves coating plastic-backed transfer paper with a buffer solution, and then pressing this into the surface to transfer any surface lead on to the paper, before spraying with the reagent to produce the staining result. This test is partially destructive as it requires the transfer of lead from the tested surface on to the transfer paper, however this does provide a 2D record of the lead distribution from a surface that can be taken away for further analysis off-site.

An alternative approach to this is the use of X-ray fluorescence, which relies on the secondary emission of X-rays from a target material being bombarded with high energy X-rays. The X-ray frequencies emitted by the target correspond to the presence of specific atomic nuclei, with each element having its own signature frequency. While more sensitive at identifying the presence of potentially miniscule amounts of lead, this method is limited in that it cannot (at present) produce a distribution map of the location of the detected lead trace. XRF also has a practical limitation for use in that it requires specialist equipment and an operator with a suitable licence for its use in a public environment due to containing a radiological source of X-rays.

Both of these methods for detecting lead residue are likely to be hampered by the exposure of a scar to weathering. Although lead does not naturally dissolve into the environment (Haag, n.d.), as the surface of a scar is weathered and the surrounding block surface erodes, this loss carries away the surviving lead residue. Lead splash has been recorded at locations where it has survived at least 140 years in sheltered conditions, as scars from the inside of the Skeleton Cave skirmish site in the Arizona Desert returned a positive test when examined using the Sodium Rhodizonate transfer method (Haag, n.d.). However weathering-exposed scars in the same desert conditions from Big Dry Wash tested negative using the same method, despite the recovery of an impacted projectile believed to be the cause of a scar (Haag, n.d.).

It is unlikely therefore that scars exposed to typical weather patterns for the United Kingdom for over three and a half centuries will produce a positive result for trace lead. Nevertheless it may be possible to test scars from this period where bullets have impacted in relatively sheltered locations. Very few promising examples have been identified during site inspections as part of this study. The most obvious example was at St. Bartholomew’s Church, Tong where at least one bullet has passed through the window and an arch more than five meters above floor level. Proper testing this scar would require the presence of scaffolding for access and is beyond the means of this study. Furthermore the shaped surface upon which it occurs would reduce the potential usefulness of examining this scar as means to link cross-sectional profile shape together with possible angle and direction of impact.

The use of NaRh or XRF testing might have a more successful application in positively identifying suspected impact holes in timber surfaces as bullet impacts as lead trace present on these surfaces, if left untreated or painted, would be less susceptible to loss through surface erosion when compared with sedimentary stone. However due to the limited potential for application at examined sites, the lead-trace method for determining direction of impact scars on stone surfaces has not been pursued by this study.

5.4.2.3 Angle of impact – ellipsis method

Measurement methodology using the dimensions of a perforating impact to determine angle of impact may be adaptable in a limited manner for rebounding impacts on stone surfaces. Wong and Jacobson (2013) demonstrated that the same method used for determining the angle of impact for a blood droplet i.e. using the difference between the length and width of an ellipsoid perforation to calculate the angle at which an object with a circular cross-section has passed through a flat surface. The ellipse formed through this type of impact extends along the direction of travel, and the trigonometric relationship between the width across the narrowest point, and the length from one end of the ellipse to the narrowest width provides a value for the angle of incidence of the bullet.

While this method could be applied directly to the investigation of perforating bullet impacts on timber surfaces, such as church doors and timber framed buildings, use of this method for archaeological impact scars on masonry surfaces carries a number of problems. The most significant detractor for this approach is that impacts on walls do not create a perforation, but rather result in rebound or ricochet marks on the surface. Another problem to overcome is that the resulting scar is created partially through the deformation of the bullet upon impact, particularly in the instance of the displacement of the spalling from the scar edge. As such the bullet is unlikely to maintain a neat circular cross-sectional shape throughout the impact process and is unlikely to produce a simple relationship between the resulting scar dimensions and those of the bullet.

5.4.2.4 Adapting the ellipsoid method

What is clear from Haag (2005) is that for ricochet impacts the resulting impact mark is elongated in the direction of travel and presents its deepest point at the point of original contact. However for orthogonal impacts the deepest point and the centre of the scar are effectively very closely positioned, suggesting that as the impact angle moves away from the orthogonal, the offset between the deepest point and the overall scar centre increases, with the overall scar centre moving down the length of the scar in the direction of the bullet impact. If a relationship between the angle of impact and the degree of offset/elongation of the resulting scar can be determined, this would allow assessment of the angle of impact for a scar using the cross-sectional profile as the measurement approach.

This hypothesis would require test firing muskets against stone impact targets at multiple angles of incidence to assess whether this relationship is quantifiable as a ratio between centre-offset of the resulting scar shape and impact angle. Furthermore testing this relationship would require producing impacts across multiple stone types to determine to what extent any identified trend is relatable to surfaces with properties that may behave differently under angled-impact. It is possible that while such a relationship exists for all stone types, the variation in that relationship between different surfaces may prevent simple application of a scar model across multiple sites for interpretation. While ballistic experimentation of this degree of repetition and intensity is not within the resources of this study to achieve, a simple recording of a range of archaeological scars at sites, limited to a single stone type at each of these sites, would determine if there is sufficient variation of archaeological scar profiles to warrant further investigation.

5.4.3 Determining impact energy and bullet size/mass

In order to begin unravelling the matter of bullet mass and impact velocity, the question over which scar features are directly related to the impact energy released by the bullet, and which may be dependent on other factors. Observation of impacts scars suggests that the deeper an archaeological scar penetrates into a stone surface, the wider the overall scar diameter (including the spalled area) will be. This leads to a supposition that for a site with a homogenous stone type used in its construction, variation in the depth scars are the result principally of greater momentum of the bullet, either due to increased impact velocity compared with other scars, or a larger bullet mass.

The factors relating to the formation of the spalled material are still unclear and largely depend on what exactly occurs when the bullet strikes the surface. If the bullet pulverises the surface material and penetrates into the surface before it begins to deform fully, then the expelled material in the spalling area will largely be the result of lateral-displacement by the deforming bullet pushing outwards. If this is accurate, then the volume of the bullet, as well as the speed of deformation is likely to play a significant role in the total expelled volume. If the spalling is the result of surface fracturing and displacement of the pulverised stone at the point of surface impact by the bullet, then fracturing due to the release of kinetic energy on impact as well as the greater volume of expelled pulverised stone in the centre of the impact point will dislodge this material rather than this being done principally by the deforming bullet

If then a correlation exists between the total depth of the scar (as a result of kinetic energy release) and total diameter of the scar including the spalled area for a single stone surface type, then this relationship is a result of the impact energy factor, and can eliminate the surface properties as being the key factor in the depth of an impact scar. If this is the case then an increase in scar surface penetration should correlate with an increase in the total scar diameter, the mean depth of the spalled area, and the diameter of the inner scar from around which the spalling is ejected.
If on the other hand there is not direct correlation, it can be reasoned that the factors determining the characteristics of the spalled area are different from those governing the overall depth of the scar. Examining this relationship, and the relationship to the dimensions of the inner scar, will be a principal goal of analysis of data collected from recording impact scars.

5.5 Developing a recording methodology for scar geometry

The principal goal of establishing a methodology for recording scars in this study is to create a simple dataset from which further analysis of the geometry of a scar can be undertaken. This dataset needs to allow for a fair comparison of the measured values for scar features between different impact scars across a single site, and across multiple locations. To this end the method of recording utilised must allow reproducible measurement of the scars features from the record, as well as a standardised methodology for measuring the internal proportions of the impact scar.

There are also practical considerations for recording that need to be considered at siege sites. The ground immediately below the walls of castles and ruined buildings are seldom level to any great extent, which is likely to hinder access to recording scars. As well as minimising risk while recording, the method of recording itself needs to be practicable within the context of site access and resources, as many ruined structures at siege sites have limited access to amenities. Finally the recording process must be able to be undertaken in a reasonable timescale for the quality and quantity of data collected for individual scars, as recording multiples scars across a site is likely to require significant time commitments for fieldwork for little data gain if the process is too time consuming.

Two approaches to recording impact scars were considered for use within this study for the purpose of measuring the three-dimensional features of scars; one direct method of scar measurement (laser scanning), and one indirect method (contour tracing). Each is discussed below as to their relative merits and shortcomings for use in recording scars.

A third option of casting the scars using a quick-setting epoxy-putty and subsequently returning the physical casts for laser scanning was also considered for the recording method. For use on archaeological scars to create a suitably detailed caste, the putty would need to sufficiently adhere to the upright surface and internal face of the scar for long enough to cure. During lab-based tests on non-archaeological stone, the most effective for recovering high-quality detail whilst remaining durable after removal was Otoform KC, a silicone-based putty used in for moulding in medical contexts. However the removal of the putty from the indentation was accompanied by surface-grain loss of the stone, as well as producing a visible colouration where the red hardening agent had bled into the porous stone surface. The risk of accelerating or exacerbating the surface wear of the internal face of the scar, and the potential defacing of the archaeology as a by-product of recording process were deemed unsatisfactory risks for a passive recording of the impact evidence. Alternative casting putties may be better suited to this task, however this recording option was not pursued beyond the lab testing stage.

5.5.1 Measurement objectives

For each impact scar a number of key measurements are being sought in order to build an understanding of the morphology of scars, and to develop the analytical study of impact scars. The features outlined below relate to the observed features of archaeological scar as discussed above, as well as aspects of their three-dimensional shape that cannot be assessed through orthogonal photography. It is from the geometric properties of the scar that we are most likely to begin building an understanding of how variation between scars relates to the impact variables that led to their formation. The recording methods trialled for this study would need to allow for relatively straightforward measurement of these features.

5.5.1.1 Mean surface level (L)

The mean surface level is the plane from which scar penetration into the surface will be determined. As exposed archaeological surfaces have undergone some degree of surface loss due to weathering since the Civil Wars, this is will not be an estimation of the contemporary surface of the stone block at the time of impact, but a value attributed to the present surface level. The recording methodology should also allow for the identification of the orientation of this plane in relation to the overall site and the surrounding landscape, as the relative angle of the surface to the surrounding landscape may have ramifications for interpreting scar shape from likely direction of impact. Future development of macro-recording strategies for entire surfaces or groups of scars may utilise a common datum-plane for this measurement, however recording methods required an individual scar focus for recording and assessment of this value.

5.5.1.2 Surface penetration (D)

This is the depth of the penetration of the scar into the surface of the stone, measured in relation to the mean level of the present surface. Where partial surface loss has occurred around the impact, the area of surviving surface will be used as the reference point on that axis, though if this is not available to for measurement, the weather exposed surface will be used with a note for future analysis.

5.5.1.3 Total scar diameter (ØT)

This is the total diameter of the scar where it penetrates below the mean surface level across the measurement axis, up to the outer edge of any edge-spalling that surrounds the inner scar.

5.5.1.4 Inner scar diameter (ØI)

This measurement is of the diameter internal face of the scar. Establishing the exact limits of the inner scar is not possible due to a combination of weathering and the intrusion of the spalling depth into the feature removing any upper edges this may previously have possessed. This measurement was initial taken from a fixed point 5mm in front of the furthest penetration of the scar into the wall surface, however it soon became clear that this was not consistent in terms of proportion for shallower scars, and for those of 6mm overall depth or less, this was essentially guaranteed to include elements of the spalling.

The point of measurement was changed to examine the diameter at a range of depth values dependent on the overall depth of penetration of the scar, discussed below in section 5.6.2, before being fixed at the two-thirds depth value as a compromise between consistency between scars, and reliability of measurement.

5.5.1.5 Spalling width (A-As, and B-Bs)

This is the width of the spalled portion of the cross-sectional profile across a given axis. This is measured separately for both sides of the impact scar by recording the distance from the scar edge (A or B) to the inward edge of the spalled area (As or Bs), unless spalling is not apparent for the scar or is not present due to some other loss of the upper portion of the impacted surface. The inward edge of the spalled area is denoted by the point along the scar profile where the surface level begins to turn towards the horizontal from the concave curve of the inner scar.

5.5.1.6 Depth of spalling inner-edge (As and Bs)

This is the depth of penetration for the inner edge of the spalling area surrounding the scar, and as with spalling width, is measured separately for each side, using the mean surface level as the reference point for how deep these enter into the scar.

5.5.1.7 Deepest point diameter (DØ)

This is the point of greatest penetration into the impacted surface within the internal shape of the scar. As the base of inner scars is typically smoothed or rounded, assessing this as a point-location is difficult to do accurately, and minor variations in the granular surface of the stone may influence the identification of this disproportionately. To combat limited variation in this measurement, the deepest point will be measured as an area within the base of the scar, the centre of which will be used to examine the off-set of the deepest point from the overall centre of the total diameter.

5.5.2 Methods of Recording

As discussed above, two approaches to recording scar profiles for measurement were considered during this study to assess their suitability for on-site application as well as the overall quality of the data collected.

5.5.2.1 Laser Scanning

Laser scanning is becoming more widely utilised tool in archaeology as the technology improves, and has been used to record engraved and carved stonework exposed to weathering for their fine-relief. The principle uses reflected laser pulses to record the distance between the laser source and the recorded object with high precision, and repeats this over an area to create a three-dimensional point-cloud digital model that can then be analysed and stored electronically.

Laser scanning provides three key advantages over other methods of measurement. The first is that the recording is taken directly from measuring the surface of the scar, thus reducing the degree of potential error in taking analytical measurements from a transposed recording of the original profile measurement as is entailed by the contour gauge method discussed below. The second is that it can record the whole scar in a single measurement and produces a digital model that could be stored indefinitely to compare against other scars or to assess long term changes in the shape due to weathering in fine detail. The final advantage is that this method requires no physical contact with the scar for recording, which for surfaces vulnerable to abrasion and surface erosion as a result of weathering is advantageous as it does not pose any additional risk to the continued survival of the scars through contact.

Despite these advantages laser scanning was not undertaken for recording scars for this study for several reasons. While field scanning units have undoubtedly improved in recent years, at the outset of this research the scanning equipment made available for use was not practical for on-site deployment. The NextEngine scanner was designed for indoor desktop recording of small objects in rotation, or single surfaces, and requires an AC power supply and connection to a computer to operate the unit. The scanning process itself requires both the unit and the surface to be completely steady, and the scanner to be positioned within 30cm of the target surface. The unit is also not weather-proof and susceptible to interference if used in direct sunlight.

The practical issue of placing the scanner in a stable, sheltered location close enough to archaeological scars made the use of this unit for most sites an unworkable proposition, largely as with any tripod mount, the higher the unit is required to be placed, the broader the footprint of the support needs to be to ensure stability, thus placing it too far from the target surface. An unpublished trial field-recording by Amanda Wynne at Holmes Chapel, Cheshire, managed to overcome some of the practical issues by utilising a site with good ground support, low-level scars and an easily accessed AC power supply from within the building (a feature not readily available at most ruined castles). The scans frequently featured data-holes in the 3D mesh-file created by the scanner, requiring a repeat scan where this occurred. In total each scan of a single scar, not including repeat scans, required between 15-20 minutes to produce a detailed digital model for analytical use in ideal outdoor circumstances. From the results of this trial and the logistical considerations for the use of this unit at potential study sites, it was decided that laser scanning could not be carried out cost-effectively within this project.

For future recording and analytical studies of impact scars, the use of a practical outdoor laser scanner is both advantageous and advisable for data collection and retention, particularly where preservation of scars is at risk due to weathering loss or structural decay. Scanned records could be used to make precision measurements of the extent and concentrations of surface loss within the scar over time, or to create a detailed, permanent digital records of impact scars for future assessment in lieu of their ability to be protected from decay. Coupled with 3D printing digital records could also allow a physical copy of the scar to be produced should the need for a practical, portable model/representation be required for educational or presentational needs.

5.5.2.2 Contour Gauge

The alternative method of recording scar profiles to that of laser scanning was to use a contour gauge to physically trace the relief of the scar across a number of axes. Once the pins of the gauge have been pushed to fill the profile of the cross-section, the shape is traced on to 1mm graph paper to allow simple measurement of each axis recorded. The contour gauge used in this study is a 150mm gauge consisting of 185 steel pins of 0.8mm each in diameter. This gives a profile recording area of 0.8mm x 148mm total, which in practice is large enough to span almost every coherent small-arms scar observed on archaeological sites. Though the pins provide a lower-resolution profile trace compared with laser scanning, for creating a large initial dataset in a short timescale at low cost for exploratory analysis the detail-level captured this method produces a sufficient level of fidelity and accuracy to the measured scar for establishing relationships and trends in the features of the impact scars under investigation.

The contour gauge provides only an indirect record of the scar from the pressed-pins. While the profile marked out by the pins is as faithful as possible to the profile of the scar that resolution will allow, the pin-profile-shape cannot be maintained if multiple-impressions are to be taken with the gauge, and thus requires copying onto another medium. This introduces an additional opportunity for error as the translation will inevitably differ, at least by a tiny fraction, from the shape marked out by the pins.

After considering alternative recording methods, including pressing the pins sideways into putty, or photographing the pins against graph paper, it was considered that tracing the edge profile with a fine pencil onto graph paper would be the most practicable method of recording the pins to allow later assessment, and ensure simplicity and ease of record-management for field recording purposes. To minimise the degree of error created in the tracing, the pins of the contour gauge are made to rest flat against the paper by use of a support-frame underneath the recording sheet (Figure 17), as any angular difference between the pins and the paper reduces the relative depth of the recorded profile compared with the original scar. Use of a sharpened pencil at an angle so that one side of the graphite is flush to the base of the pins when pressed to the paper ensures the pencil-trace remains as faithful to the contour-gauge record as feasibly possible.

Figure 17: Photograph of a profile-pressed contour gauge positioned against the recording sheet within a supporting frame

To provide a sufficient amount of data to assess scar shape for direction and angle of impact evidence within the data, and to create a more complete data set for elements such as mean diameter of the scars, four measurements were taken per scar: the horizontal axis, the vertical axis, and each of the diagonal axes. It was quickly identified that to provide a reliable and comparable set of recordings, a template would be required to ensure the recording process was identical for each scar, and that the measurements were each taken at the correct angles. Figure 18 shows a scar recording frame utilised for this study, designed by the author and produced by Stephen Calcutt at the University of Huddersfield in laser-cut acrylic. A small spirit level was added to assist in setting the frame horizontally against the wall surface.

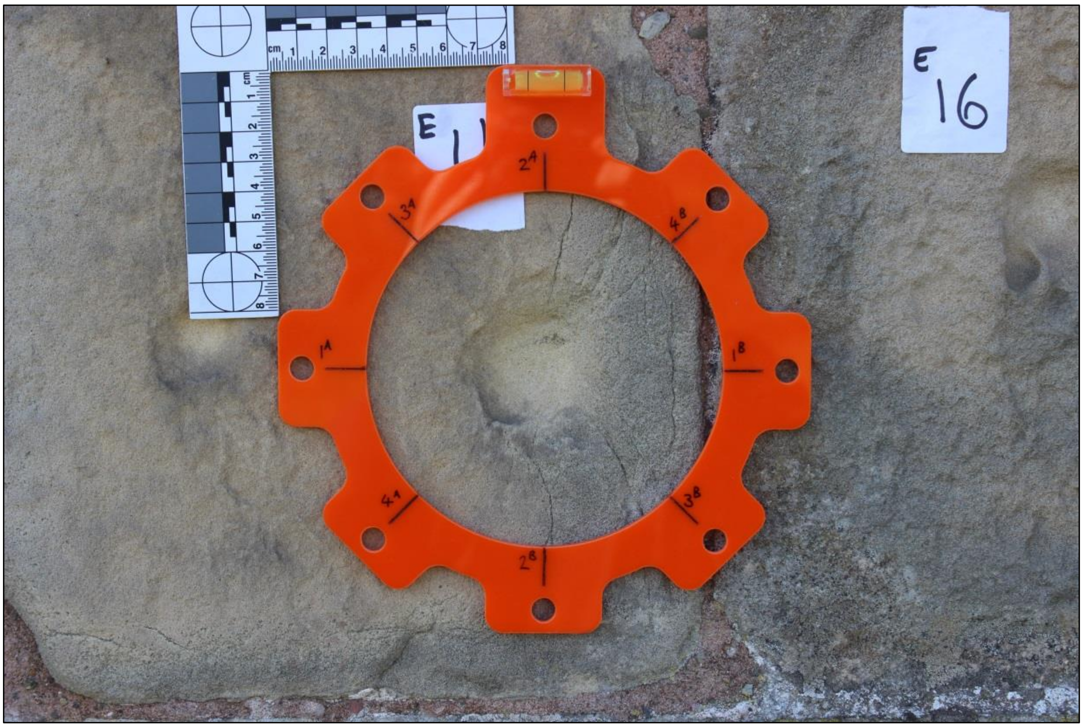

Figure 18: Photograph of a scar recording frame in use at Moreton Corbet Castle

5.5.3 Scar recording process

For each recorded scar, an initial set of photographs is taken before recording, including a ‘macro’ image of the scars in context of the wider structure and wall surface, complete with labels, forensic scale and level staff so that height and relative position on the wall are recorded for each scar. The recording frame is then aligned visually placing the approximate centre of the scar within the centre of the frame, whilst using the attached spirit-level to ensure the axes are aligned consistently across all recordings. The frame is then adhered to the surface using a small quantity of blue adhesive tack to hold it to the wall, attaching this only on parts where the surface is not at risk of becoming damaged or detached. For each scar a close-up image is then taken with the frame, a photographic scale, and the scar label in situ, so that trace records can be related back to the visible scar as required.

Each axis on the frame is then recorded following a numerical order (Figure 18), with the labelled ends of the contour gauge matching up with the letters marked on the frame to ensure that the profile gauge maintains the same orientation for each axis between recording and tracing and avoid confusion once the gauge is removed from the wall. On the recording sheet the scar number is written down at the top of the page, with the digital image file number at the base. Each axis-measurement is labelled to indicate which axis is shown, with the location of side “A” on the gauge noted above the trace on the recording sheet such that, if a recording is unintentionally inverted during the tracing process, it can be corrected by adjusting the labelling rather than requiring a re-tracing of the profile. An example excerpt from a recording sheet is shown in Figure 19 with data entry annotations made during post-recording analysis.

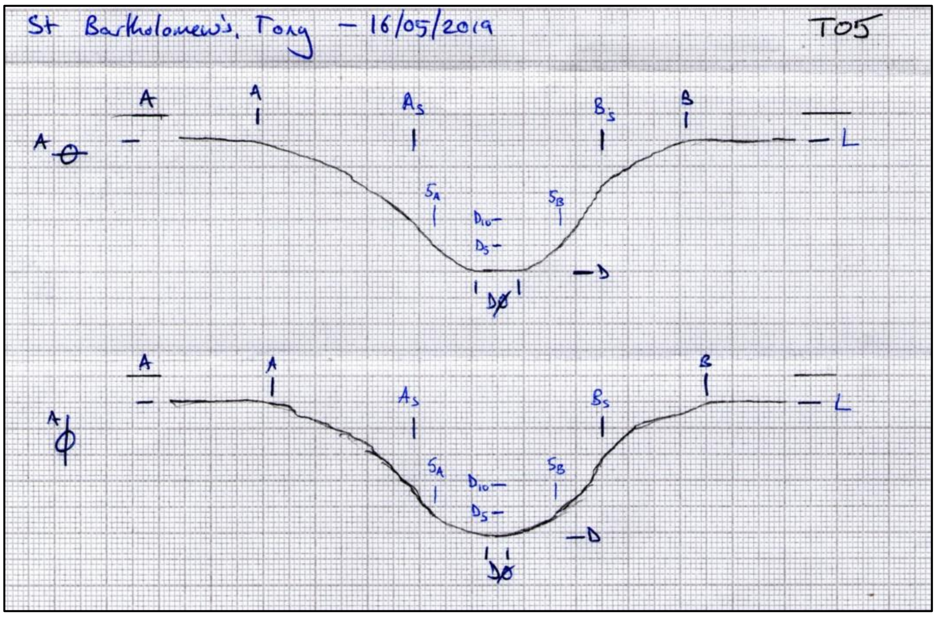

Figure 19: Image of an annotated recording sheet after analysis of the scar features

Once a record sheet is completed the data can be collected from the transposed profiles for each measurement as required. The record sheet is annotated to show the points from which each measurement has been taken for the aspects being recorded. Measured values are typically rounded to the nearest whole millimetre, with measurements taken from the upwards edge of the pencil line to reduce exaggeration of measurement values as a result of the recording method. Once input into the database, the data is ready for assessment.

After the initial set-up of scar number stickers, recording table, and wide-angle photographs the process to place the recording frame, photograph the individual scar, press the gauge and trace the profile four times, annotate the sheet and reposition the frame (and occasionally ladder) for the next scar was timed by the author at 10-12 minutes. This time was further reduced to an average of 6 minutes per scar when supported by a second archaeologist, as this allowed tasks such as moving the folding-table used for recording along to the next scar, repositioning and annotating the recording sheet between traces and managing completed sheets after each recording set, and where weather required such, sheltering of the recording table with an umbrella. Compared to the NextEngine scanner this is an increased productivity rate over three times as fast (without accounting for re-scans), and without having to overcome accessibility hurdles for the set-up of an AC power supply for the scanner, connecting and positioning an operating laptop, stable placement of the scanner in proximity to the scar for recording, and shelter for the scanner to prevent wind-induced wobbling or sunlight interference. This recording methodology by contrast allows rapid, repeatable recording of scar profiles at a low-cost entry point and low-tech support infrastructure, making this both practical for individual researchers, and to groups or organisations without resources to invest in the option of laser scanning.

5.6 Examination of impact scar geometry

With a methodology for recording scar geometry established, the next step was to apply this to recording scars across a number of sites. Though past studies have identified the presence of impact scars at siege sites, a systematic recording of scars for their size and three-dimensional geometry has never been undertaken for a group of impacts at a single site, nor in a comparative manner across multiple sites. This section will compare data drawn from a sample of impact scars across three fortified sites that were besieged at various times during the Civil Wars.

Observation of scars across multiple sites indicates that scars typically vary in size, but that the internal shape and features of the scar are visually proportional to some degree. Through cross-sectional profile measurement of the scars, this degree of proportionality, as well as the spread of values for scar size and shape can be examined statistically for their distribution and correlations in the data. It was also the goal of this analysis to identify elements of the scar profile that could be indicators of specific impact variables that could then be identified or quantified through ballistics experiments.

5.6.1 Scar data sample set

Ten scars were selected for measurement at three separate siege sites to produce an initial comparative dataset of thirty impact scars for analysis. The scars at each site were measured using the contour gauge method outline above, and recorded as traced lines onto sheets of 1mm squared graph paper. The impact scars selected for this investigation were those on St Michael’s Church in High Ercall and St Bartholomew’s Church in Tong, both in Shropshire, and on the ruined tower at Ashby de la Zouche Castle, Leicestershire.

The above sites were selected as each had an excess of identified impact scars accessible to measurement with the contour gauge and measuring frame from the ground or atop a stepladder. Each site had a large enough quantity of impacts to allow a decent sample size, and with the exception of three scars measured at Tong, all of the impacts occurred along a single facing of the structure, reducing the influence of differential weathering caused by exposure to different prevailing weather directions. Selecting three structures rather than sampling across numerous sites also reduces the degree of potential variability in profile that might result from the surface stone type is more likely to be largely homogenous being drawn from a common source for each individual structure.

5.6.2 Data distribution across sampled sites

Though some variation is observable for scars between the sites regarding overall size and depth, there is significant overlap of between sites within the dataset. Figure 20, Figure 21 and Figure 22 show the distribution of total scars diameters within the data between the three sites based on mean total diameter (including spalling), mean maximum depth of surface penetration, and mean diameter of the internal scar at two-thirds of the penetration depth.

The walls at Tong showed minimal signs of surface loss due to weathering, and typically presented the greatest degree of detail of both spalling and radial fracturing within observable scars. The scars at High Ercall showed the greatest visible signs of surface reduction due to weathering of the stone reducing/softening the overall profile of the scars, with the boundaries of the spalled surface edge and the inner scar also being the hardest to determine from the profile trace and photographic records of these scars. Despite this the degree of weathering of scars at Ashby presents the most concern. The scars selected for measurement on the keep were generally intact and readily visible despite several being coated with black air-pollution deposits. Several of the adjacent ashlar blocks however had suffered surface loss to a depth where the speculative remains of the inner scar elements were barely visible as slight surface shape or colouration change on the present surface. Elsewhere the depth of surface loss to weathering was greater still, allowing only for speculation of the quantity of impact evidence that may have been lost to environmental decay.

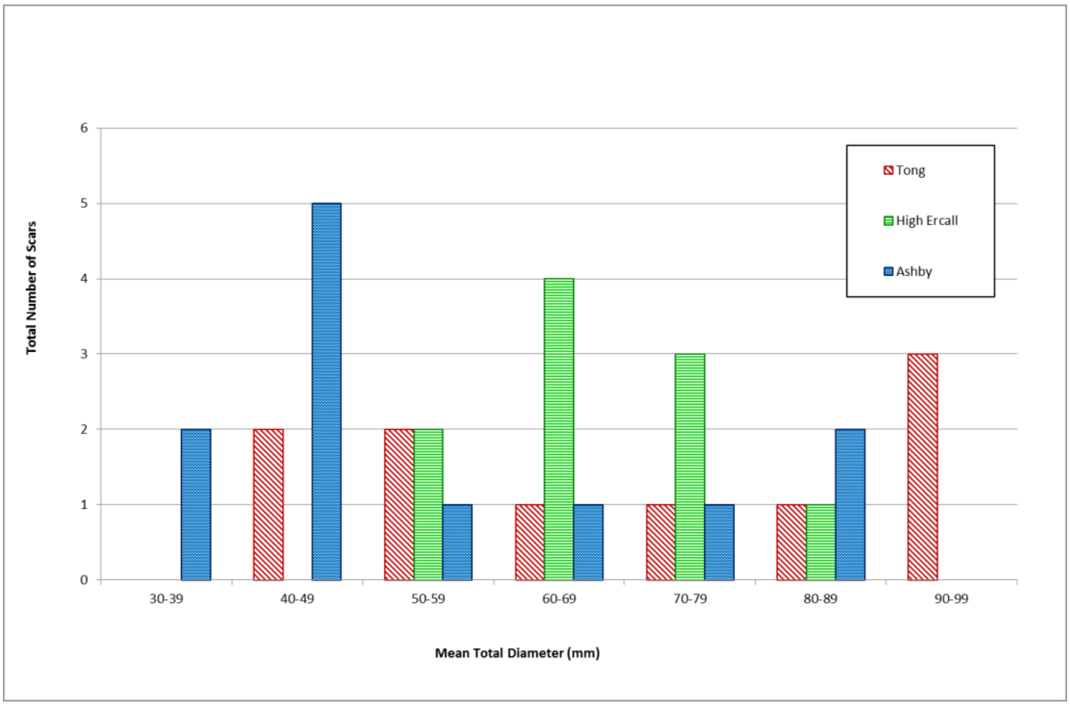

Figure 20: Graph illustrating the distribution of mean total scar diameter values between sampled sites.

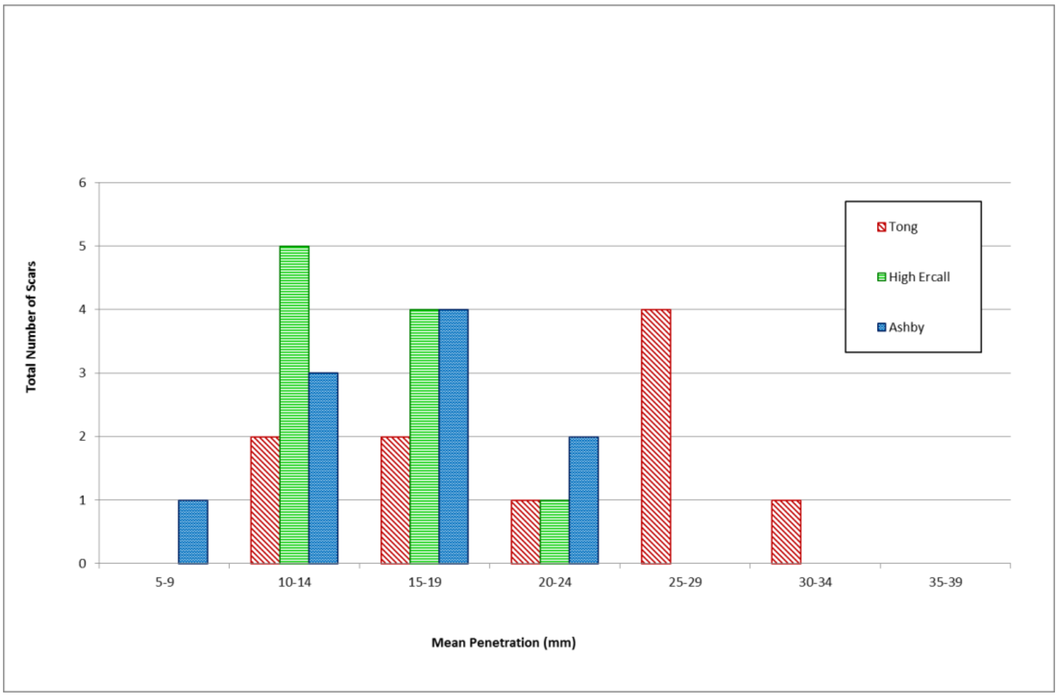

Figure 21: Graph illustrating the distribution of mean scar penetration between sampled sites.

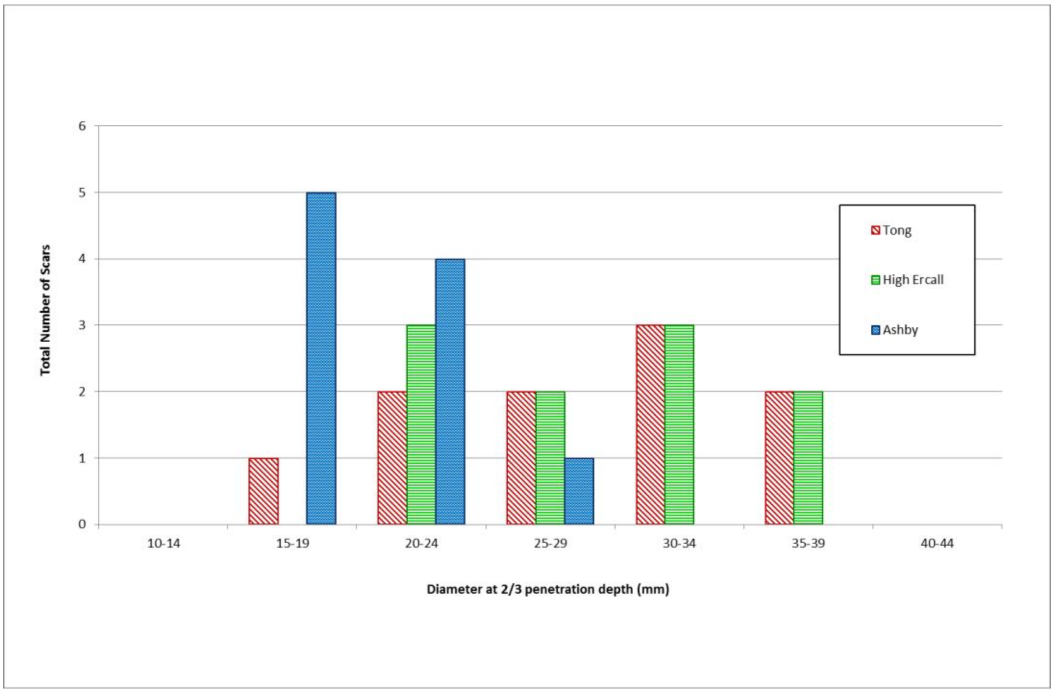

Figure 22: Graph illustration the distribution of mean scar inner diameter at 2/3 penetration between sampled sites

The expectation was that those sites with the greatest degree of visible surface weathering would present scars with the shallowest total depth (D) values owing to surface erosion reducing the overall profile depth of the scar through surface loss of the stone. It was also suspected that weathering loss of the surface would produce scars with a smaller total diameter (ØT) value as the layers containing the spalling would be lost, reducing the surviving scar to a portion of the inner scar as observed at sites with significant weathering reduction of the scars.

What the data shows is that, while there is indeed a general inverse correlation between mean total depth of scars and the severity of weathering influence on the stone surface, there is significant overlap in the range of scar depth values measured across the three sites. The relationship between weathering and the measured scar diameter is less clear, as the scars at High Ercall with the worst average surface weathering gave a mean overall diameter nearly equal to those scars judged to be the least weathered at Tong. The only indicator in the data of a difference between the sites was that the diameter values for High Ercall spanned a smaller range of values than for those at Ashby or Tong.

Site	Mean scar diameter (mm)	Mean scar depth (mm)	Mean scar inner diameter (mm)	Weathering condition (subjective)
Ashby	48	16	20	Moderate
High Ercall	68	14	29	Poor
Tong	70	22	29	Good

Table 5: Mean values for total diameter, penetration and inner diameter for all measured scars at the sampled sites

This may indicate that the internal stone surface of a scar is susceptible to differential rates of weathering, with greater loss at the surface resulting in a shallowing of the profile, but widening at the weaker parts in the perimeter of the spalled area, creating wider diameter profiles without resulting in a significant increase in the volume of the scar cavity. To test this hypothesis, measurements were taken at intervals of the penetration of the scar profile into the surface of the stone a one-half, two-thirds and three-quarters of the total depth, and the ratio of the diameter measurement to the depth of the scar at that point calculated to assess the changing profile shape of the scar. After this initial examination, the value for measuring the internal scar was settled at the two-thirds total depth mark, as this this was deep enough for the vast majority of scars to be below the intersection with possible spalling influence, whilst avoiding the increased inaccuracy of measurement at deeper points due to the 1mm resolution of the measurement methodology. The mean ratio values for all ten scars as each site are shown in Figure 23.

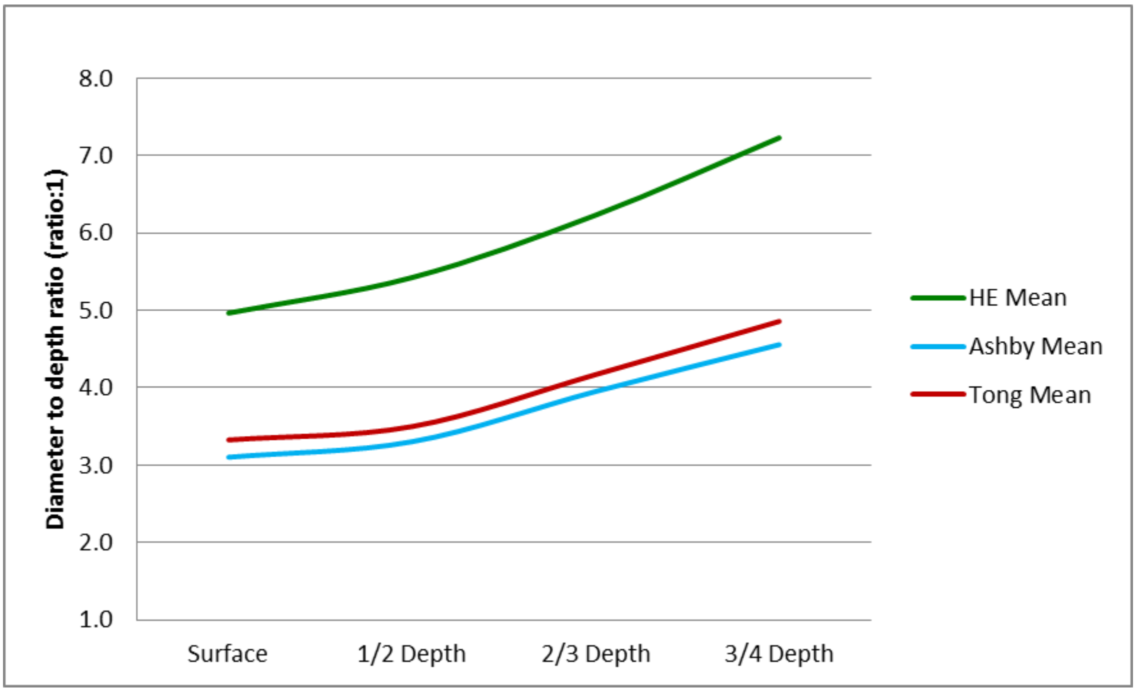

Figure 23: Graph showing ratio relationship of scar diameter to depth at various points of penetration into the surface

Perhaps most striking in the data is that despite variation in surface material, weathering response and formation context, the ratio curves for each site are almost identical in their rate of progression relative to the starting value. What this means is that for an average scar profile, whatever the ratio of overall diameter to depth at the surface, the rate of progression of this relationship is proportional, increasing by a factor of between 1.4 and 1.5 for the mean scar profile. In short this is numerical confirmation of the anecdotal observation that scars generally look similar between sites, though examination of the individual scar ratio curves for each site sampled illustrates that significant variation exists between the scars. The cause of this variation may be tied to the impact process, weathering, localised surface differences, or a combination of all of the these.

5.6.3 Examining feature correlation within dataset

In order to try to find an avenue for investigation of scar variance, the relationship between different measured values from the sample set were compared to test for correlation. The aim of this exercise was to identify features that should be proportionally linked if scars follow an homogenous form, but for which no correlation could be found.

Without an existing framework to examine scar form relationships, various pairs of measurements were taken from the collected data and tested for correlation using Spearman's rank correlation coefficient. This allowed the two sets of data to be directly compared and an assessment of the statistical significance of their relationship to be assessed. Each data pair examined is presented below in a scatter graph showing the overall trend in the data, together with the correlation coefficient (r_s). A coefficient value of 0.5 or -0.5 shows a statistically significant positive or negative correlation i.e. the likelihood of the data values showing this relationship is greater than can be accounted for by random distribution. Unless a measurement axis is specified, all values are based on the mean value for that measurement of a scar across all four axes.

5.6.3.1 Total diameter vs. Total penetration

The relationship between total diameter and total penetration of the scar showed a strong positive correlation that was statistically significant, i.e. wider scars penetrate further into the stone surface. The coefficient value for this correlation was +0.604.

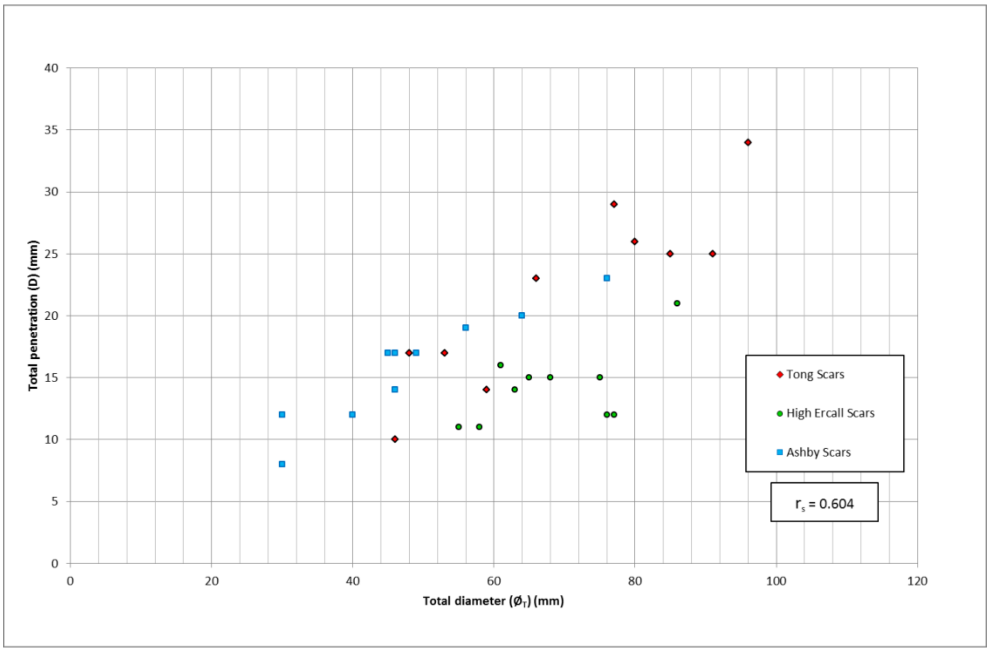

Figure 24: Graph showing the correlation between total scar diameter and total scar penetration for all sampled scars

5.6.3.2 Total diameter vs. Internal diameter

The relationship between total diameter and internal diameter of the scar showed a strong positive correlation that was statistically significant, i.e. surface diameter of scars is proportional to the internal diameter. The coefficient value for this correlation was +0.932.

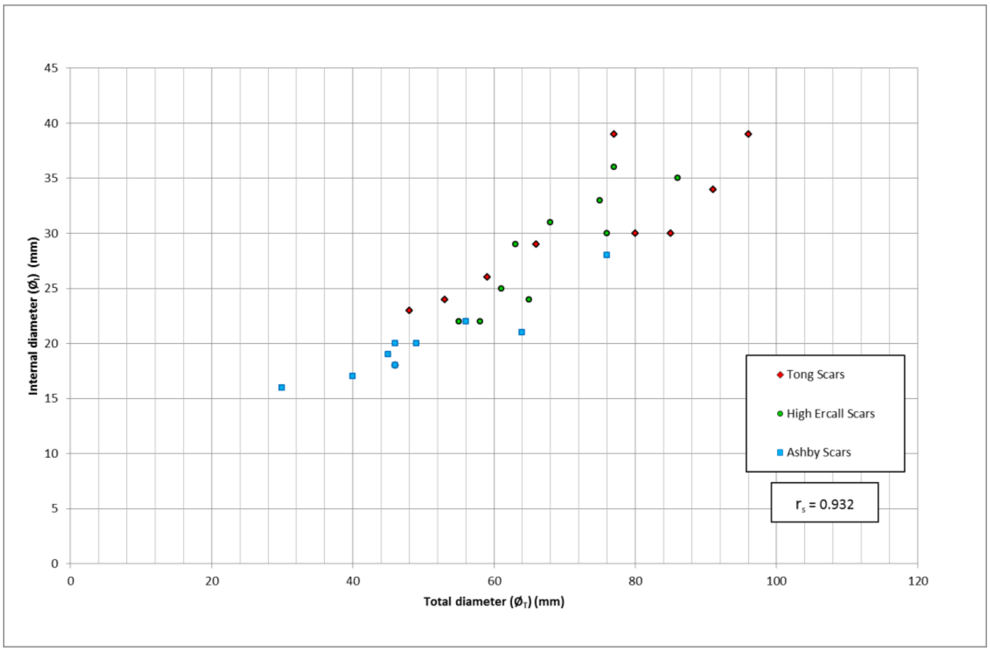

Figure 25: Graph showing the correlation between total scar diameter and internal scar diameter for all sampled scars

5.6.3.3 Total diameter vs. Spalling diameter

The relationship between total diameter and spalling diameter of the scar showed a strong positive correlation that was statistically significant, i.e. wider scars have greater overall width of spalling. The coefficient value for this correlation was +0.858.

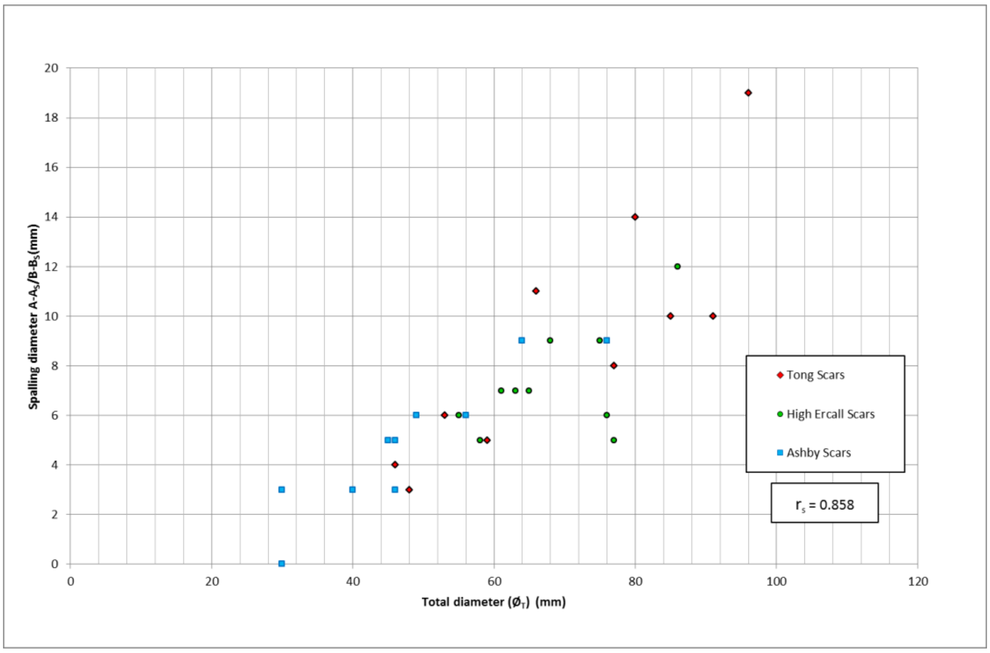

Figure 26: Graph showing the correlation between total scar diameter and spalling diameter for all sampled scars

5.6.3.4 Total diameter vs. Spalling penetration

The relationship between total diameter and spalling diameter of the scar showed a strong positive correlation that was statistically significant, i.e. wider scars have deeper spalling penetration. The coefficient value for this correlation was +0.948.

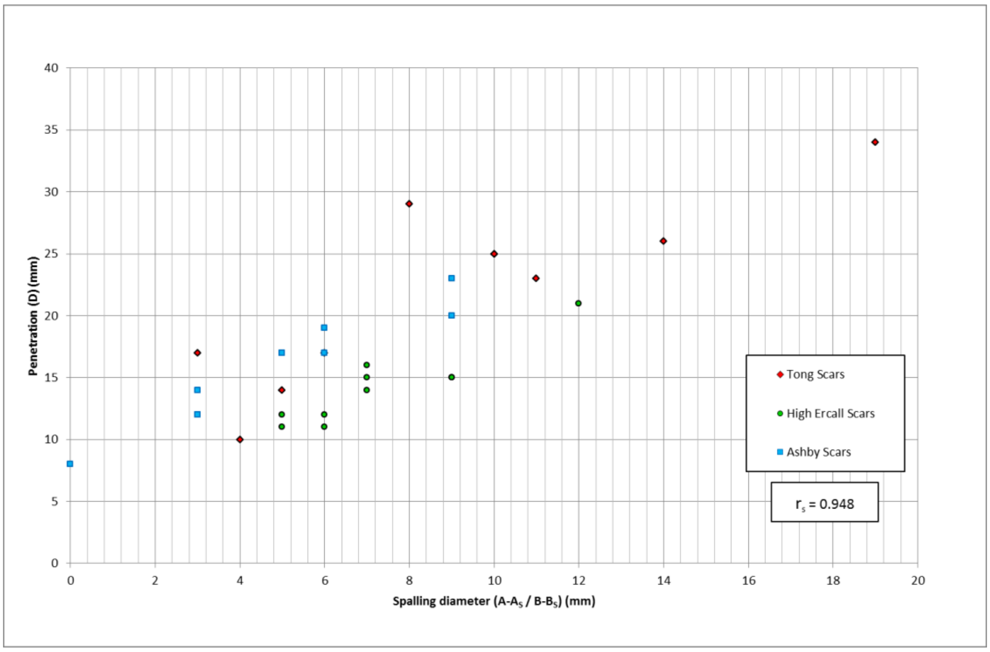

Figure 27: Graph showing the correlation between total diameter and depth of spalling penetration for all sampled scars

5.6.3.5 Spalling diameter vs. Total penetration

The relationship between spalling diameter and total penetration of the scar showed a strong positive correlation that was statistically significant, i.e. deeper penetrating scars have broader area of spalling. The coefficient value for this correlation was +0.745.

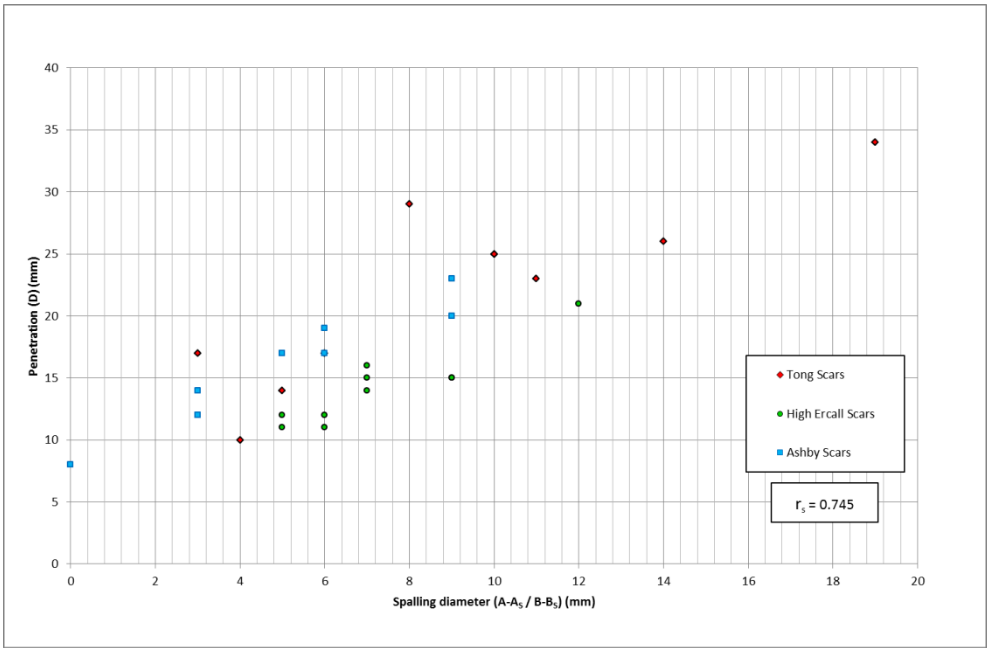

Figure 28: Graph showing the correlation between spalling diameter and total penetration for all sampled scars

5.6.3.6 Spalling penetration vs Total penetration

The relationship between spalling diameter and total penetration of the scar showed a positive correlation that was statistically significant, i.e. deeper scars have deeper penetration of spalling, The coefficient value for this correlation was +0.512.

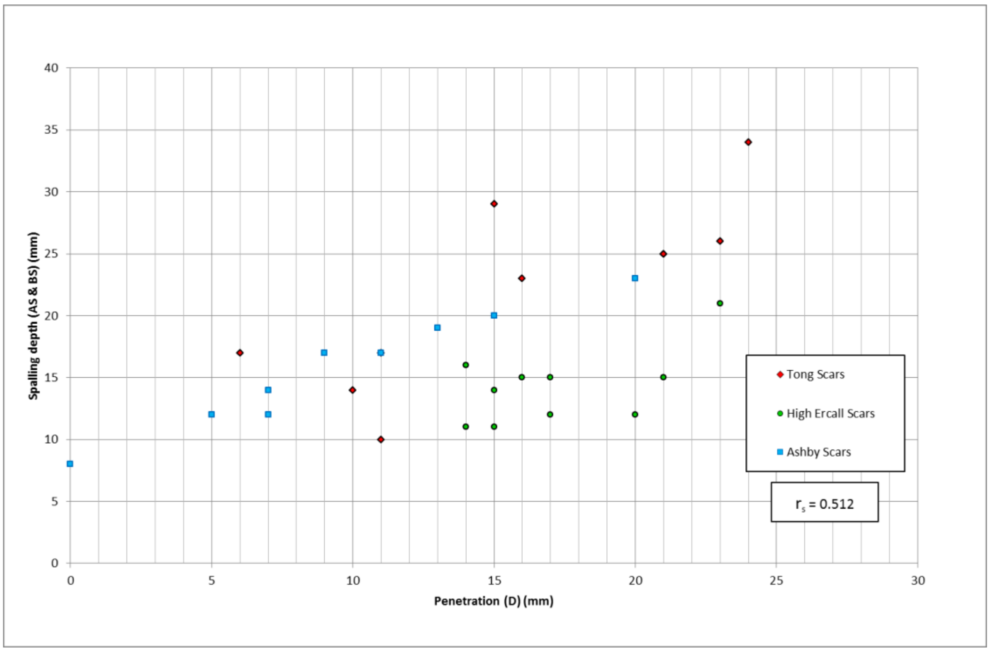

Figure 29: Graph showing the correlation between total penetration and penetration of spalling for all sampled scars

5.6.3.7 Internal diameter vs. Total penetration

The relationship between internal diameter and total penetration of the scar showed a positive correlation that was statistically significant, i.e. Scars that are wider on the inner scar are typically deeper. The coefficient value for this correlation was +0.518.

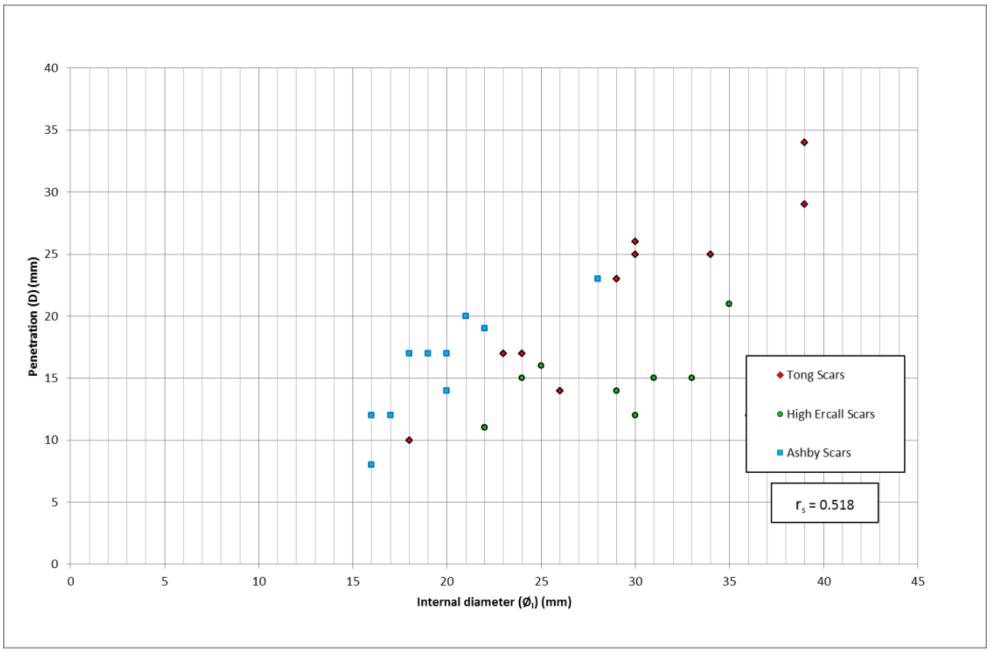

Figure 30: Graph showing the correlation between internal diameter and total scar penetration for all sampled scars

5.6.3.8 Internal diameter vs. Spalling penetration

The relationship between internal diameter and spalling penetration of the scar showed a positive correlation that was statistically significant, i.e. Scars that are wider on the inner scar also have deeper spalling. The coefficient value for this correlation was +0.844.

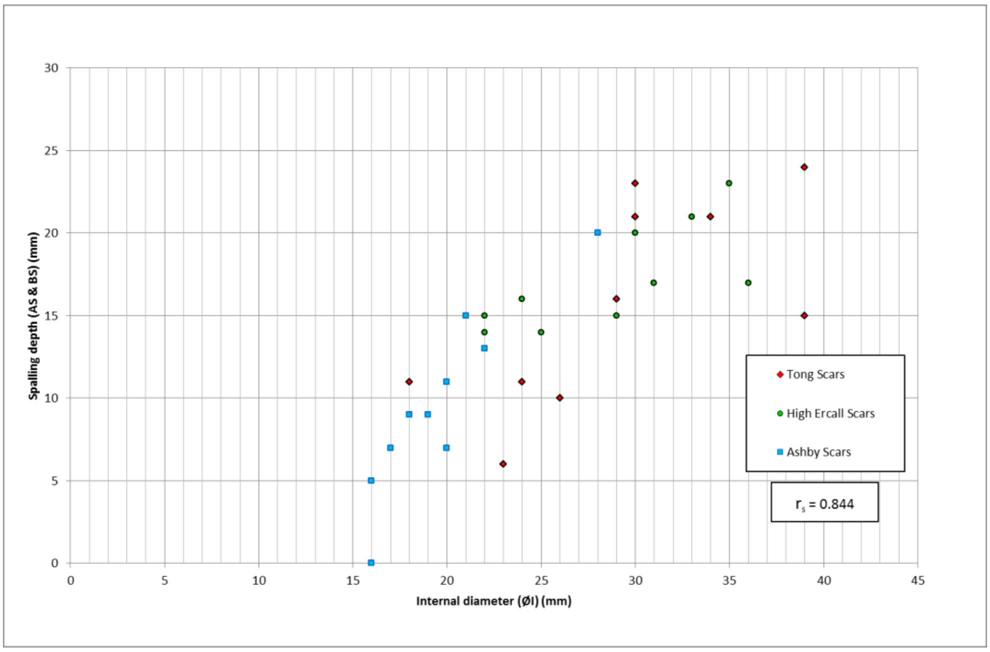

Figure 31: Graph showing the correlation between internal diameter and depth of spalling penetration for all sampled scars

5.6.3.9 Summary of correlations

The correlations show that, as a strong rule, larger scars have larger features in every measured dimension, and that no feature varies independently of other measurable dimensions. The weakest correlations (though still statistically significant) were between the overall penetration of the scar and the depth of the spalled edges, or the width of the internal scar. As the diameter of the internal scar and the degree of edge spalling is hypothesised to be related to the overall bullet size (i.e. deforming bullets of greater volume displace greater quantities of spalled material at the surface, and pulverise a greater overall area in the centre of the scar), this may indicate that depth of penetration is governed by a combination of variables that do not directly influence the area of pulverisation and fragmentation of the surface. This may need investigation in further studies, however the correlation observed above does not indicate a significant avenue of further research for the present study.

5.6.4 Examining Axis feature correlation

In light of limited statistical anomalies in the above data, focus switched to examining the relationship between features in the horizontal axis (axis 1), vertical axis (axis 2), and between axes.

5.6.4.1 Axis 1 total diameter vs. Axis 2 total diameter

This relationship tests whether scars are largely circular in overall shape at the surface level. A coefficient value for this correlation of +0.841 indicates that scars are predominantly circular at the edges of the spalled area.

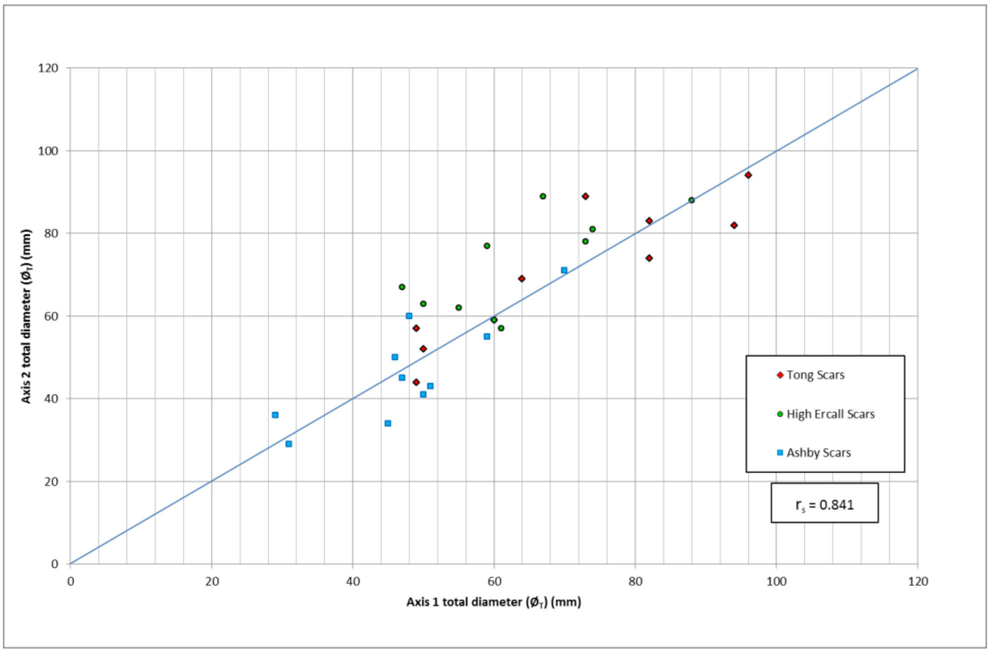

Figure 32: Graph showing the correlation between the total surface diameter in the horizontal and vertical recording axes. The line plots equal width and height diameter values

5.6.4.2 Axis 1 internal diameter vs. Axis 2 internal diameter

This relationship tests whether scars are largely circular in overall shape in the internal diameter. A coefficient value for this correlation of +0.838 indicates that scars are predominantly circular internally.

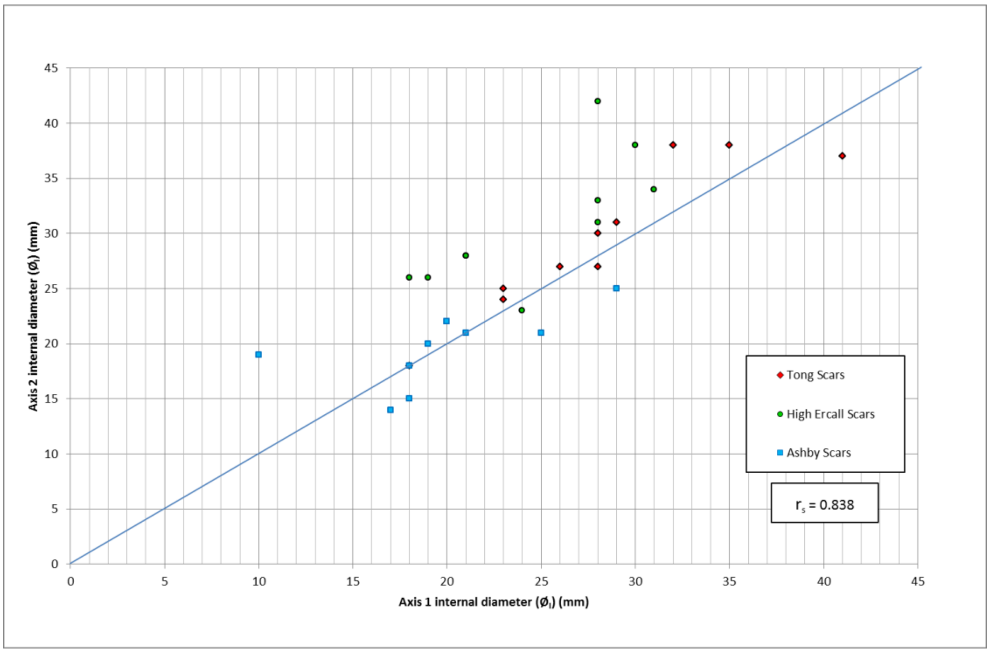

Figure 33: Graph showing the correlation between the internal surface diameter in the horizontal and vertical recording axes. The line plots equal width and height diameter values

5.7 Scar distribution analysis

The distribution of impact scars across a site offers a manner by which the focus and intensity of attack against a garrison can be interpreted. There are problems with directly assessing the intensity of incoming fire using scars alone. For instance it is clear that not all shots fired against a fortified location will impact the structure, and it is possible that not all impacts will form a scar, though this issue needs further exploration. Furthermore not all scars created during a siege survive to the present day due to factors including the loss of impacted walls as a result of demolition, and the loss of wall surfaces due to weathering. It is not possible therefore to directly translate the number of impact scars visible across a structure into the total quantity and concentration of fire against the garrison.

Nevertheless the scars that exist in a given area are evidence of a focus of attack of some form, even though the absolute density and duration of fire cannot be inferred from the quantity of impacts. To use scar evidence effectively for the interpretation of a siege action, two aspects must be identified. Firstly, how the scars relate to each other on the impacted surface, and to features on that surface such as doorways, windows or other components. The second is the overall distribution of scars about a site, as identifying how the scar evidence relates to the fortified site as well as the historic terrain is key to understanding why scars occur in the location they do for a specific site, as well as deducing the likely form of attack from which they were formed.

5.7.1 Height distribution of scars

Observation of scar height distributions across a number of garrison and skirmish locations in England from the Civil Wars reveals a recurring pattern in the height distribution of scars at sites from approximately knee height, to one metre above head height (Foard and Morris, 2012, pp. 129). A rapid photogrammetric analysis of the height-above-ground-level values for impact scars at seven individual siege locations, stemming from site assessment visits in Chapter 4, reveals that this pattern extends for most sites with surviving impact scar evidence (Figure 34). The majority of the scars at the investigated sites occur predominantly in the range of around 1m above present ground level, up to approximately 3m. There are exceptions in this particular dataset to that trend, as the scars at Taunton occur at some height on a surviving original buttress as part of the rebuilt castle (Webster et al., 2016, pp. 189) and may reflect fire against soldiers atop the curtain wall. Similarly a number of scars at Tong occur at greater heights, though these are typically in relation to windows, and the church itself occupies an elevated position to the surrounding terrain, likely forcing the attackers to aim at an angle of elevation when firing to begin with. This underlines the importance of site context in understanding the height distribution of scars, as it is the nature of the target and the historic terrain (including the defended structures) that influences the height distributions at these sites.

For the remaining sites, the lack of a targeted feature implies that the impacts were not in fact aimed at the structure or its occupants, but at targets in front of the impacted surfaces. In this case, the wall acts as a screen for bullets that pass by the target, and in battlefield contexts might be located hundreds of metres down-range of the target. Where this type of evidence is apparent at a site, it is will be necessary therefore to search for evidence of a defended position or likely target in front of the location of the impact scars to enable interpretation of the engagement at the site.

The method of height distribution analysis is limited in usefulness beyond an examination of the likely targeting at a site for a given elevation. The height values do not, for instance, reflect the changing contours of the terrain extending away from the impact point, and cannot therefore indicate the location of the target in the landscape without additional data. It also does not take into account changing ground level around a structure, as many of the scars on Moreton Corbet Castle, Shropshire, occur in a similar height band relative to other scar sets on the ruins, yet due to the ground level falling away progressing north along the east wall, several scars are depicted much higher than their relative spread may indicate.

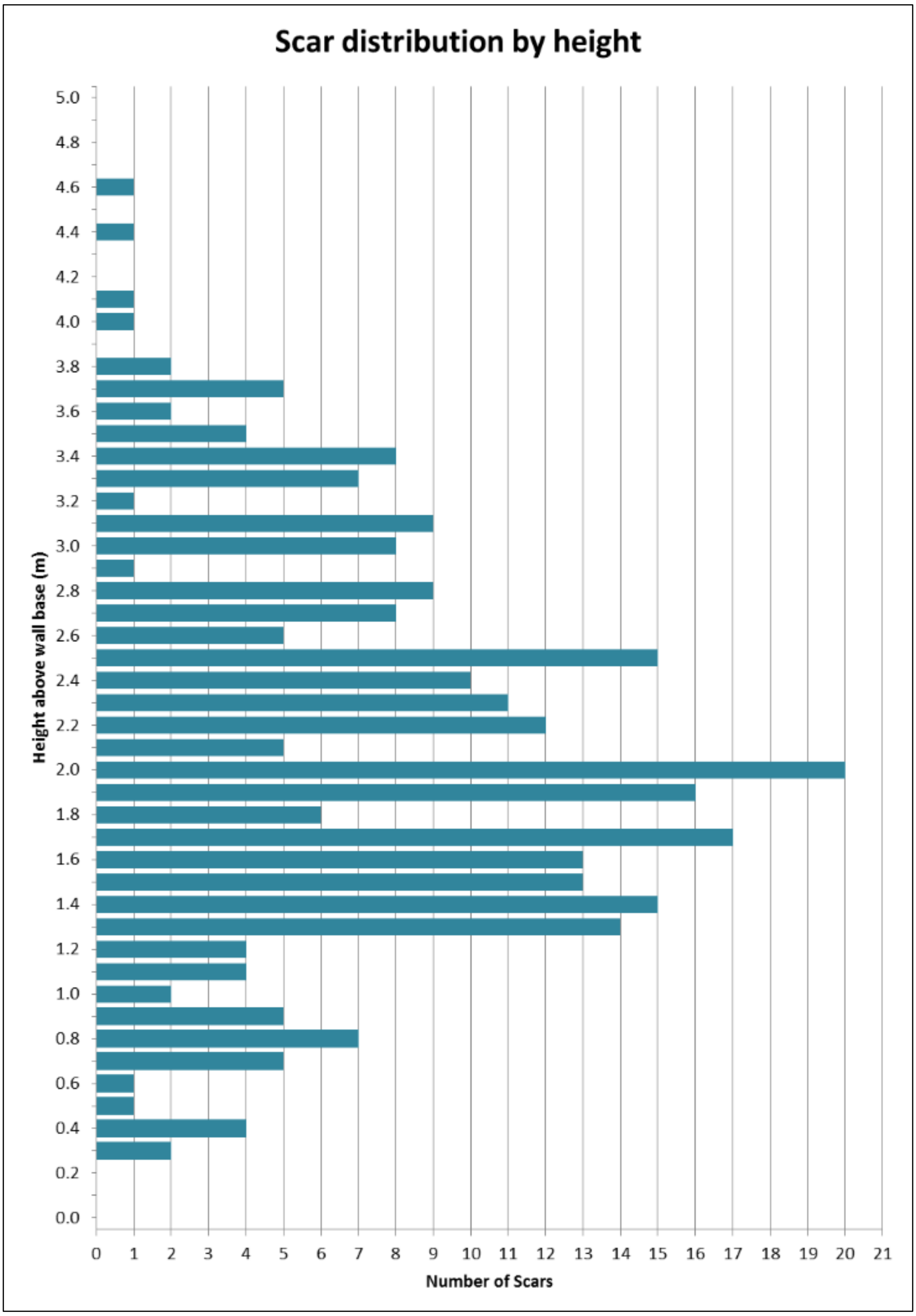

Figure 34: Graph illustrating the quantity of impact scars occurring at given height values as measured across seven siege locations in England

Nevertheless using the height information for an individual scar also provides a useful reference point for analysis of the flight path of the impacting bullet. Ballistic studies of seventeenth century musketry demonstrate that for a shot shoulder-fired from an average height of between 0.9m and 1.7m (a kneeling man and a tall man respectively) at horizontal elevation, a musket ball would drop to ground level (fired point blank and assuming level ground) between approximately 140 and 180m for a muzzle velocity of 400ms^{-1} (Miller, 2010, pp. 113-114). This alone cannot be used as a method to assess the distance of the original shot as a number of variables further complicate the issue of range such as muzzle velocity and angle of elevation, however if an indication of impact velocity can be determined from scar by measuring the scar geometry, when combined with bullet-flight trajectory models, it is becomes possible to begin to pin down the variables for distance to a narrower range of possible values in the search for a reconstructive model.

The only site identified within this study where significant quantities of impact scars occur outside of the height bands discussed above was Old Wardour Castle, Wiltshire. In this instance impact scars occur around window frames and around doorways on the keep, with fewer incidental impacts occurring either at the same height on the walls away from the windows, or closer to ground level. In this instance the impacted walls and window frames represent an obstacle, rather than a backdrop to the shots being fired, with the implication that the defenders at this site were utilising the windows as cover from which to shoot at the attackers. For this site specifically, as the target of the impacted shots is apparently clear, there is an opportunity to investigate deflection of impacts from the apparent target as a means to assess the likely range limit from which shots were fired. This is explored in a limited manner further below within this chapter.

5.7.2 Plan distribution of scars

The overall distribution of scars at a site is necessary for relating scar evidence with the historic terrain, and enabling the interpretation of scars on a site as a whole for an historic engagement. Site-wide plotting of scars showing overall distribution has been given some attention by Foard and Morris (2012), though for the vast majority of sites with impact scars across England no such attempt has been published. Even at a simplistic level, a plan spatial diagram allows a basic analysis of scar concentrations and areas of potential focus of attack. Plan diagrams are also necessary to illustrate issues relating to the analysis of individual scars, such as angle of direction of fire and possible range of firing locations that led to the scar. Using a plan diagram to illustrate impact data for individual scars and scar groupings is problematic however.

The most obvious issue is that a plan diagram does not convey elevation. A wall is for practical purposes a two-dimensional surface expressed in height and width when viewed perpendicular to the surface. The position of an impact scar on that surface also has both a vertical and lateral position on that surface. By conveying the location of an individual scar on a plan diagram, the location of the impact is effectively rendered into a single dimension, losing the context of its vertical position on the structure in favour of illustrating its lateral position against the structure outline. By extension the loss of the vertical element inhibits the ability of a plan diagram convey density for multiple scars. In the instance of Old Wardour, scars on the gatehouse towers would all appear to be closely related in plan, whereas the vertical separation and association with the windows becomes clearer with an elevation. Where scars occur in close clusters, plan drawings become convoluted with overlapping plots, as with the plan diagram of Moreton Corbet presented in Foard and Morris (2012, pp. 132). The plan of scars at Acton Church attempts to address the issue by making the quantity of scars identifiable (Foard and Morris, 2012, pp. 131), however to do this sacrifices all lateral position data.

The most effective method of recording scar-distribution in a localised space is through an elevation diagram of the surface of the structure showing the location of scars on surfaces, combined with a plan diagram of the site showing the sections of wall presented in the elevation diagrams. Where elevation diagrams are not available, orthogonal wide-angle photography of the wall section with measurement markers (such as levelling staffs) may be sufficient, with scar locations highlighted for clarity. Where individual scar plots in plan are required for more detailed analysis, translation of elevation plots to a plan diagram can be achieved using GIS software where the digital elevation is adequately georeferenced, or a datum-reference in the plan and elevation can be measured to the scar's lateral position.

5.7.3 Recording the spatial context of scars

This combined elevation and plan recording methodology was undertaken by this study in a limited manner for Old Wardour Castle's gatehouse (below) and in more detail for Moreton Corbet Castle (Chapter 7) with some success. Producing technical elevation diagrams requires surveying skills beyond the capabilities of the author, so for Old Wardour and existing digital stone-by-stone elevation diagram was used for plotting the location of scars in GIS software. For Moreton Corbet, in lieu of a complete digital set of elevations for the site, elevations were produced from photogrammetric recording, and then used to plot scar positions in GIS.

Recording of scar distribution requires for each scar on a site, once identified, to be photographed individually, with a wide-angle contextual image to allow the location of close-up images to be identified. Where this was combined with scar profile recording, scars were labelled using simple adhesive paper labels to indicate allocated car number, so that recorded scars could be more easily identified and associated in elevation plotting. Scars beyond the reach of profile recording required individually centred images to ensure accurate identification on review of the digital images.

Although some degree of perspective distortion arises when translating photogrammetric records of elevations, particularly for surfaces towards the edge of frame or those occurring closer too or further away from the lens than the target recorded-surface, the two-dimensional plane of the impacted surface can recorded with enough accuracy to allow good measurement of the spatial relationships between scars, estimated to be accurate to +/-1cm across the recorded surfaces at Moreton Corbet. The distribution data for Moreton Corbet is presented further below; however the elevations of Old Wardour presented an opportunity for further analysis of scar distribution that will be explored in this chapter.

5.8 Impact scar distribution case study: Old Wardour Castle

Old Wardour Castle in Wiltshire was twice besieged during the Civil Wars, with the south-western part of the hexagonal keep being largely destroyed by a prematurely detonated mine during the second siege in 1644 (Girouard, 2012). The surviving keep elevations bear a number of scattered small-arms impact scars near ground level and in proximity to window openings, as well as and a handful of artillery impacts of different sizes and overall forms. The greatest quantity of identified small-arms impacts by far occur on the towers flanking the main gate on the north-east face of the keep, clustered predominantly around the window openings on the tower-fronts. As discussed in the previous chapter's site-visit case study, the apparent targeting of the window openings on this structure is distinct amongst siege sites in terms of both the quantity and distribution of the scars that can be found.

This case study will examine the distribution of these scars through digital plotting of their positions on the structure, and analyse their spatial relationship to the window openings. Using a bullet deflection model derived from ballistic performance experiment data for seventeenth century muskets, an attempt will also be made to assess the probable distances from which the groupings of bullets were fired, and make predictions about where evidence related to the location of the attackers might be found and of reciprocal fire might be found within the landscape.

5.8.1 Recording and plotting scars at Old Wardour Castle

The majority of impact scars across the keep and towers at Old Wardour occur in excess of 2.5m height above the present ground level, rendering them inaccessible for profile recording without the aid of a raised platform or secure scaffold. Recording of scars was thus limited to a simple plot of their spatial position against an elevation diagram of the keep using GIS software.

The overall height of the scars around the windows creates an additional challenge to investigation and recording not typically an issue at other sites. Reliable visual identification of a scar relies on being able to discern that the shape of the feature is generally (or partially) circular, and has a depth dimension penetrating into the wall's surface, achieved through parallax vision in close visual inspection. With the angle of observation from ground level causing a foreshortening effect, together with added the distance to the observer as a result of height, accurately identifying scars is extremely difficult and further compounded by moving away from the wall to reduce the acuteness of the observation-angle.

This issue could be resolved through the employment of drone technology, fitted with a pair of cameras to achieve parallax imaging or video capture that could be analysed separately, or compiled into a three-dimensional digital model. The employment of a telephoto lens might also prove a simpler solution to the distance and observation angle issue if used from the raised ground close to the eighteenth-century grotto at the opposite end of the gardens, though the issue of depth perception remains.

As neither of these was available at the time of recording, identifying scars on the wall surface relied on use of oblique lighting, utilising direct sunlight as it passed across an axis almost parallel with the walls to emphasise scars through internal shadowing. Recording photographs were taken as the sun passed across the axis of the walls, with each window and surrounding area of scarring captured in numerous close-zoomed images from an acute angle to provide sufficient resolution for greater reliability of identification. These were used in tandem with several wide-angle images at a less acute angle to provide context for the close-ups, and allow translation of the scar locations onto a stone-by-stone diagram of the gate and tower front sourced from Historic England.

Scars located on sections of wall where the sandstone ashlar was clear of surface loss or biological covering were the simplest to identify. Areas of surface loss or surface texturing and discoloration due to biological covering (moss or lichen) of the walls increased the difficulty of identification of scars. The grey lichens on the tower faces offered less hindrance to identification than those with darker, variegated hues, as the colour variation obscured the contrast of the internal shadow of the scars from the lit surface in a manner effectively camouflaging their presence. No scars on the connecting wall between the towers above 6m as this elevation of the keep was almost completely cast in shadow by the leftmost tower, and here too the wall surface is predominantly covered in variegated lichen. In total only around seven percent of the identified small-arms impact scars occur within areas of significant lichen distortion. Figure 35 illustrates the visual difference between scars on the bare ashlar and a grey-lichen covered portion of the ‘right’ tower.

Figure 35: Photograph of a window opening on the ‘right’ tower of the Old Wardour gatehouse, illustrating the visual contrast for identifying scars on the bare ashlar, and on surfaces covered in textured lichen

Plotted distribution points for scars represent the approximate centre point of identified scar. Due to the method of plotting relying on visual translation from distorted images, the resolution accuracy of the plotted scar centre-points is likely accurate to within ±5cm with the accuracy level improving for plotting of scars closer to ground level. This degree of accuracy is unlikely to have a drastic influence on analysis of the overall dataset, however further investigation of scar distribution at Old Wardour using improved recording techniques is likely to provide a more reliable dataset against which the analysis here could be re-examined in future.

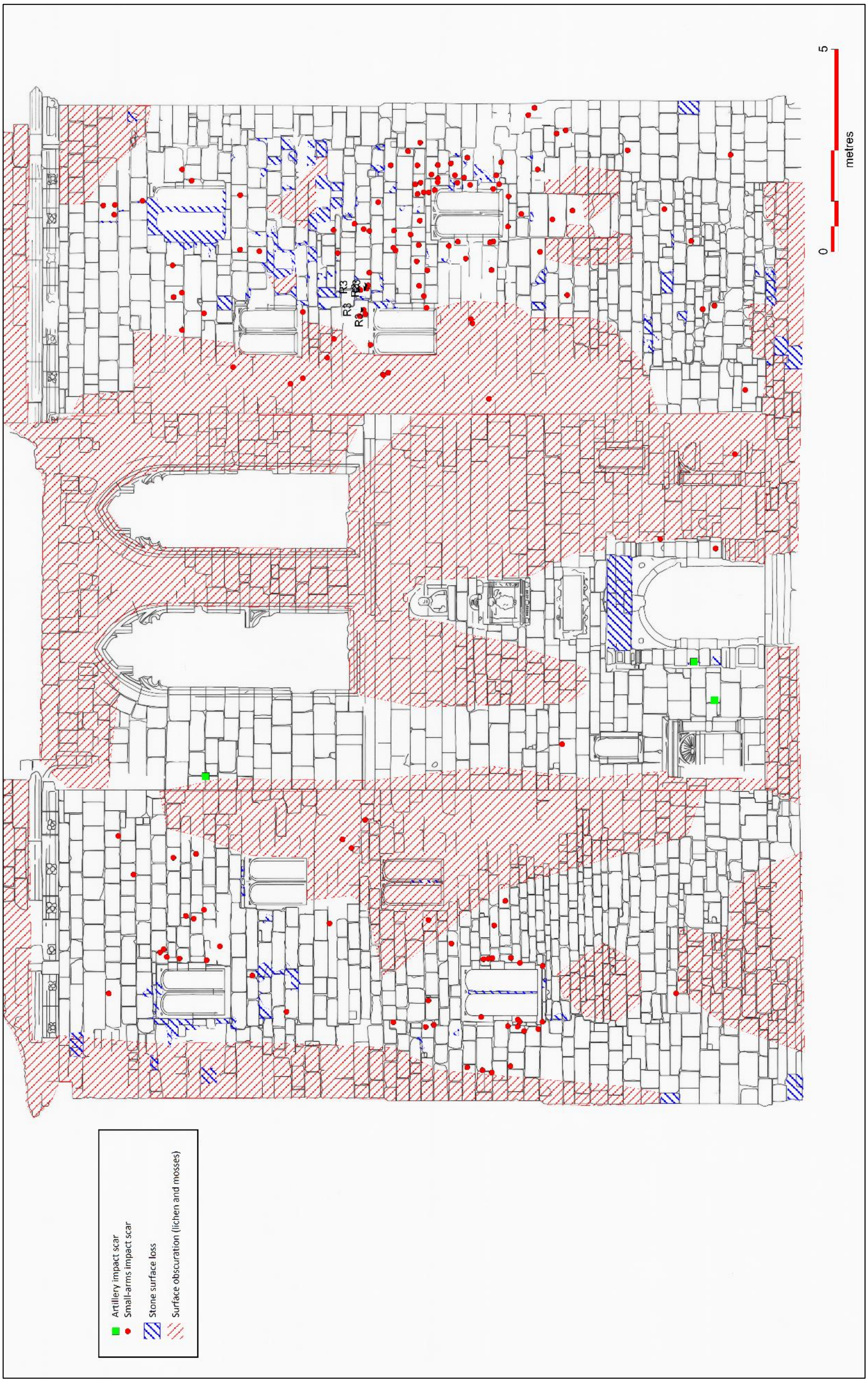

Figure 36: Identified impact scars on the gatehouse elevation of Old Wardour Castle keep indicated against biological surface covering and areas of faced-surface loss. Elevation diagram of Old Wardour keep ©Historic England

5.8.2 Scar data

A total of 153 impact scars were identified on the wall-face of the keep main gate and flanking towers (Figure 36). These include three artillery and four small-arms impacts scar identified on the wall between the towers. Of the 146 small-arms scars occurring on the tower faces, 47 were identified on the south-east (left) tower with the remaining 99 occurring on the north-west (right) tower. Height values above present ground level for the scars measured from the GIS plotting range from 1.4m to 17.35m, though the majority occur in height bands concurrent with the windows on these towers.

5.8.2.1 Distribution assessment

Although there are likely to be numerous scars not identified through this methodology due to the problems outlined above, the vertical and lateral distributions of those that have been identified show a clear association between the locations of the windows on the towers, and the overall distribution of impact scars. Establishing the relationship between an individual scar and window is more problematic however as the spread of impacts around each window suggests that there is an overlap between adjacent groups.

To allocate scars an association to a window opening, each scar was measured for its distance to the centre and to the frame of the closest window opening (or for window R1, the approximate position of the former frame stonework). Scars on the centre gate-wall connecting the towers were excluded from the associative process, as were ground-level scars occurring on the tower faces, delineated as those occurring below 5m in height above ground (the highest identified scar on a structure with no associated targeted feature occurs on the tower wall at Ashby Castle at 4.7m height above ground level). This left 138 scars occurring on the tower faces at heights above 5m.

The furthest deflection between an associated scar and nearest window (Scar 144) was measured at 4.25m. If this is taken as an upper limit for the spread of impacts targeted at any window, then it is clear that there is significant potential for overlap, as the encompassing area for each window would incorporate the adjacent window opening(s) as well as a significant portion of scars likely to be associated with another window. While the possibility exists that an impact on the frame of a given window could potentially be the result of a stray bullet fired at an adjacent window, it is less probable than an association with the closest window opening.

The methodology for assigning a scar with a window association was adapted from this to include the likelihood of spread overlap and reduce the degree of selective bias in the data caused by simple measurement to the closest window. For each window an association circle of radius 1.7m was drawn around the centre point, based on a mean separation of 3.4m between adjacent window centre points. Each scar within the association circle of a given window was allocated to that window. A second, 4.25m radius maximum-spread circle was drawn, and each scar not within an association radius of another window was measured to each window for which it was located within the maximum potential spread (Figure 37). While this resulted in a number of scars being measured multiple times, it accounts for the potential maximum spread of impacts without limiting analysis to linear distances. Table 6 below shows the number of associated scars for each window opening, breaking down how many of those scars have been associated with that window alone, the number of additional scars for which a primary association is considered, and the number of associated scar that are considered primarily for another window.

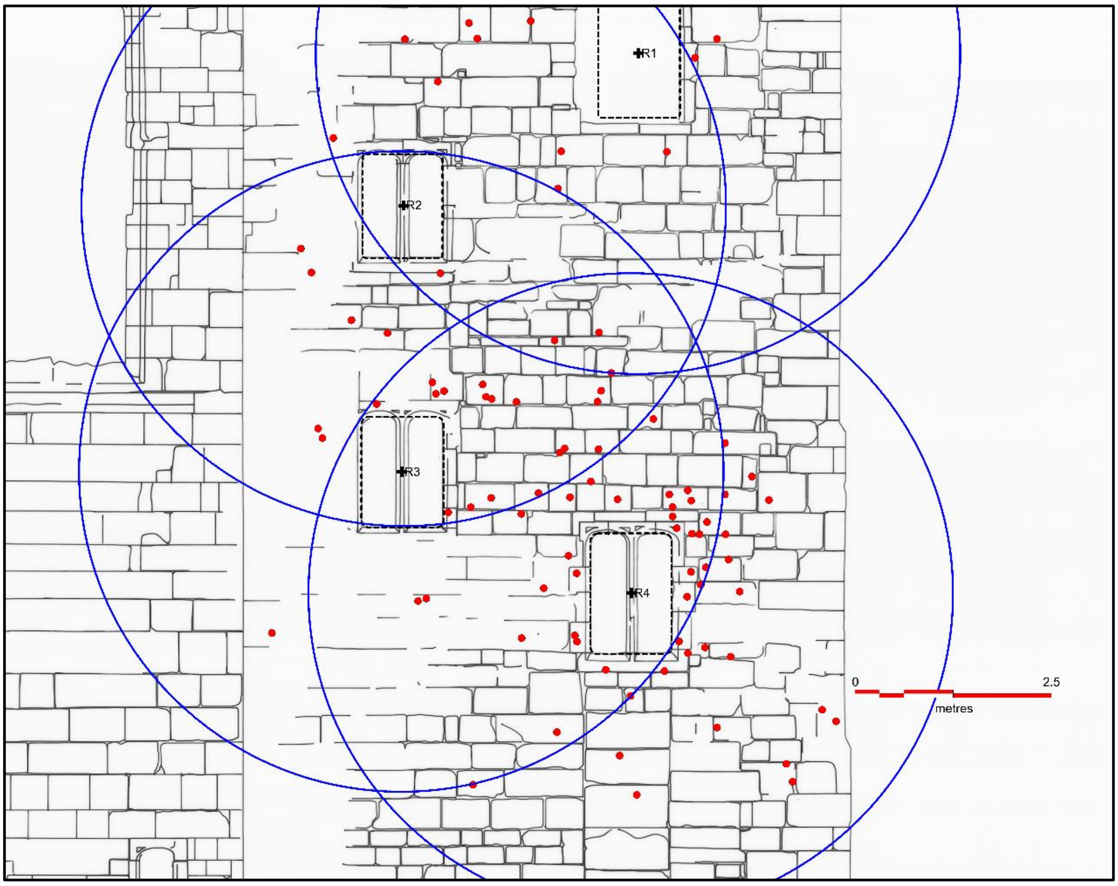

Figure 37: Impact scar plots on Old Wardour Castle, enclosed by 4.25m association circles

Window Opening	No. of associated scars			
	Single association	Multiple associations		Total
		Primary	Secondary	
L1	9	2	1	12
L2	2	3	3	8
L3	2	1	5	8
L4	22	3	-	25
R1	9	3	-	12
R2	6	3	4	13
R3	16	1	10	27
R4	47	4	-	51

Table 6: Associated scar counts for windows on the gatehouse of Old Wardour Castle. Windows are numbers top-to-bottom for each tower e.g. L1 is the upper most left-tower window

5.8.3 Determining distance from impact spread

For smoothbore seventeenth century firearms, the flight path of a lead bullet is influenced by differential drag across the bullet's surface in flight, rotation of the bullet as it leaves the barrel, the initial muzzle velocity, the deceleration of the bullet due to aerodynamic drag, and the acceleration of the bullet towards the Earth due to gravity. Plotting the ballistic path of a bullet uses complex computer modelling algorithms and typically involves calculations of the velocity and height above ground at points along the flight trajectory of a bullet based on initial parameters (Parkman, 2017). It is known from contemporary source material that musket accuracy was unreliable enough to require point-blank discharge of the weapon in massed volley to ensure likelihood of hitting a target (Louth, 2016).

While the exact position deflection of a bullet in flight is unknowable without identifying properties of the bullet in flight that are for practical purposes unable to be determined, the position of a musket ball at any given point in flight lies within a cone of probability, and with a sufficiently sophisticated dataset, it would be possible to determine the range of probable impact points at a given distance for a shot fired from a smoothbore musket. For this purpose, a limited data set created by Miller (2010) can provide a simplified model of bullet deflection over distance.

In Miller's experiments 'witness screens' were set-up at regular intervals to identify the flight characteristics of musket balls, and particularly the distance to first ground impact from firing at 0° angle of elevation of the barrel, seeking to determine variation in ground-impact distance and the subsequent bounce-and-roll of a musket ball to identify final resting position after firing (Miller, 2010). This witness screen data also provides the lateral and vertical deflection of bullets in flight from the firing point to a point of impact at a given distance. In this modelling, the stone walls of a structure act as witness screen to an impacting bullet fired from an unknown location, with the obvious difference being that the bullet does not pass through the wall in the same manner as for the cartridge paper screens used in the experiment. For most sites this is not necessarily helpful as the target point of the impacting shots is unclear, however as the target point(s) can be reasonably inferred for Old Wardour, this data can be adapted for use in this investigation.

5.8.3.1 Building a model for deflection over distance

Miller's data shows that while musket balls can be reliably expected to deviate from straight flight the nature of the deviation is often unpredictable, and in at least two firings the bullet deviated one direction, then back across the zero-axis in the other before reaching the ground-impact point (Miller, 2010, pp. 127). For the model for bullet deviation to be used to examine Old Wardour, the data from the firings carried out in May 2008 labelled as A1-A5 will be used. Though this limits the dataset to only five example shots for bullet deflection, these have been selected specifically because these shots were carried out using the same gun assembly and bullet bore, and at comparable muzzle velocities. Other firings utilised different variables for barrel diameter and muzzle velocity, as well as different witness-screen spacing intervals, thus making direct comparison between the data from these more difficult. Further experimental firing using a fixed set of variables, or altering only one of these would greatly enhance the data drawn upon for the deflection model derived here.

Taking the upper and lower limits for vertical deflection values, and the maximum lateral deflection values from witness screen data in (Miller, 2010, pp. 180), a table of maximum deflection values for each axis was drawn from the shot data (Table 7). The last recorded distance value for this table is from the 140m witness screen, as by the next witness screen interval (170m) two of the five shots had made ground contact, and of the remaining three struck the lower portion of the frame holding the witness paper in situ. At the point of origin for the shot (0m) all deflection values are zero (muzzle location) at the point of firing.

	Bullet deflection				
	X-Axis		Y-Axis		
Distance (m)	Max. single axis deflection (mm)	Max. potential spread (mm)	Max. upward deflection (mm)	Max. downward deflection (mm)	Max. potential spread (mm)
50	148	296	70	-80	150
80	290	580	60	-240	300
110	450	900	-30	-375	345
140	615	1230	-190	-986	796

Table 7: Maximum bullet deviation over distance, derived from data by Miller (2010)

The values for lateral deflection in the X-axis, and relative upward and downward deflection in the Y-axis in this table are drawn from Miller's data directly. The maximum spread of X-axis deflection is inferred on the presumption that the maximum bullet deviation in the lateral axis is the result of random chance, and that a bullet can curl as easily to the left as to the right after firing. The cause of this lateral movement is a result of drag influence across the bullet's surface in flight, exacerbated by marks and deformation of the bullet's surface incurred through contact with the barrel during firing (Miller, 2010). The Y-axis values represent the upper and lower deflection values at which the bullets passed through the witness screens. These have been separated as in contrast to the lateral deflection, the vertical axis is also subject to the accelerative force of gravity, and as distance increases these Y –axis values will turn increasingly negative until ground contact is made. Though some of the shots had begun to climb immediately after being fired, presumably due to the same reasons for lateral deflection, all of the bullets had descended below the level of the barrel by the 110m screen as downward acceleration due to gravity had overcome any upward motion. The graphs below show the maximum spread over distance in the lateral and vertical axes, with the area between the two lines representing the range of possible positions of the bullet after firing.

This predictive model is basic, and limited to the scope of the data from which it is built. The shape of the overall area of possible impact at the end of the cone for instance is unclear and is influenced by different factors in separate axes of motion. The maximum deflection from the zero mark for each range is depicted in as concentric circles based on the greatest deviation from the zero point for each range, however if depicted accurately, these would gradually extend further to the base of the image with distance as the cone bends downward to reflect gravitational influence. Despite the limitations of this model, the study from which it is derived is to date the only attempt to assess the performance and deflection of seventeenth century firearms and projectiles over distance.

5.8.3.2 Applying the spread model to Old Wardour Castle

As the windows are for the most-part larger than the extent of the spread circles if measured from the centre, the overall opening within the frame was take as the measuring point to assess deflection values for scars, as it cannot be reasonably inferred where in the window, if more specifically than the opening itself, the firer may have been aiming. The boundary of each deflection circle if measured to the window frame would form a quasi-rectangular radius around the extent of the frame, thus to save repeatedly applying a set of four circles to each of the 138 scars, the rectangles were drawn in relation to the eight windows, and scars within each noted (Figure 38).

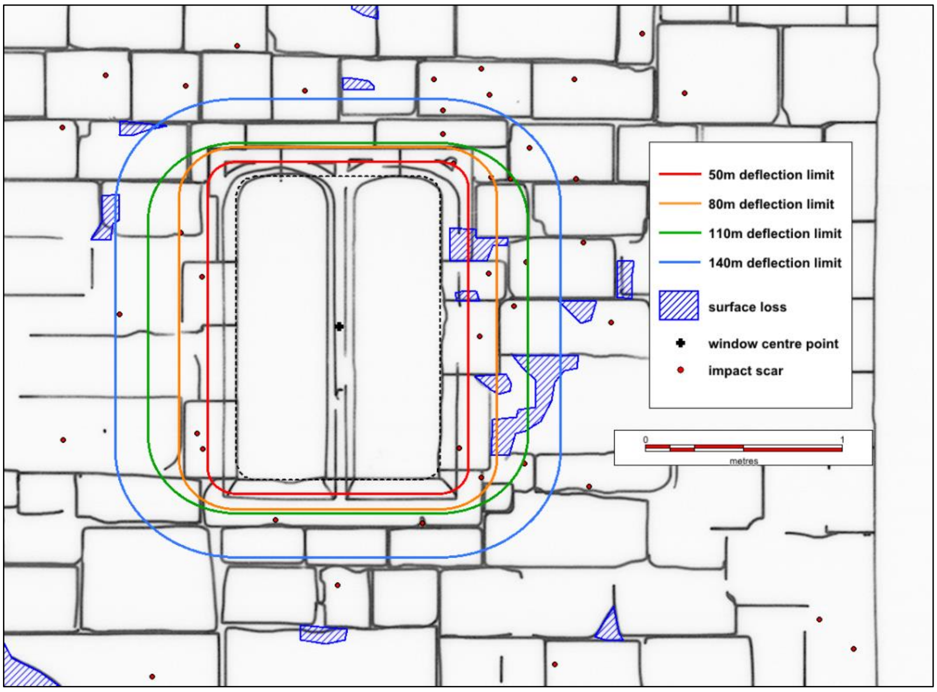

Figure 38: Diagram illustrating the application of spread rectangles to window plots for counting.

A problem encountered in applying spread rectangles directly to the example of the gatehouse windows is that the data for the deflection model is based on firings from a level gun-barrel. The influence of elevating the initial shot-trajectory on deviation of the bullet within the Y-axis is unclear. If the bullet behaviour remains the same, the bullet would tend to strike below the target for any firing distance greater than 110m where the barrel of the weapon is aimed directly at the target window. This contrasts with the observed centre point for the spread surrounding most of the windows, where the mean centre lies above the centre point of the window, and well above the base of the opening. It seems reasonable however to expect that soldiers knowledgeable in the behaviour of their weapons would aim higher than the intended target to account for the drop of the bullet over distance, which might account for the higher overall centre of distribution. Without any additional data upon which to adapt the model, the existing spread-rectangles were applied centred on the relevant window for each distance bracket.

5.8.4 Scar-spread analysis

As each range rectangle includes all of the scars from the previous bracket, taking the largest quantity as the probable range is insufficient. Instead the greatest increase in number of scars between brackets was used as an indicator from this analysis. For windows L4 and R4, those with the greatest number of associated impacts, this was in the 110m range bracket. A tentative prediction of the possible locations of the attackers is offered in Figure 39 based on this distance evaluation.

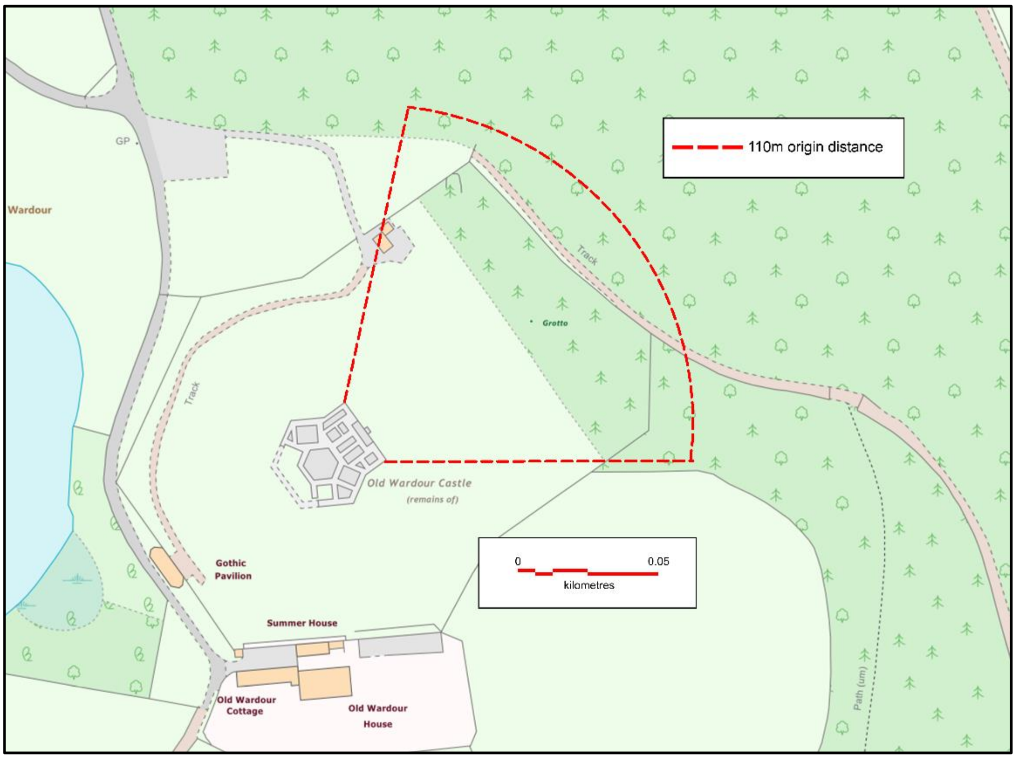

Figure 39: Map of Old Wardour Castle and grounds indicating possible locations for a shot origin of 110m. OS MasterMap® Topography Layer 1:1,250 © Ordnance Survey EDINA Digimap Ordnance Survey Service

The matter of the remaining 85 scars in the vicinity of the windows that did not fall into these brackets however underline the complexity of the issue of aim, elevation, and deflection over distance. The wide spread of impacts across the structure may reflect poor aim, variation in the bullet deflection owing to any number factors including muzzle velocity, bullet deformity and differential drag. Dismissing scars outside of the angle brackets as 'poor shots' would rely on the assumption that those within the brackets were indeed 'good shots' and not part of the spread from another window. Indeed it may be that these scars were not the result of shooting for accuracy on the part of the besiegers, but are the remnant evidence of a form of early fire-suppression by the besieging forces to prevent the defenders from taking shots at the attackers whilst preparing artillery positions, or even raiding the defended position. Further research of the primary sources for the sieges may yield help settle the matter of small-arms fire exchanges against the castle and a siege actions more generally, where forces tended to keep out of musket range of each other when not actively sallying/attacking (Louth, 2016).

It is also unclear if the scars that are present are a proportional representation of those fired, as not only is there considerable surface loss adjacent to most of the window openings, but we also have no information about how many bullets passed through the frames. It may not be a coincidence or an artefact of scar selection that the mean centre point for each window falls within the opening, and may reinforce that the scars we see are a proportion only of the shots taken that missed the target compared with an overall success rate that is not visible in the data. It is also possible that these scars are not properly targeted at all, but represent a form of suppressing fire against the defenders to prevent them using the windows to give fire back to the attackers. This would potentially explain the seemingly high number of shots that fall some distance outside of the expected areas of impact to account for bullet-deviation inaccuracy against the windows, though without more data about bullet behaviour when fired at an elevation, or without being able to account for poor marksmanship on the part of the attackers, this would still be very broad speculation.

The issue of whether this model can effectively predict range based on distribution will most likely be settled if evidence of the outgoing fire from the defences can be identified in the surrounding landscape through use of metal detector survey. A transect search moving outward from the castle might identify peaks in the impacted bullet density that indicate a focal area of fire radiating outward from the defences, however on the gatehouse side of the Old Wardour keep later land use and the wooded slopes may have already compromised this evidence beyond analysis. Until this can be examined, or another suitable site for similar analysis can be explored, this assessment shall remain an untested hypothesis.

5.9 Chapter summary

While impact scars follow a common form and appearance, significant variation exists in the specific elements of their cross-sectional profile that could yield significant information from further study. The reason for these variations may be limited to weathering action and variation in the stone surface alone, however without further exploration of how scars from and develop over time as part of a longitudinal study, this will remain an unknown quantity.

Experimental investigation of issues such as the influence of bullet mass, size, impact velocity and angle of incidence on the resulting scar could identify trends that, although not directly applicable to archaeological scars across all sites, may provide enough insight to begin to draw stronger conclusions from the evidence. Exploration of special site-specific circumstances for archaeological scars, such as the internal impact on the arch in Tong church, may help to develop a theoretical framework for scar properties, but this will require further exploration of the archaeological resource for opportunities that can be investigated practically and cost effectively before it is likely that detailed research programmes will become possible. Development of recording methodologies for scars may also drive better understanding of scar variation, but it has not been possible to undertake a deeper investigation of this issue as part of the present study.

Localised impact evidence can provide clues as to the focus of fire and even potentially the location of the shooters, however the range of variables that influence bullet flight and deflection over distance require greater exploration before sufficiently reliable models are likely to be developed for the interpreting of this evidence. Similarly the hypothesis for targeted archaeological investigation at the old Wardour siege site would begin to answer the question of whether the scar distribution at a site can be used to make meaningful predictions as to the likely location of archaeological evidence at siege sites beyond the fortified location, however this remains to be explored before this can be applied to sites without the very specific form of evidence encountered at Old Wardour.

6. Ballistic Investigations for Stone Impacts

The preceding chapter has examined the variation in appearance and shape of archaeological impact scars identified at siege sites of the Civil Wars in England. To identify how differences observed between archaeological scars might relate to the causal impact variables, it is necessary to turn to experimental archaeology and ballistic science. This chapter will discuss previous experimental studies that have investigated elements of the response of lead bullets and stone surfaces to ballistic impacts. This discussion will identify how observations from these studies enhance understanding of impact scar formation and development, and how this can be applied to understanding archaeological examples from the seventeenth century.

These issues will then be explored further through presentation and discussion of two ballistic trials carried out for the present study to specifically investigate scars created through bullet impacts simulating seventeenth century firearms. The first of these trials was carried out by Amanda Wynne in 2012, and explored whether bullet impact scars could be created under firing-range conditions for investigation of their formative processes. The second trial, devised and carried out by the author in 2019, explored variation in impact mark and impacted-bullet form using controlled impact conditions at two different impact velocities. These marks were examined visually following formation, and again after exposure to weathering and after pressure-washing of the stone surface. Conclusions drawn from these trials will be explored for how these influence future examination of archaeological impact scars and approaches to stone-impact experiments, as well as implications for the conservation of scars and impacted bullet fragments at siege sites.

6.1 Previous impact studies

Attempting to recreate impact scars through ballistic trials does not constitute a scientific experiment in that the exact starting conditions of archaeological scars can neither be known exactly, nor perfectly recreated. The purpose of experimentation in this instance is to aid in the analytical process of the archaeology by using experimental results that serve as an indicator for approaches to assessment of data drawn impact scars.

Impacting stone blocks with seventeenth century small-arms projectiles is an unsurprisingly uncommon pursuit both in forensic science and experimental archaeology. Two factors underpin this; the first is that there has (as outlined in the chapter above) been an historic lack of investigation of archaeological impact scars to warrant an investigation of bullet impacts on stone through ballistics trials. The second issue is the logistical and resource challenges posed by impact experiments, requiring as they do both a supply of target masonry, and a safe facility and apparatus set-up that these can be shot without risk of harm to individuals or equipment, poses an additional barrier to such investigation to have come about through curiosity alone.

Of the three studies that have involved experimentally impacting stone targets with small-arms bullets, for the two that utilise historic firearms and munitions against stone surfaces the focus has unsurprisingly been on the recovery and condition of the resulting bullet, with the form and visual characteristics of the resulting impact mark essentially treated as a secondary concern (Green, 2010, Haag and Jason, 2012). This is almost certainly because of the importance of bullets as an object type in assemblages from historic fields of conflict, as it is the distribution and examined detail of bullets that typically allows for archaeological interpretation of early modern period actions.

The remaining studies of stone impacted by small-arms fire has focussed on the effect of impacts on the surface material rather than the shape and appearance of the impact scar itself. Investigation by Mol et al. (2017) sought to determine the influence on weather resistance and structural hardness of stone blocks impacted by small-arms fire as part of informing conservation strategies for heritage sites damaged by conflict. While the 2017 study utilised modern small-arms impacts to test block responsiveness in a laboratory environment, the conclusions drawn from this informed further investigation of impacts on heritage structures, including scars from the tower of Powick Church relating to the Battle of Worcester, 1651 (Mol and Gomez-Heras, 2018).

6.1.1 Impact-ballistics trials by Green (2010)

An unpublished MSc study by Green (2010) tested the relationship between impact velocity and impacted-bullet condition for bullets striking stone surfaces. The aim of the study was to establishing a relationship between the impact velocity of the soft lead musket balls and the resulting degree of deformation or fragmentation as a result of impact with unyielding or frangible surfaces, including steel-plate impacts, and impacts on a variety of stone types and surface hardness (Green, 2010, pp. 1). This was carried out by firing 12-bore and 22-bore lead musket balls from a simulated smoothbore musket (barrel and firing chamber assembly) using changing gunpowder propellant quantities vary the muzzle velocity of each shot, and consequently the impact velocity of the bullet (Green, 2010, pp. 14-15). The sources of the stone targets used in the latter stages of the experiments is not given by Green, aside from a description of the targets as ‘chalk’, ‘sandstone’ and ‘Yorkstone’, and although it is noted that there was an attempt to assess the difference in hardness of the stone types using a Schmitt hammer (Green, 2010, pp. 15), there is no discussion or analysis of this testing process (methodology or results) beyond the provision of the raw data provided in the appendix.

The majority of Green’s tests provide data of limited usefulness for an investigation of impact scars. The earlier stone impacts occur as individual impacts at differing velocities against a variety of target blocks and slabs (many of which did not survive the impact), and lack detailed assessment or good quality images of the resulting impact marks, hindering attempts at comparison of data. The impacts against the single sandstone block (Stone 6) are more helpful in that Green was able to demonstrate a relationship between increasing impact velocity of a bullet, and increasing scar size both in area and depth of penetration of the displaced stone (Green, 2010, pp. 38). While the methodology for measuring the values of the depth and area of the impact marks is not presented, the graph data shows a curve that indicates a correlation between increasing scar area and depth with increased impact velocity (Green, 2010, pp. 38). Although Green was also able to demonstrate that an increased impact velocity produced a greater fragmentation of the resulting bullet for extremes of impact velocity, the variation in the resulting fragments for intermediate velocity impacts would prevent establishing the impact velocity of a bullet from fragment analysis alone (Green, 2010, pp. 40).

This identification of a proportional relationship for scar area and depth together with changing impact velocity is important in several regards. Firstly it supports the observation made through measurement of archaeological scars that there is a correlation between scar diameter/area and depth, and more specifically that this correlation extend to the impact mark in its initial form as well as the weathered archaeological scar. How this relationship changes with variables such as bullet calibre is unfortunately not explored in Green's study, as the 22-bore bullets were used only in the steel-plate impacts. Secondly is that surfaces of a single stone type appear to behave in a relatively predictable manner, indicated by the graph identifying increasing size of impacts on a single block (Stone 6). A greater number of impacts across multiple blocks of a single stone type would be required to test this more thoroughly, and it is unclear whether Greens data represents impacts on a freshly-cut stone surface, or one that has undergone case-hardening through weather exposure. Nevertheless this common behaviour for a single stone type also matches the correlation observed in the previous chapter that archaeological scars are broadly comparable for their relationship between total diameter and depth of penetration across an homogenous stone type than for between stone types at different geographical locations.

If the behaviour of a stone type could be sufficiently modelled either from collected data about aspects of the properties of the stone, such as compression strength or surface hardness, or through experimental impact results derived under laboratory conditions, it may be possible in future to model a prediction what the resulting impact mark would look like for a given bullet calibre and impact velocity on a known stone type. Building this modelling system would require significantly more research than is within the bounds of the present study, and would need to include an understanding of the influence of angle of impact and calibre on the changing profile of impact marks, as well as a better understanding of how weathering influences resulting scar shape over time. Nevertheless this may be an achievable research goal for future studies.

6.1.2 Impacted bullet recovery trial by Haag (2012)

Haag and Jason's investigation of bullet fragmentation sought to understand why no recognisable bullets and few large fragments remained in the vicinity of bullet impact craters at the Palomas Creek (1880) battle site in New Mexico (Haag and Jason, 2012, pp. 196). While these craters were caused by firearms almost two centuries later than those of the English Civil War, the projectile material (lead) and the impact velocities would be broadly similar for weapons still utilising gunpowder propellant, and indeed the experimental shots carried against a test rock-face impacted with a velocity of approximately 300ms^{-1} (Haag and Jason, 2012, pp. 197), well within the range of plausible impact velocities for a smoothbore musket based on a muzzle velocity of c. 450-500ms^{-1} (Eyers, 2006, Parkman, 2017). This further investigated the impact process for a number of modern projectiles (round-nosed lead and copper-jacketed lead bullets) against steel plates using high-speed footage to calculate the rate of deceleration and the resulting g-force experienced by the bullets within the time frame of first contact to complete stop of forward motion.

These experiments showed that upon impact with unyielding surfaces, the degree of fragmentation is related to the material of the bullet, and the internal g-force experienced by the bullet as rate of deceleration from impact velocity to the arrest of forward motion. This rate of deceleration was calculated through the use of high-speed footage to measure the difference in frame-number between the point of contact between the bullet and the steel-plate, and the point at which the bullet ceases forward movement. Haag and Jason found that lead bullets of differing calibres and sizes fragmented entirely for orthogonal impacts against the unyielding steel-plates for velocities in excess of the range 183-213ms^{-1} (Haag and Jason, 2012, pp. 206), leaving only small fragments and the base of the bullet in the case of conical projectiles, allowing a calibre assessment to be made. The internal g-force experienced by the non-jacketed lead bullets was calculated for shots at velocities of 152ms-1 and 160ms-1 to be in excess of 105,000'g's, with a decelerative time scale of 15 ten-thousandths of a second from contact to arrest. Reciprocal rebound velocities were also measured through this method and found to be c.3.0-3.7ms^{-1} (given as 10-12f/s) (Haag and Jason, 2012, pp. 206) or approximately 2-3% of the impact velocity, though this did not account for the perpendicular velocity of ejected fragments or the lead-splash, which appear from the frames of the impact process to have a much greater velocity. The experimental shots carried out close to the archaeological site against outdoor sandstone surfaces failed to produce an impact mark beyond a surface transfer of lead, the sandstone surface instead acting as a hard, unyielding surface in a similar manner to the steel plates used during later investigation, and regrettably no measurement of the impact marks is presented within the published study.

While this study relates specifically to unyielding surfaces and the influence of deceleration time and force on a bullet's deformation and fragmentation, this information is nevertheless useful for assessing archaeological bullet impacts at siege sites. This data suggests that recovery of anything but small bullet fragments for archaeological impact scars is likely to be impossible as the threshold velocity for bullet survival against unyielding surfaces is relatively low in comparison to the ballistic velocities of seventeenth century musket balls. Ballistic trials by Miller (2010) tested the bounce and roll of musket balls after ground impact, and used 12-bore musket balls fired at zero-degrees elevation from a barrel height of 1.39m. For shots fired with a muzzle velocity 412-429ms^{-1}, significantly below the expected 450-500ms^{-1} muzzle velocities indicated above, ground impact occurred at distances of 153-203m at velocities between 239-266ms^{-1} (Miller, 2010, pp. 182). Ballistic trials by Parkman using 19-bore bullets model that for a bullet fired at the same elevation and height with a muzzle velocity of 467ms^{-1}, ground impact will occur around 191m from the muzzle at 234ms^{-1} (Parkman, 2017, pp. 211). This suggests that for the majority of shots fired at anything shorter than 150m, the impact velocity is likely to exceed the threshold of bullet destruction for soft lead bullets as identified by Haag and Jason (2012) (213ms^{-1}). This is dependent on the degree of yield of the stone surfaces after impact, and it is possible that for some stone types the degree of yield may be sufficient to allow the bullet to rebound partially or largely intact albeit distorted. However, for distances between muzzle and target of 150m or less, the probability of recovering a bullet that has not significantly fragmented appears to be very low, and decreases with increased proximity to the impact point. This in turn would suggest that recovered examples of flattened or 'pancaked' bullets found in archaeological contexts are not the product of shots that have directly struck a wall surface, unless these bullets were travelling at sufficiently low velocity (either due to distance or possible misfire) to slow to below the fragmentation threshold for a surface.

6.1.2.1 Bullet survival threshold versus impact scar formation threshold

With the identification that bullet fragmentation is dependent on the impact velocity of the bullet (and the deceleration time from that velocity to zero), the result of the impact process can be broken down into two logical thresholds; the threshold at which a bullet will fragment upon impact, and the threshold at which a scar will form as a result of impact. This creates a set of four possible outcomes for an impact which can be charted as shown in Figure 40 below.

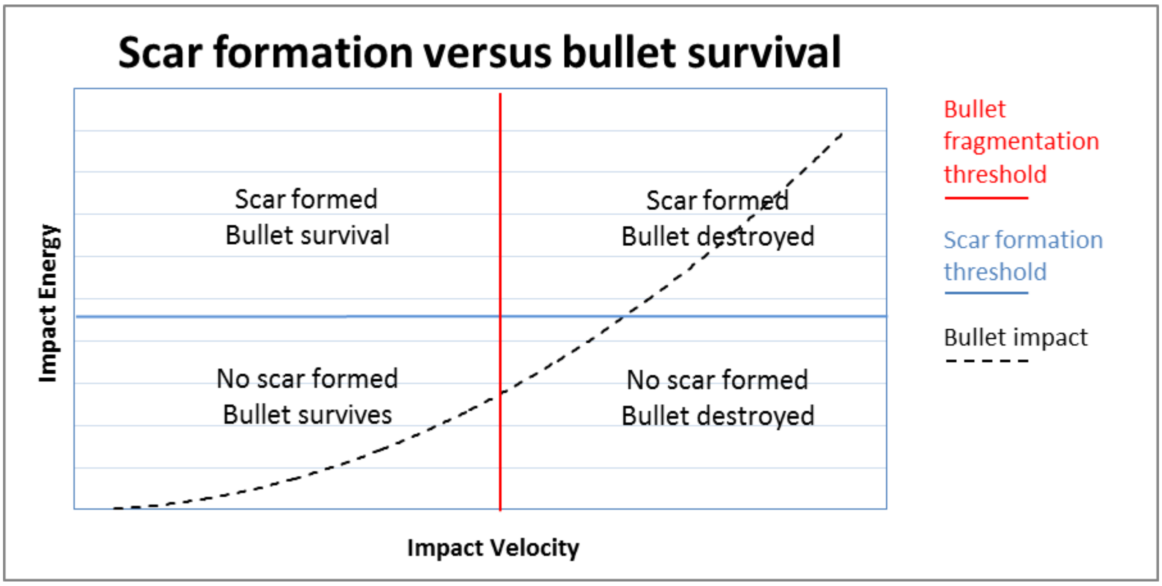

Figure 40: Chart illustrating impact outcomes for bullet and impacted surface. Here the hypothetical threshold (represented by the bullet impact curve) indicates a scenario where intact impacted bullets could not have produced an impact scar.

The dotted curve shows the increasing impact energy for a bullet of fixed mass at increasing impact velocities (KE =$\frac{1}{2}mv^2$). The bullet fragmentation threshold will be dependent on the yield of the impacted surface, with more yielding surfaces shifting that line to the right along the x-axis (i.e. higher velocity before surpassing the threshold). The scar formation threshold is dependent on the failure point of the surface of the stone type, with stone more resistant to impact before surface fragmentation occurs pushing the line upwards along the y-axis (i.e. higher energy required to overcome the threshold).

If the intersection of the threshold lines falls below the curve for a surface type, largely intact impacted bullets could be found in an associated context with the scars they formed at that location. If the intersection lies above the curve, any surviving bullets found could not have caused visible impact scars at a site, and consequently all scar-forming bullets will be present only in very small fragments. Identifying where each of these lines should be drawn for any given stone type will be dependent on identifying the behaviour of stone surfaces to impact through experimentally testing how the different properties (surface hardness, compression strength, density) relate to impact characteristics determined by impact variables (bullet calibre, impact angle, and impact energy), and the degree of yield these surfaces offer to an impacting bullet that will influence deceleration and the subsequent depth of the initial impact mark. Detailed analysis of this issue is beyond the means of this study, though identifying and understanding how each of these elements influences the form of impact marks and archaeological scars should be incorporated into future ballistic experimentation.

6.1.3 Impacted surface response by Mol et al. (2017)

The only study identified by the author using ballistic impacts on sandstone where the impacted surface was the focus of the research was produced by Mol et al. (2017) as a means to investigate the influence bullet impact scars have on the subsequent vulnerability of masonry to weathering, and how this might inform conservation strategies for built heritage. The experiment consisted of testing the surface hardness of several small stone blocks prior to shooting, after being shot, and further after a series of environmental stress-tests using moisture and temperature. As the blocks were all of freshly cut sandstone (sourced from northern Spain), half of the blocks were subjected to surface treatment using a consolidant (Wacker OH 100) to simulate case hardening of the outer surface of the stone blocks (Mol et al., 2017). The impacts were produced using rifle-fired .22 calibre bullets, with multiple impacts inflicted on the target site of each block to enhance the overall impact effect. Though the impact velocities and projectile size are notably different to those contemporary to the English Civil Wars, the behaviour of the stone structure subsequent to impact was the principle focus of the study, rather than the resulting impact marks themselves.

What Mol et al. found is that, while bullet impacts weakened all of the stone surfaces the artificially case-hardened stone suffered a greater degree of weakening in the surface levels due to the reduced plasticity of the response of the surface to impact, and changed the moisture conduct through the stone, likely as a result of microscopic fracturing at the surface levels acting as capillaries for the movement of moisture (Mol et al., 2017). The assessment given by Mol et al. is that the case-hardened surface acts as a boundary layer to the impacts, redistributing the shock damage through the outer surface. While the consolidate layer acts as an effective barrier to the ingress of the impact scar fracturing removing only the outer consolidated surface, the fresh-surface sample presented a more jagged internal surface, and was more likely to have deeper structural damage following natural faults in the material due to the lack of surface resistance (Mol et al., 2017). While this resistance effectively protects the subsurface surrounding the impact due to shock-realignment of the clay matrix without the fracturing seen in the fresh sample, the increase in the conduction of moisture in this level, as well as in the area behind the scar, puts these areas at greater risk of weathering within the rock surface as internal moisture is a key driving force in weathering processes (Mol et al., 2017).

6.1.4 Impacted stone assessment at Powick Church (Mol and Gomez-Heras, 2018)

Subsequent investigation of the impact scars on Powick Church, a result of fighting during the Battle of Worcester (1651) carried out by Mol and Gomez-Heras, revealed that the resulting structural changes brought about by low-velocity impacts, such as musket fire, can actually enhance the surface strength of the stone in the immediate vicinity of singular impacts (Mol and Gomez-Heras, 2018, pp. 5-6). However for blocks carrying multiple impact scars, the repeated shock effect has the reverse effect on the stone, creating multiple re-alignment directions and producing a generally weaker surface (Mol and Gomez-Heras, 2018, pp. 6).

The study misidentify the typical muzzle velocity of a smoothbore musket, citing it as 180ms^{-1} (Mol and Gomez-Heras, 2018, pp. 5) rather than a value of 450-500ms^{-1} as agreed by recent ballistics studies of smoothbore muskets (Eyers, 2006, Roberts et al., 2008, Miller, 2010, Parkman, 2017). The impact velocity values upon which the 2017 experiments were based fall in the range of 275-365ms^{-1} (Mol and Gomez-Heras, 2018, pp. 5), and remain within the region of low-velocity impacts as termed by the authors. What has not been taken into consideration in either of the 2017 or 2018 investigations, however, is how the kinetic energy of the bullet factors into the resulting structural changes. A 1.9g[1] .22 calibre round-nosed lead rifle bullet travelling at 300ms^{-1}, for instance, would have a kinetic energy of 85.5J. By comparison a 12-bore (37.8g) musket ball with the same impact velocity has a kinetic energy of 1.7kJ, an almost 20-fold increase. While the surface hardness tests at Powick Church match the findings of the 2017 study, the overlooking of the influence of impact energy at this velocity range, whilst acknowledging the influence of this same factor for the difference between musket impacts and those of AK-47 (Mol and Gomez-Heras, 2018, pp. 5), is something that should be addressed in future impact studies of the surface properties of impacted stone targets.

6.1.4.1 Weathering development and survival bias of scars

The identified weaknesses of impacted stone surfaces above have implications for both the development of impact marks into impact scars, and the survival of scars to the present day. As the key weakness to moisture movement within an impacted block is in the boundary between the case-hardened layer and the area immediately behind the impact, this means that weathering of material is most likely to result in deepening of the impact site, and loss of the outer surface of the block in areas of weakness, such as the edge of the block, or immediately around the scar. This raises the possibility that the most visible features of archaeological scars, the inner scar and the edge spalling, may be principally developed through weathering processes, and not a direct result of the impact process. The visual form of impact marks produced in experiments discussed above and below in this chapter would suggest that the scar formation process is at least a combination of impact process and weathering development. Exploration of the way in which different stone types better resist one or other of these processes would aid in understanding whether archaeological scars on specific structure surfaces are predominantly the result of the impact fragmentation or subsequent weathering. If weathering proves to be the fundamental process for all surface types then further investigation of how the measured characteristics of weathered features relate to the initial impact marks will be vital for translating variables used to create experimentally formed impacts into an analysis of archaeological scars.

The issue of multiple impacts enhancing surface weakening is an irony for the study of impact scars, in that a greater quantity of impacts in the past may result in fewer scars for study in the present due to the heightened risk of surface loss due to sub-surface fracturing. Surface loss has the potential to either reduce the upper levels of scar detail, specifically removing the edge spalling and reducing the depth of the overall scar, or in the worst case could result surface degradation and loss of the entire depth of impact scars across and entire stone block, with minimal evidence of the present of an impact scar surviving through to the remaining surface (Figure 41).

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[1] The ammunition used is not explicitly stated. This mass is identified for a standard .22 short lead-round-nosed rifle bullet produced by Cascade Cartridge Inc. (CCI) - *https://www.cci-ammunition.com/products/detail.aspx?use=5&loadNo=0037*

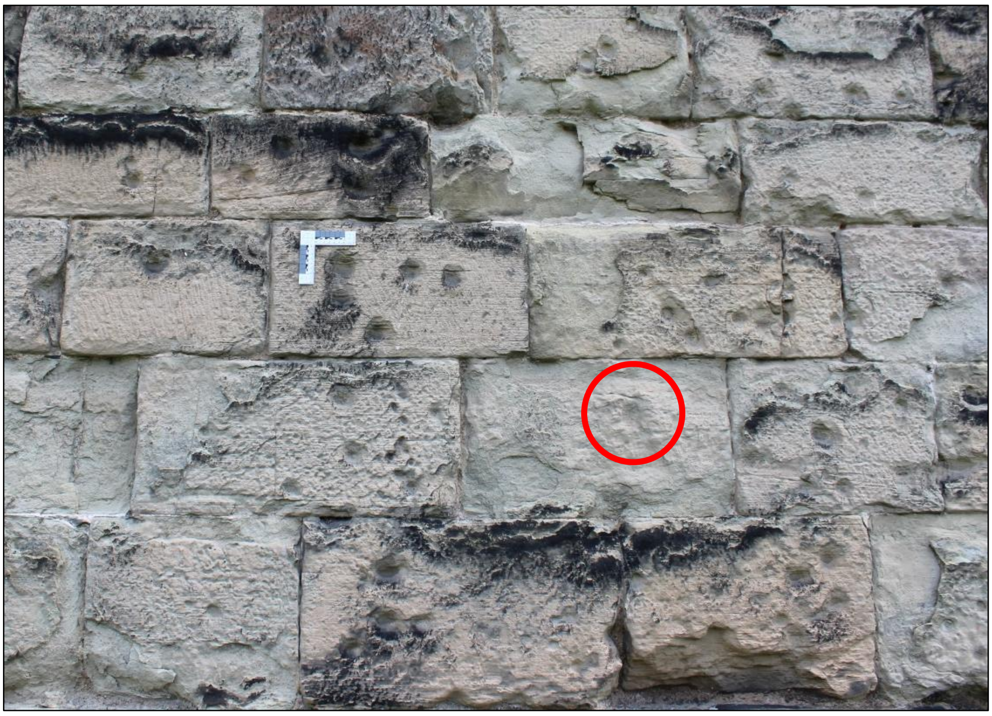

Figure 41: Photograph of impact scars at Ashby Castle. Circled is a scar where the original surface level has been lost due to weathering

This last point should be considered in any effort to establish impact density and distribution across a structure where obvious surface loss of stone blocks can be identified in areas adjacent to impact scarring. Loss of the surface of a stone block may reflect a result of natural weathering action on a structure, however there is an increased probability that the loss is due to, or may have been exacerbated by, the presence of scars on the former surface where adjacent blocks also carry impact scars in any quantity, leading to a survival bias in the assessment of distribution. An approach to assessing whether surface loss may be due to scarring could be to quantify the average percentage of any given surface area of a structure that has been lost to weathering, and compare the mean value against the density of surface area loss within locations of impact concentrations. This may prove difficult to adequately assess for ruined structures where significant portions of surface loss may also be due to accelerated weathering through damage, destruction or demolition of the site, however a limited attempt at this type of assessment is presented in the chapter below in the examination of impact evidence at Old Wardour Castle, Wiltshire.

6.1.5 Issues that require further exploration

As identified in the above studies, understanding of historic impacts and archaeological impact scars can be enhanced, though in a limited way, through related studies utilising ballistics experiments. Confirmation of trends identified in the examination of archaeological scars through investigation of freshly-created impact marks highlights the need for a better understanding of how impacts lead eventually to weathered scars, and the links between these two aspects. Understanding the influence of weathering and the degradation of stone surfaces as a result of impact processes and moisture ingress will be key to identifying how scars develop, as is understanding which aspects of marks that are a direct product of impact are reflected in scar features once weathering has modified these into the measurable examples on present day sites.

While research indicating that bullet fragmentation may be too significant at sites to allow any comparison between bullet and scar pairs, what has been taken from this research is an analytical question about range and muzzle velocity for those sites where impacted but largely intact bullets can be found archaeologically. These bullets having decelerated to an impact velocity too slow to cause fragmentation, indicate either an extreme of range of distance from firing to impact, or possibly issues of poor muzzle velocity performance of the firearm for that loaded-shot, adding to the opportunities for interpreting siege engagements and small-arms firefights from archaeological impacted-bullet evidence.

Further questions remain about how the variables of impact influence the initial mark that goes on to form an impact scar that, while within the realms of the studies discussed, fell outside of their objectives. The question of how impact energy and bullet calibre relate to impact mark characteristics requires further investigation, as while Green (2010) identified that scar area (and by extension diameter) and depth increase with impact energy for a fixed bullet mass, does this overlap with bullets of smaller size and mass impacting with the same energy due to higher impact velocity? Haag and Jason (2012) identified the threshold for bullet disintegration for orthogonal impacts on unyielding surfaces, but how do frangible surfaces affect the deceleration of the bullet, and do non-orthogonal impacts have a similar threshold for bullet survival? How do the vulnerabilities to accelerated weathering for the scar and the subsurface behind case-hardened layers, identified by Mol et al. (2017), influence the weathering-development of individual scars differently from those occurring in groupings on a single stone block? Do these weaknesses eradicate the original impact mark features through weathering, or does erosion in archaeological scars enhance those features directly or proportionately to the original mark? Further studies will need to tackle these issues before a complete picture of impact scar formation and evolution is understood, and for the identification of controlled variables within the resulting marks to be properly explored through archaeological impact evidence.

6.2 Exploring scars through experimentation

The studies outlined above raise questions about what a fresh impact mark for an early modern small-arms bullet impact looks like prior to development into an archaeological scar. Limited imagery available from the study by Green (2010) suggest the impact features created on the sandstone block in these experiments vary considerably from those produced by Haag and Jason (2012), and by Mol et al. (2017). The fundamental problem with attempting to reconcile these differences is that each impact was made against a different stone type, with different munitions at different impact velocities. As such it is entirely unclear from these studies what form a fresh impact mark should take, and which elements of that mark are likely to develop into the form of an impact scar. This is complicated by the fact that the appearance of impact scars from the Civil Wars is a product of nearly four centuries of exposure to weathering action upon both the original impact mark and the surrounding stone surface. In order to begin linking the initial impact conditions of an impact mark to the form of a present-day archaeological scar, it is necessary to establish what the former should look like experimentally.

To answer this question more directly, two ballistic studies were undertaken in support of this studentship. The first, unpublished, experiment was carried out by Amanda Wynne in 2012 in an effort to prove the concept that lab-generated archaeological scars could be used to advance impact scar research. The second study, carried out by the author in 2019, set out as an attempt to examine changing impact mark shape with increasing angle of incidence to the target surface. However, concerns over the likelihood of producing useable data following an initial set of trial impacts, this developed into an examination of variation in impact mark size and bullet-remnant form for a series of comparable impacts on case-hardened sandstone. These impact marks also serve as the initial dataset for an ongoing study into the influence of weathering on the developing form of impact scars.

6.2.1 Impact experiments at Shrivenham Defence Academy (Wynne, 2012)

An experimental set of trial impacts of musket balls against stone targets was carried out by Amanda Wynne in 2012 as a precursor to the present study. This preliminary investigation was to test the feasibility of using impacts created under controlled conditions on a firing range to compare with and evaluate archaeological scars (Wynne, 2012). These impacts were carried out at the Small Arms Experimental Range at Shrivenham Defence Academy and incorporated the use of Doppler radar tracking of velocity of the fired bullet, and high-speed camera footage of the impact process of each shot. Wynne's aim was to create a set of comparable scars formed across a set of blocks of a single stone type and a consistent bullet mass, impact velocity and angle of incidence, to examine the variation in resulting scar shape and the usefulness of precision measuring (particularly laser scanning) for examining archaeological sites (Wynne, 2012). This work built on the observation of the relationship between impact velocity and scar size noted by (Green, 2010).

6.2.1.1 The methodology and experiment set-up

The experimental set-up comprised a stone target positioned 10m from the muzzle of a simulated musket, consisting of a smoothbore barrel and a firing chamber with an electronic detonator (Figure 42). Into this apparatus a single pre-weighed 12-bore lead musket ball and a pre-measured quantity of G12 gunpowder was loaded, and fired remotely at the target blocks. The bullet velocity down range was tracked by Doppler radar to record the impact velocity of the bullet, allowing for a calculation of the kinetic energy of the bullet at impact. The impact moment itself was captured in video using a high-speed camera.

Figure 42: Photograph of experimental firing set-up as used by Wynne (2012)

Thirteen shots were fired, initially with a variety of powder charge quantities, before settling on a 6g charge due to practical reasons of survival of the stone block, as well as producing a clearly defined impact feature (Wynne, 2012). The target blocks consisted of two selected stone types sourced from separate quarries in northern Shropshire and South Yorkshire to account for potential problems with surface behaviour not producing a measurable scar (Wynne, 2012). The majority of the blocks were shot twice (once each on opposing sides) to maximise the number of impacts possible from the supply of stone available, however this lead to at least one block being catastrophically fractured during its second impact whilst on the range (Wynne, 2012), and the resulting structural weaknesses cause by impact fractures penetrating from opposing sides led to another two blocks being broken in half as a result of movement in storage whilst at the University of Huddersfield, following the conclusion of the experiments. Only nine of the impact marks formed during the experiments was available to be profile measured and photographed by the author. Bullet fragments from each impact were recovered after individual firings and re-weighed afterwards to examine mass lost due to impact and missing fragments (Wynne, 2012).

6.2.1.2 Data losses

While this trial produced the first set of experimentally created impacted surfaces available for examination and assessment by this study, there are a number of barriers to a detailed analysis of these results. The principal issue is that, while each bullet was recorded for mass, impact velocity and recovered mass, the data linking the bullets to the impacted stones is not available for investigation. Though each impact is individually numerically labelled for the shot order in which it was formed, the bullet data does not reflect firing order, and only five of the impacting shots can be attributed to specific bullet records with any confidence, due in part to careful matching of some of the rebounding bullets or bullet fragments visible in the high-speed video footage with individually bagged fragments that are labelled with identifying details from the bullet table. Of those five identified shots, 'MB16 (shot 3)' and 'MB08 (shot 4)' impacted a block that was destroyed by 'shot 4'. Of the remaining eight unidentified shots, the block upon which impacts 9 and 10 occurred was broken as a result of movement in storage, with a bisecting fracture passing through both impact sites rendering them immeasurable (the final block breakage for impacts 12 and 13 occurred after profile-recording had taken place). This left a total of six surviving, unidentified impacts across five blocks of stone for which the details relating to the impacting shot and bullet are lost. Despite the missing data however, it is evident from the results table that each of the remaining impacts were formed using bullets fired with 6g of propellant producing an impact velocity range of around 311ms^{-1} (+/- 12ms^{-1}) and impact kinetic energy of 1.81kJ (+/- 0.14kJ).

6.2.1.3 The results

The results data from Wynne (2012) is presented below in Table 8 with records for unfired bullets removed for clarity, calculated kinetic energy values at impact, and the shot/block number where identified from the high-speed footage. Table 9 presents the mean values for cross-sectional profile measurements taken by the author from each of the intact impacted blocks, in storage at the University of Huddersfield.

Shot No.	Bullet No.	Mass (g)	Stone Type	Powder Charge (g)	Velocity (ms^{-1})	Kinetic Energy (kJ)	Recovered Mass (g)	Impacted bullet condition
1	-	-	Derby	4	259	1.26*	17.2	Fragmented
2	-	-	Derby	2	159	0.46*	38.2	Flattened disc
3	MB 16	37.6	Grinshill	3	148	0.41	37.7	Flattened disc
4	MB 08	37.4	Grinshill	10	355	2.36	34.7	Uneven disc
-	MB 01	37.4	Grinshill	6	316	1.87	30.8	Fragmented
-	MB 02	37.4	Grinshill	6	299	1.67	9.5	Fragmented
-	MB 05	37.6	Grinshill	6	312	1.83	31.3	-
-	MB 07	37.6	Grinshill	6	304	1.74	33.6	Fragmented
-	MB 09	37.6	Grinshill	6	322	1.95	33.6	Fragmented
-	MB 13	37.4	Grinshill	6	320	1.92	22.7	Fragmented
-	MB 14	37.6	Grinshill	6	321	1.94	30.0	Fragmented
-	MB 17	37.1	Derby	6	323	1.94	17.6	Fragmented
13	MB 19	37.4	Grinshill	6	311	1.81	17.9	Fragmented

Table 8: Recorded bullet data from impact experiments carried out at Shrivenham Defence Academy. Kinetic energy values marked with * are approximate values based off of an assumed mean bullet mass of 37.47g. Data reproduced from (Wynne, 2012)

Shot no.	Mean total diameter (mm)	Mean depth of penetration (mm)	Mean ratio of diameter to depth (:1)	X-axis deviation of deepest point (mm)[1]	Mean depth of spalling inner-edge (mm)	Mean width of spalling (mm)
1	45	5	9.0	3	2	8
2	45	5	9.0	6	2	5
5	93	19	4.9	-3	11	25
6	59	13	4.5	1	6	14
7	99	21	4.7	-9	11	28
8	93	21	4.4	-12	13	28
11[2]	59	8	7.4	-1	5	18
12	82	21	3.9	2	12	21
13	65	13	5.0	7	6	14

Table 9: Mean measurements from cross-sectional profile recording of impacts across all four axes

1- *Deviation measured as x-axis offset of the deepest point from the overall impact centre including spalling.*
2- *Mean values for impact 11 incorporate horizontal and vertical axes only due to problems encountered recording the uneven surface surrounding the impact mark.)*

6.2.1.4 Examination of the impact profile measurements

A notable observation from the impact mark data is the similarity in the profile measurements for each of the impacts formed on the Grinshill cream sandstone using a 6g propellant charge at an orthogonal impact angle (Impacts 5, 7, 8 & 12). These are largely identical in their overall diameter, depth of penetration, and the degree of spalling within the impact mark. The inference from this is that the surface of multiple blocks from a single source of stone behaves in a broadly uniform manner under the same impact variables. If this is found to be true for other stone types, this implies that variation in the measured size and shape of archaeological scars across a structure of an homogenous stone type will be more dependent on variances in weathering and the impact variables of the impacting shot. If through experimentation the process of weathering on impacts upon a single stone type can also be found to be broadly similar, this would directly connect variation in scars to the changes in the variables of the shot that formed these scars. It also needs to be examined whether case-hardened stone reacts more or less variedly upon impact than for unweathered stones as used here.

The remaining impacts (1, 2, 6, 11 and 13) cannot be directly compared to the above set for a number of reasons. Impacts 1, 2 occurred against a different stone type at much lower velocities than for the other shots, and left surface marks without penetrating the block surface to any depth greater than 5mm.

6.2.1.5 Impacts 1 and 2 – low-velocity impacts on weathered Derby stone

One unexpected outcome from the profile measurements occurs in relation to shots 1 and 2 (the initial test shots) against the weathered 'Derby' stone block. Here shot 1 was fired with a 4g charge of propellant striking the block at 259ms^{-1}, while shot 2 using a 2g charge impacted the block at 159ms^{-1}. Despite a 100ms^{-1} difference in impact velocity, and an approximately threefold greater release of kinetic energy in the shot 1 impact compared with shot 2, the resulting impact marks were practically identical in mean values for diameter and depth. This stands in contradiction to the observation by Green that impact size increases with greater impact velocity for a fixed projectile calibre at targets of the same stone type (Green, 2010).

A possible explanation for this may be that the greater hardness of the Derby yellow sandstone compared with the Grinshill cream stone of the sandstone block used by Green, though this is difficult to ascertain for certain as Green does not state the source of the sandstone block nor indicate whether the block was freshly cut or had been subject to weathering prior to impact. Even so, it is reasonable to expect that an impact of increased energy should result in a larger impact mark due to a greater transfer of energy into the stone surface, and there is no reason to doubt that weathered stone surfaces would follow this same general rule even if the degree of variation is less pronounced. A more likely hypothesis is that for both of these impacts, the failure point of the case-hardened and natural tougher stone surface had not been reached by these impacts, and that these surface marks reflect only the area of the stone immediately adjacent to or behind the impact point. Abrasion by the bullet alone is insufficient to account for the overall impact diameter, as the recovered flattened bullet from shot 2 measures a mean diameter of approximately 35mm, compared with the total diameter range of 40-48mm across the four measured axes. The hypothesis presented here is that bullet contact and abrasion is compounded by abrasion from the displaced grains of pulverised stone from the impact point that are ejected outward at high velocity after impact. Examination of the video footage for both shots shows significant quantities of 'dust' being ejected from the impact point without signs of larger fractured surface pieces amongst the pulverised grains.

Both of these impact marks are extremely superficial and could be rendered undetectable as archaeological scars if the stone is prone to 'flaking' or 'scaling' types of weathered surface-loss. Alternatively the impact may have resulted in a weakening of the surface immediately behind the impact point, and over time may become more visible in the stone surface resembling more typical archaeological scars. The only shot with a comparable impact velocity and resulting bullet shape to shots 1 and 2 would have been shot 3, however the destruction of this block means a direct comparison cannot be made between the non-penetrating impact marks from the case-hardened and the unweathered stone blocks used in this experiment.

6.2.1.6 Impact 6 – unidentified target block

Shot 6 was fired with a 6g propellant charge, and produced an impact with a comparable diameter to depth ratio with the above group of four shots also fired using 6g charges, although the profile measurement values from this impact are smaller. The stone itself is visually different to the other Grinshill cream blocks, suggesting that this may be the unidentified 'Derby yellow' stone target for bullet MB17 (Table 8), however this would contradict Wynne's observation that the impacts on the weathered 'Derby' stone barely formed an impact scar (Wynne, 2012), so this cannot be stated with certainty. If it were indeed an impact on weathered stone under the same impact parameters, the possibility of a connection in scar size ratios to the other scars would suggest there may be a connection between shot variables (in this case angle, calibre and impact velocity, which were broadly the same) and impact mark ratios for resulting impact marks where the failure point of the stone surface has been surpassed. However as scar depth to diameter ratios are also broadly similar across single stone types, this could also be indicating that this is another Grinshill block with a slightly different outer appearance.

6.2.1.7 Impact 11 – rough surface impact

Shot 11 impacted an unworked surface of the target block which presented a backward-sloped incline towards the direction of impact. As such the surface shape and angle of impact do not allow for direct comparison to the other impact scars. Furthermore the unevenness of the original surface made measurement of the cross-sectional profile difficult to achieve or reliably quantify as what degree of the impact mark's volume was lost through impact, or reflected the unrecorded surface before impact, could not be reliably estimated. The subtlety of the impact mark may identify this as the MB17 shot as per Wynne's observations, though the stone visually more closely resembles some of the Grinshill cream blocks. While further exploration of rough-surface impacts may be warranted for future research aimed at identifying impacts on unworked stone surfaces, due to a lack of sufficient archaeological examples for comparison this is not explored further in the present study.

6.2.1.8 Impact 13 - angled impact on Grinshill stone

Shot 13 impacted a block of the Grinshill stone use the same propellant charge as for impacts 5-12, however this impact was angled to occur at a 40° angle of incidence to the surface of the block. The resulting impact mark penetrated the block to a lesser extent than for the orthogonal impacts using the same stone type and propellant charge. There is also a pronounced off-set of the deepest point of the impact from the overall centre of the diameter of the cross-section taken from the horizontal axis. The cross-sectional profile of impact 13 is presented in Figure 43, together with that of impact 12 on the reverse side of the same block.

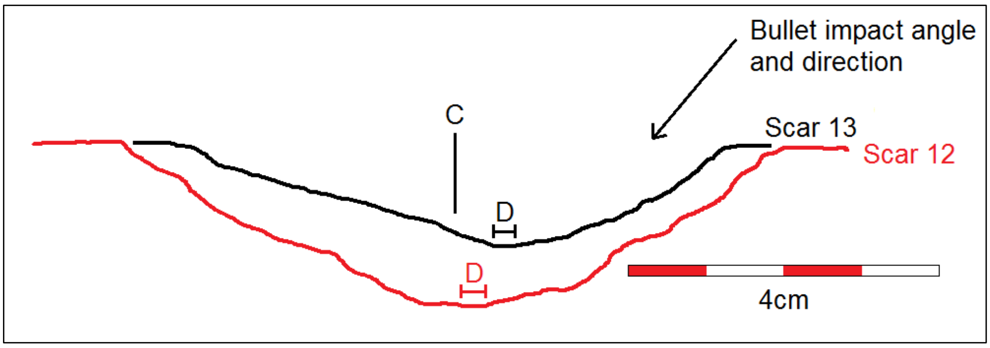

Figure 43: Profile comparison of x-axis for impacts 12 (orthogonal impact) and 13 (40° impact) on a single block of unweathered Grinshill sandstone. D denotes the deepest portion of the resulting mark. C denotes the overall centre of the total diameter for both

While this elongation along the direction of travel supports ballistic theory presented by Haag and Haag (2011) for ricochets in modern impacts on frangible surfaces, the measurement data taken for this impact compared with some of the orthogonal impacts suggests that data analysis of profiles alone may not find these elongations. The data from impact 8 for instance shows a remarkable 12mm offset of the deepest point to the left of the overall impact centre, implying an angled impact from left to right, rather than the orthogonal impact that created it. On inspection this is revealed to be a result of the asymmetric edge-spalling at the surface adjacent to the apparent 'inner scar', and does not reflect the internal profile generally. If the diameter measurement instead from 5mm forward from the deepest point, the offset of impact 8 shifts from 12mm to the left to being 1mm to the right, making the impact almost symmetrical in the internal geometry. However if a similar approach is take with impact 13 in the same axis, the offset is eliminated entirely and the data returns a value indicating a symmetrical impact mark, despite the visible elongation.

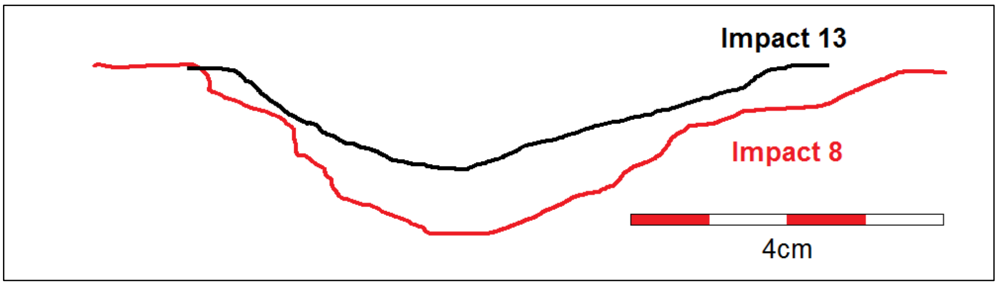

Figure 44: Profile comparison of x-axis for impacts 8 and 13. The cross-section of impact 13 has been reversed to allow direct comparison between the off-sets and profiles of these impacts

The issue appears to be that simple measurements of the traced profiles of impacts are not sophisticated enough to show overall impact shape with regards to identifying possible angled impacts from the recorded data. There is need either for a different measurement approach to measuring depth distribution across impact marks and scar, or for an additional visual assessment of the overall cross-sectional shape to be incorporated into the digital record for each recorded impact mark and scar. An intuitive visual comparison of the profiles (Figure 44) would indicate that impact 13 has a more distinct offset than impact 8, nevertheless this requires a subjective assessment where the ideal would be for a more objective quality drawn from the measurement data alone.

6.2.1.9 Comparing experimental impacts with archaeological scars

Using the impacts created in this trial may be an unfair test of the assessment methodology of the cross-sectional shape. The assumption is that these impact marks reflect the real-world behaviour of impacted surfaces as would have occurred in the past, and would over time come to resemble the archaeological impact scars we see now. However as is identified above and discussed further below, the surfaces of the Grinshill stone blocks had not been exposed to weathering that induced case-hardening in sedimentary rocks. As such the surfaces of these blocks have fragmented and fractured in a manner that does not generally reflect observed archaeological examples of impact scars, particularly those on stone from the same quarried source used at Moreton Corbet Castle. The irregular internal shape of impact 8 particularly leads to difficulty in objectively measuring the boundary of the outer spalling and the inner scar, as the outcome of the 'spalling turn' approach discussed in the previous chapter produces a very deep and wide spalled area in the measurements due the stepped internal profile. Once again an intuitive observation suggests that the spalled component should appear much closer to the surface of the block, but this is not reflected in the approach previously used above. The presence of genuine outer spalling may in fact be a result of the presence of case-hardening in the outer layers of the stone surface, where the hardened shell break away around the impact site, instead of being pulverised and pushed out as seems to occur for the area of impact directly beneath the bullet.

The impacts created in this experiment visually differ somewhat from archaeological examples in their overall appearance. The obvious differences lie in the internal surface of the impact mark both in texture and shape, with fresh impacts having an undulating internal surface with a granular appearance, whilst being extremely vulnerable to loss of material through contact abrasion. By contrast archaeological examples are generally smooth in profile shape and appearance and the internal surfaces are typically resistant to light contact, with exceptional examples where surface stonework is decaying poorly at sites such as St. Michael's church, High Ercall. For a number of the experimental impacts there were also large sections of the adjacent outer surface showing additional fragmentation and risk of breaking away, however unlike archaeological examples of spalling, these sections frequently penetrated to more than half of the depth of overall impact (Figure 45).

Figure 45: Photograph of experimental impact 5 from Wynne (2012), showing the excessive depth of the spalled radius at the edge of the scar

It could be assumed that the process of exposure to weathering over more than three-hundred years would serve to smooth the internal profile of the scars and consolidate the internal surface of the impact scar as it evolves. However in order to do this weathering must remove the excess material in order to 'smooth' the surface, and is unlikely to strengthen the faults in the fragmented surface of the impacts. This makes these impacts unlikely to be candidate for the starting point of archaeological impact scars, as these marks are excessively large when compared to the mean impact scar size from siege sites generally, for those recorded at the sampled sites in the previous chapter, and for archaeological examples from Grinshill stone surfaces at Moreton Corbet Castle (Chapter 7).

In attempting to compare these impacts with archaeological scars there is however a selection issue. The experimental impacts are particularly large when comparing diameter and depth dimensions with those of typical impact scars at other sites. While larger scars have been measured at each of the sampled sites examined in the previous chapter, these represent a small subset of those recorded, and are larger than typical scars observed at other sites examined by the author. It is possible that these larger scars formed under comparable impact variables to the experimental impacts resulting in their size-characteristics, or alternatively the large experimental impacts could reflect an uncontrolled variable not considered in the trials. However the most likely answer is that the unweathered Grinshill stone surfaces behave differently in response to impact fragmentation that would be expected from sandstone that had a case-hardened outer surface, and subsequent experimentation will need to take this into account when sourcing target stone blocks.

6.2.1.10 Comparison with similar-diameter scars across sites

Figure 46 and Figure 47 below shows impact 8 compared with scars of similar diameter from sites examined in the previous chapter that have a similar overall diameter. The scar profiles have been aligned with the deepest points of the scar in vertical alignment, with block-surface level used as the datum for horizontal alignment.

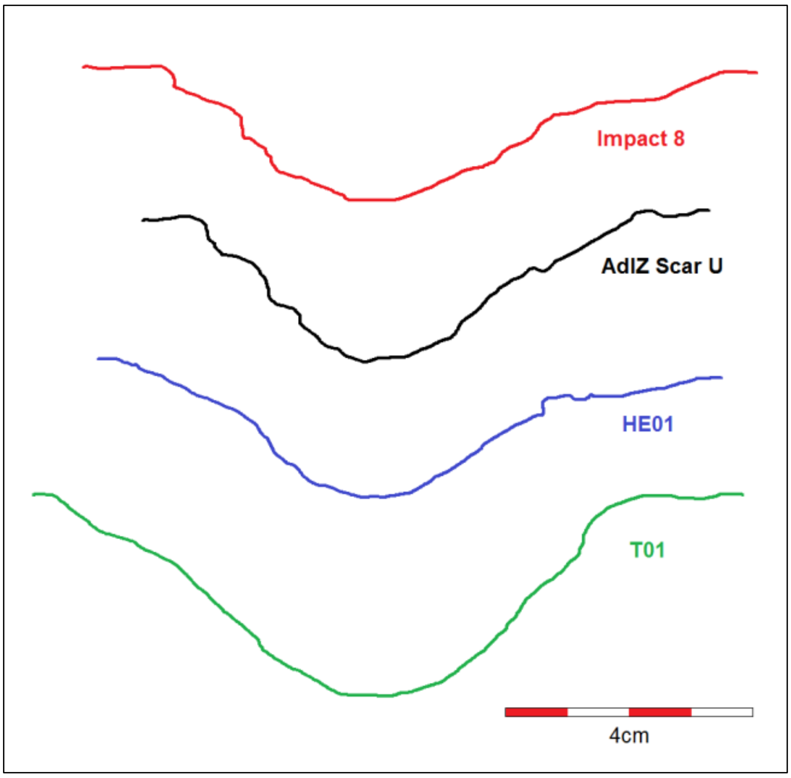

Figure 46: Cross-sectional diagram of impact 8 with scars sampled in chapter five

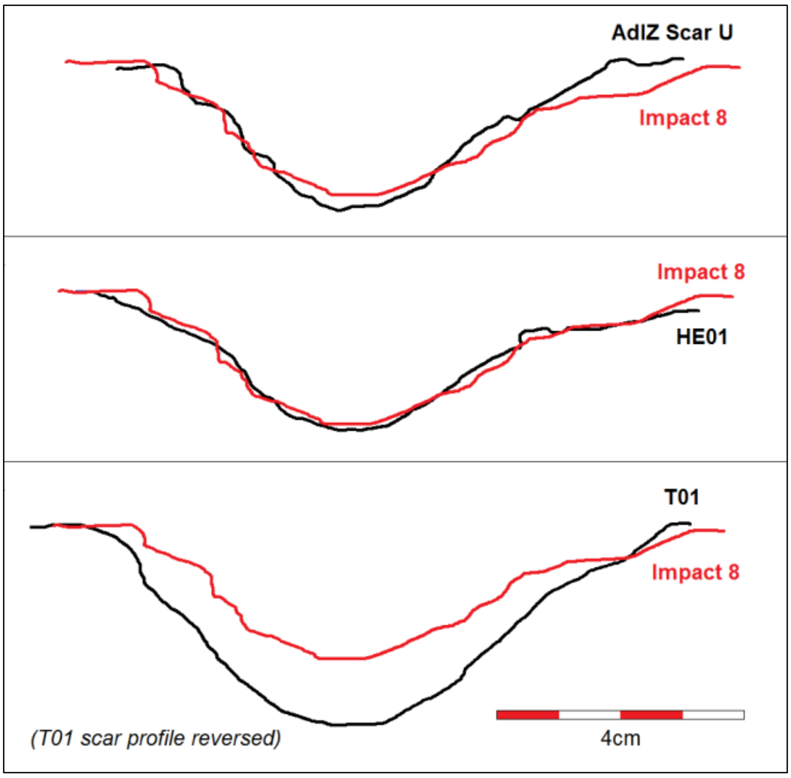

Figure 47: Cross-section diagram showing scar 8 profiles overlapped with sample scars

The cross-sections of the weathered archaeological scars show a more softened profile shape overall, with some exception for the scar measured at Ashby Castle (AdlZ Scar U) which is due in part to uneven weathering of vulnerable bedding planes within the sandstone block creating a stepped effect internally. A similar prominent step feature occurs on the right side of the profile of the scar from High Ercall church (HE01), however this is due to surface loss of the adjacent wall surface through flaking and reflects a small section of the wall surface that is now exposed and will likely fall away in the near future. While these steps are largely a result of the influence of weathering on the surface stone at these sites, this is a post-impact feature for impact 8, and is thus produced by different processes to those in the archaeological scars.

A broad similarity can be observed between the experimental scar and the archaeological scars, and while the Tong church scar (T01) is much deeper than the experimental impact, it is possible to see how impact 8 could feasibly soften and deepen with weathering to produce a scar of similar depth and profile to T01. What is not evident from these profiles however is the degree of fracturing in the surface of adjacent block material, and if subjected to weathering impact 8 would undoubtedly become wider as well as deeper across the scar.

6.2.1.11 Comparison with median-sized scars across sampled sites

Figure 48 below shows the scar from impact 8 compared with the median diameter and depth measured scars from the sites examined in the previous chapter. These profiles are aligned vertically and horizontally as for the above comparisons.

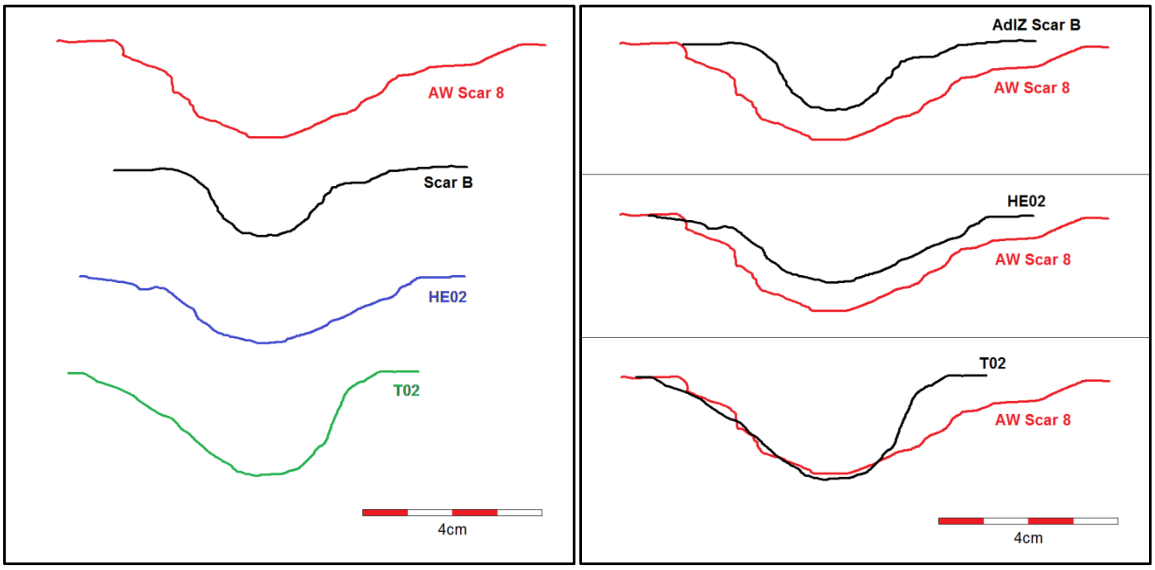

Figure 48: Cross sections of scar 8 compared with sampled scars

In comparison with the median scars the dramatic difference in size becomes much more apparent. Of all the cross-sections, the only scar that matches the overall profile to any reasonable degree is the scar from High Ercall (HE02), as were the upper centimetre of the block surface removed from impact 8, the remaining lower profile would match the overall shape of HE02. This scenario however, where the outer block erodes evenly and more rapidly that the remainder of the impact, also assumes that the impacted, loose-surfaced material at the base of freshly formed impact mark for shot 8 would be somehow more resistant to weathering than the cut face of the block upon which it was formed.

In practical terms the surface loss of the block at High Ercall is unlikely to be as great as 10mm despite the poor surface condition of much of the stone surfaces at the tower base. This could potentially occur for stone surfaces that had undergone significant surface loss through contour scaling, however this type of erosion cannot be seen on the tower at High Ercall. Furthermore the presence of inclusion-seams of harder-wearing material within and protruding from the faces of some blocks of the sandstone masonry implies that these represent the original surface level and would suggest the occurrence of an average surface loss of no more than 2-3mm. It seems highly improbable that impact 8 resembles a formative stage for any of the compared median scars.

6.2.1.12 Comparison with archaeological scars on Grinshill sandstone

For the final comparison with an archaeological scar, impact 8 is compared below with the cross-sectional profile of an impact scar at Moreton Corbet Castle, occurring on part of the structure that was faced in the same cream sandstone from the local Grinshill quarry when constructed in the late sixteenth and early seventeenth centuries. Figure 49 below shows the same experimental scar as above compared with a scar of similar diameter measured from Elizabethan southern range of Moreton Corbet Castle (MC E05). These archaeological scars are discussed in more detail as part of Chapter 8.

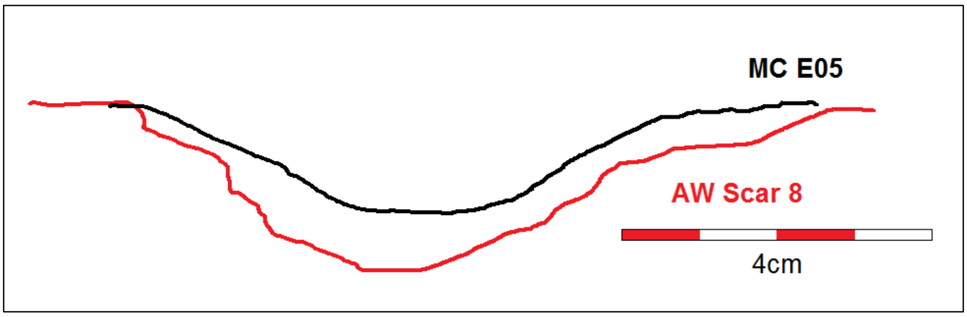

Figure 49: Cross section of scar E05 from Moreton Corbet and scar 8

As with the median scar comparisons, the archaeological example from Moreton Corbet Castle is considerably smaller than that for impact 8. The overall profile shape is broadly similar as with the High Ercall median scar, and it is worth noting that these two locations are separated by a linear distance of less than 7km and the possibility that the stone sourced for both structures comes from a common underlying geology for this area. Nevertheless the experimental impact once again is significantly in excess of the archaeological scar before weathering is even factored in to the process.

6.2.1.13 Impacted bullet examination

While the lack of identifying data between bullets and shot-surfaces poses an issue for detailed examination, for each bullet the impacted surface stone type, impact velocity, initial mass and impact angle are recorded for each bullet. The recovered fragments of the impact bullets were also retained, and available for measurement and visual assessment.

The experimental results by Green (2010) and Haag and Jason (2012) identify that, as impact velocity increases for an unyielding surface, the degree of fragmentation of the bullet increases as well, although quantifying the fragments to identify velocity proved beyond the capabilities of the former study, and was not a factor in the latter. The data from the shots and bullets gathered by Wynne (2012) indicates that the fragmentation threshold for the bullets lies somewhere between impact velocities of 159ms^{-1} and 259ms^{-1} for the Derby stone blocks. However quantifying this for the Grinshill blocks is more difficult owing to the variability of the degree of fragmentation observed in the recovered bullets (Table 10). While the fragmented Derby stone bullet (Test 1) broke into multiple small fragments akin to observations by the aforementioned studies, with a maximum recovered-fragment mass of 4.7g (12.5%), the Grinshill impacts behaved differently, with the orthogonal impacts using 6g of propellant producing fragments between 2.9g[2] (7.8% of MB02) and 27.8g (74% of MB05), with a median largest fragment size of 13.5g (35.8%).

Bullet no.	Shot no.	Impact velocity (m/s)	Heaviest recovered fragment (g)	Original bullet mass (g)	% of mass in largest fragment
Test 1	1	259	4.7	37.5	12.5
Test 2	2	159	38.1	37.5	101.7
MB16	3	148	37.6	37.6	99.9
MB08	4	355	34.5	37.4	92.3
MB01		316	25.9	37.4	69.3
MB02*		299	2.9	37.4	*7.8*
MB05		312	27.8	37.6	74.0
MB07		304	18.1	37.6	48.1
MB09		322	11.5	37.6	30.6
MB13		320	8.6	37.4	23.0
MB14		321	15.4	37.6	41.0
MB17*		323	6.0	37.1	*16.2*
MB19*	13	311	5.7	37.4	*15.2*

Table 10: Mass of largest recovered bullet fragments. In each case the largest fragment was, or was attached to, the core fragment of the bullet where initial contact with the impacted surface occurred. For bullets marked with an asterisk, the core bullet fragment was not recovered during the experiment.

As identified by Haag and Jason (2012), bullets are able to survive the c.200ms^{-1} impact velocity threshold for fragmentation if impacted surface yields to the projectile, increasing the distance and time interval over which the bullet decelerates and thereby reducing the internal g-forces that cause its destruction. While the case-hardened Derby stones apparently provided an unyielding target, the unweathered Grinshill stone pulverised and fragmented to such a degree that bullets hitting these surfaces were able to survive destruction, despite carrying on average velocities of 150% of the impact value required for fragmentation. This yielding could be the result of two possibilities; the Grinshill stone blocks are exceptionally soft by comparison with the Derby yellow stone, or the unweathered and unhardened Grinshill stones are more easily pulverised and fragmented due to lack of surface resistance to the impacts. The influence of yield is most noticeable in the instance of MB08, which impacted at the highest impact velocity of all of the shots (355ms^{-1}), yet survived intact as a single distorted bullet fragment due to the destruction of the impacted block (shot 4) acting as a dramatic form of yielding of the surface. The resulting bullet has a distinctive shape as a result of the impact, and while retaining the central rough-texture and outer striations seen on other impacted bullets, has an unusual 'stepped' appearance in contrast with the simple stations seen on the sub-threshold impacted bullets (Figure 50).

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[2] MB02 for which only 9.5g (25.4%) of the bullet mass was recovered

Figure 50: Resultant impacted bullet MB08 from shot 4 showing unusual, stepped impact surface, compared with MB16 from shot 3 which shows typical radial striations and embedded block material

The visual form of fragmentation in the Grinshill impacted bullets also differs from the Derby stone example. While the Derby stone fragmented bullet impacted and fragmented around the point of contact, producing a 'core-fragment' and detached sections of petalling, as is the observed behaviour of the bullets tested by Haag and Jason (2012) , the Grinshill-impacted bullets appear to have formed a disc that has subsequently inverted itself and bisected through tears in the lead disc, illustrated by comparing examples MB08 and MB05. This 'inverting-bullet' fragmentation phenomenon from the Grinshill impacts may need further investigation to determine the cause, however if this is as is most likely a result of the interaction between the bullet and the penetrated layer of the stone upon impact, examples of these kinds of bullets would not be expected to occur in archaeological contexts. For both of the non-penetrating impacts where the bullet survived intact, the examples from both the Grinshill impact and the Derby impact are nearly identical, producing a slightly curved and radially-striated disc on the contact surface, with embedded stone in the focal point of contact. Although the impacted surface from MB16 was lost due to the destruction of the block in shot 4, the similarity between the resulting bullets indicates that these impact marks may have been virtually identical.

6.2.1.14 Conclusions

Although a limited trial experiment to establish the practicality of creating impact scars under experimental conditions, Wynne's results provide a useful basis from which to approach future impact experiment planning. The issues raised provide opportunities for further investigation into the relationships between impact variables, surface type and variation in the resulting scar shape. Aside from the problems of loss of data linking the impacted bullets and shot parameters to the resulting scars, there are a number of methodological issues that also need to be addressed before further ballistic experimentation.

The principal issue arising from observations of the impact marks and impacted bullets from this experiment is whether or not these are representative of the archaeology. The doubt arises chiefly from whether the Grinshill impacted surfaces, which constitute eight out of eleven of the impact marks and the only surfaces upon which the impacts showed any variation or detail, behave in a realistic manner for producing the starting point for the development of archaeological scars. The key difference between the targeted blocks and the walls of contemporary structures at the outset of the Civil Wars is that the exposed external walls of buildings will almost certainly have undergone some degree of case-hardening due to exposure to the weather. How this toughened outer-skin of the impact surface influences the impact processes, and the formation (or not) of an impact scar for a given impact is unknown. The impacted examples of weathered stone used in Wynne's experiment comprised of a different stone type from the unweathered examples, and while two were impacted with bullets at different velocities, while the third appears to have been a non-orthogonal impact on an unworked surface. The upshot of this is that none of the resulting impact marks can be directly compared with the impact variables of the unweathered stones, and as such the behavioural differences remain speculative based on observations of the impact marks and bullets separately.

Without understanding whether the Grinshill block impacts are a true reflection of the starting basis for the formation of an impact scar, it becomes impossible to say whether observations from these impacts can be used to support hypotheses derived from theory and archaeological observations. Visible differences in the profile shape arising from the angled impact of shot 13, for example, could be supporting evidence that angled impacts produce a scar-elongation that could be measured from archaeological sites and used to make assessments of the direction or angle of impact of the bullet that produced the scar in the past. Alternatively it may only show that frangible stone surfaces behave according to theory as already established by Haag and Haag (2011), and that in reality non-orthogonal impacts on case-hardened surfaces the bullet might not sufficiently penetrate the surface to produce the elongated impact shape observed from the experiment. The two orthogonal impacts on the weathered Derby stone block offer little help in identifying the potential issues with case-hardening in impact behaviour, as both of the impacting bullets fired at orthogonal angles produced impact marks of the same overall size and depth, indicating either that the surface was too resistant to produce a sufficient mark for scar formation to occur, or more intriguingly that impact mark diameter might not influenced by impact velocity but instead by the calibre of the bullet, in contradiction of observations by Green (2010).

Although exposure to weathering of the impacted blocks from this experiment would provide useful information as to how the variances observed in the impact develop over time from their initial condition, attempting this is problematic without knowing the potential value of the impacts as indicators of the starting condition of impact scars. These would need a suitably secure outdoor location for them to develop undisturbed over an indeterminate timespan (likely several years), and the logistical commitment necessary for transporting, installing and retaining these due to their size and weight makes this an unwarranted use of resources without being certain of valid results. Future impact experiments should therefore also consider the practicalities of moving and storing blocks used as targets, as this would improve their practical usefulness for further investigation of the impact marks or stones, and their suitability for use in longitudinal studies of weathering.

6.2.2 Ballistic experiments at Yorkshire Shooting Centre (2019)

Following from exploratory experiments by Wynne (2012) it became apparent that a more focussed study would be required to identify how fresh impacts present themselves on case-hardened sandstone, and how specific impact variables might translate into features of freshly-formed impact marks that could be identified in archaeological scars. Previous investigations have highlighted the difficulty of using limited datasets to make significant statements regarding impact behaviour or the relationship between scar features and impact variables when looking at multiple variables within a single experiment. Given the limited resources available to this new investigation, the focus of these experiments was thus placed on creating a larger set of impacts to examine the influence of a single variable in order to better address questions relating to the feasibility of identifying impact variables from archaeological scars.

6.2.2.1 Aim

Ballistic trials carried out over two days at the Yorkshire Shooting Centre (Mirfield) sought to explore two issues pertaining to impact variables within a single experiment; the appearance and surface behaviour of case-hardened stone to small-arms impacts, and the variance in shape/form of impact marks with increasing angle of incidence to the target surface. After a set of initial test-impacts were produced, the resulting marks failed to produce a deep scar as had been initially expected based on the results of previous studies, and thus an examination to relate angle of impact to scar profile would have limited productivity within the timescale of this study, and the experiment was modified to examine the variation in impact size and shape for a collection of impacts at two impact velocity ranges for a single bullet calibre.

6.2.2.2 Methodology

The experiment was carried out using the 25m indoor small-arms range at the Yorkshire Shooting Centre in Mirfield, West Yorkshire. The indoor range was used to reduce the risk of stray bullet or stone fragments leaving the immediate vicinity of the range and causing harm or injury, with the additional benefit of reducing any limited interference upon the flight of the bullet from changing weather conditions.

The delivery firearm was positioned and secured at 10m from the vertical target-surface on a fixed support to ensure consistency in position, elevation and direction of the barrel and muzzle for each shot. The target block was positioned within a covered housing comprising of bullet-proof rubber blocks designed and constructed by the range staff to arrest any deflected bullet fragments and control as much as possible reduce the dispersal of the bullet fragments after impact. The range and housing were swept clear between each shot, however due to the degree of bullet fragmentation and the nature of the rubber blocks, an unknown proportion of the resulting bullet fragments were lost after each firing either due to rebound outside of the protective housing, or becoming wholly embedded in the rubber itself. A diagram of the range set-up is illustrated in Figure 51.

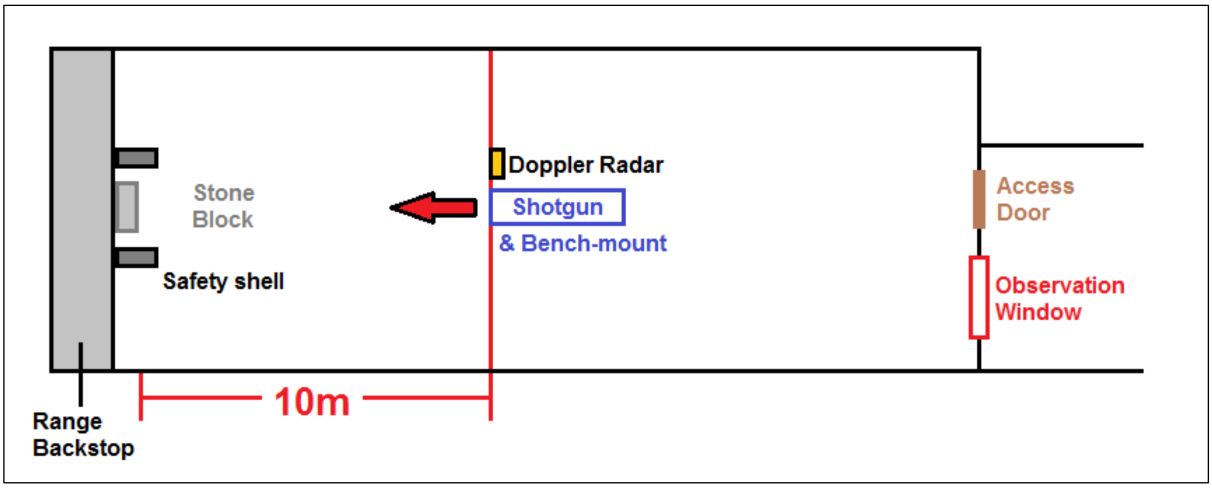

Figure 51: Diagram of experimental firing set-up

6.2.2.3 Firearm and loading process

As consistency in bullet impact velocity was a principal requirement for this experiment, the use of a replica musket was discounted in favour of the use of a 12-gauge smoothbore shotgun, provided for use by the Yorkshire Shooting Centre. The use of shotgun cartridges as a means of firing a musket ball in ballistics trails had been established by Green (2010) and utilised by Parkman (2017) during experiments to investigate the deformation of a bullet through impact with various surfaces. The use of a shotgun was determined not to adversely adulterate the bullet shape as a result of the firing process, evidenced through examination of a bullet fired during sighting of the weapon and recovered from one of the rubber blocks in the protective housing (Figure 52).

Figure 52: Recovered 14-bore musket ball fired from 12-gauge shotgun cartridge, showing firing evidence in the form of banding and surface. The compressed face (not shown) has small quantities of the target paper sheet embedded within it

The bullets to be used in this experiment were commercially available 0.695cal (14 bore) swaged lead musket balls manufactured by Davide Pedersoli & Co. Though advertised as 32.4g mass and 17.65mm diameter, the musket balls used in the experiment averaged 32.2g (with a standard deviation of 0.2g) and an average diameter of 17.59mm (standard deviation of 0.1mm). As opposed to bullets cast in moulds from molten lead, swaged musket balls are made through pressing lead into a die at room temperature to produce a bullet. The resulting bullets have none of the manufacture evidence from casting, such as mould seams, pouring lines, sprue stems or flashing. Casting voids that occur during the pouring of molten lead into the mould also do not occur in swaged bullets, with any voids being pressed out by the die. Swaged bullets are therefore generally more consistent in shape and mass, and free from most of the surface inconsistencies identified by Parkman (2017) as contributing to the drag effects on the bullet, with the exception of those marks imparted through firing such as banding.

Each 12-gauge cartridge used during the experiment was prepared with a pre-measured gunpowder charge, followed by a 14-bore musket ball separated from the powder by a greased-felt wad. The wad was utilised principally to retain the loose gunpowder grains from falling out of the cartridge upon loading into the shotgun, and prevent the musket ball from rolling out of the cartridge by taking up any additional space between the bullet circumference and the cartridge internal surface. Prior to firing each bullet was individually recorded for weight and measured diameter, before being assigned a bullet number. Each prepared cartridge was separately marked with the gunpowder quantity and bullet number, and these in turn were logged for each shot. For consistency in method, each cartridge was prepared and loaded by a single YSC staff member, who was responsible for firearm and ammunition safety during the experiment. Firing of the shotgun at stone targets was carried out using a remote-controlled servo mechanism to pull the weapon trigger, allowing the team to both discharge the shot and observe the impact from behind a bullet-proof observation window, eliminating the risk of accidental injury from bullet fragmentation or ricochet.

6.2.2.4 Impact velocity selection and setting propellant charge quantities

As bullets lose velocity with distance from the muzzle due to drag forces, it is possible to simulate distance in a range setting by reducing the muzzle velocity of the bullet. Although this approach to simulating distance was used by Green (2010), this did not relate velocities to predicted distances. Ballistic modelling created from experimental data gathered by Parkman provides a predictive model for the velocity of a bullet at fixed distances from the muzzle for a typical 19-bore musket ball with a muzzle velocity of 457m/s (Parkman, 2017, pp. 212-213). While the bullet size used in the modelling data differs from those used in this experiment, the modelling predictions are comparable to the experimental observations recorded by Miller (2010) for ground impact distance and velocity of a 12-bore bullet (Parkman, 2017, pp. 212).

For this experiment it was decided to use two different impact velocities from which to compare resulting impact marks. These were selected to reflect simulated distance of approximately 100m between muzzle and impact with a target impact velocity of c.298m/s, and 50m with a target impact velocity of c. 377m/s (Parkman, 2017, pp. 212-213). These distances were picked as approximate upper and lower distance values over which musketeers of the period would typically engage (Foard, 2008, pp. 226) and up to which accuracy against a person-sized target would be around fifty percent (Parkman, 2017, pp. 194). Practical issues of how muskets are employed during siege actions are not addressed by this, such as the presence of more accurate fowling muskets being used by sharpshooters in protracted sieges, or the possible use of suppressive fire against defended positions. Both of these types of fire would extend the engagement range of the muskets while representing different degrees of accuracy in the fire type. However until basic principles of impact mark formation are understood through experimentation, accounting for exceptional instances of impact variables relating to range is an unproductive and unnecessarily specific.

The propellant used for this experiment was a commercially available medium-grain powder sourced from Henry Krank & Co. (Leeds). To identify the quantity of gunpowder needed to achieve the velocities cited above, varying charge sizes were tested with the loading system described above and fired on the outdoor 100m range, using a LabRadar Doppler radar unit to track the bullet velocity at intervals downrange from the muzzle of the shotgun. The values noted were those for the velocity of the bullet at the 10m distance from the muzzle, at which distance the target block would be located on the indoor range. As muzzle velocity performance varies on quasi-random factors, such as the windage between the barrel and the bullet as it passes down the barrel during firing, the consistency of the projected impact velocities was tested through repeated shots to establish a mean velocity. The velocity values of these shots as collected from the Doppler Radar are shown below in Table 11.

80gr propellant - target velocity 298m/s (100m)

Shot Number	Muzzle velocity (m/s)	Velocity at 10m (m/s)
1	319	311
2	309	301
3	304	296
4	332	322
5	296	289
Mean velocity (m/s)	312	304
Standard deviation:		12.9
Deviation from target velocity:		6

Shot 6 failed to record on the Doppler radar

120gr propellant - target velocity 377m/s (50m)

Shot Number	Muzzle velocity (m/s)	Velocity at 10m (m/s)
1	383	369
2	383	369
3	361	348
4	380	366
5	383	369
6	400	386
Mean velocity (m/s)	382	368
Standard deviation:		12.1
Deviation from target velocity:		-9

Table 11: Doppler radar data for test shots to establish muzzle velocity

Although the mean velocity value at 10m did not match the target velocity for either of these propellant charge sizes, the target velocities still fell within one standard deviation of the mean recorded velocities, therefore it was decided that these propellant quantities were sufficiently close to the original velocity target to serve as charge sizes for the two impact velocities during the experiment.

6.2.2.5 Stone targets

The stone for the target blocks used in this experiment were sourced from the Crosland Hill quarry operated by Johnsons Wellfield Ltd. in Huddersfield, West Yorkshire. The Crosland Hill blocks were cut from a 'carboniferous millstone grit' sandstone, referred to as "Yorkstone", and is notably hard in comparison with other sandstones, rating a compressive strength rating of 99.4MPa (Holt). By comparison the Grinshill cream sandstone, used in the experiments by Wynne, is rated with a compressive strength of 27MPa (Anonymous, 1644), while a typical compressive strength rating for granite falls around 130MPa (America, 2016). In practical terms this means that the Crosland Hill stone requires over three times more the amount of pressure to crush the surface of a block as for the Grinshill stones.

Although it was clear that the Crosland Hill stone would be less yielding to the localised force of bullet impacts, and likely produce much less significant impact scars than those formed in the trial above, there were several practical reasons for the selection of this stone as the target source for the trials. Firstly, the sourced blocks measured on average 290mm x 290mm on the front and rear faces, and on average 100mm deep, with a mass of approximately 20kg per block, and able to be handled by a single individual. By contrast the stones used for Wynne's experiment were over 40kg per block on average, and unsuitable for safe handling without two or more people.The relatively compact size and weight also made them practical for transport, and the proximity to the experimental range location allowed for a greater quantity of target blocks to be acquired and transported for the experiment.. Finally, these blocks were sourced from the quarry's open-air storage yard, and as such had been in a moisture-exposed environment for at least six months prior to use in the experiment, though the total time in exposure to the weather may have been much longer. It is unclear how this exposure time and the unknown preceding interval may have influenced the overall strength of the surface of the stone blocks, particularly as there is no established timescale for the case-hardening process for sedimentary stone (Dorn, 2004, pp. 119). Had custom-cut blocks been sourced from another location, the additional cost for the specific block size cutting and transport to the range, and exposure time needed to be reasonably confident that the freshly-cut surfaces had suitably case-hardened, would have put the experiment beyond the means of this study to undertake.

6.2.2.6 Recording and Doppler Radar

In addition to the measurement of the mass and diameter of each bullet, each block of stone was measured for width, depth and thickness prior to shooting, and the target faces of each block were photographed before and after each impact. The block faces were each labelled with a letter for the individual block, and a number on the corresponding face to indicate the propellant quantity used in the shot causing the impact mark. Each block was also marked with an arrow to indicate the upright position, as during transport the distinction between top and bottom can become lost, which would have significant bearing on any assessment of impact profile distortion as a result of an angled impact.

Initially the LabRadar Doppler Radar was used to set the required propellant quantities for the experiment and establish the mean impact velocity for a given gunpowder charge. It was also planned to utilise the LabRadar unit on the indoor range for the experiment, and during initial testing of the shotgun loading and firing concept using a bench position approximately 1m above the ground, this performed satisfactorily. However on positioning the weapon at a ground level to begin firing at the blocks seated in the protective housing, it became clear that the required proximity of the radar unit to the concrete floor to track the bullet, coupled with the concrete wall at the base of the range's back-stop caused signal interference that reduced the overall returning signal-strength from the bullet, preventing a clear measurement of the bullet's velocity for each impact. Without any likelihood of returning useful data, it was decided not to deploy the Doppler unit during the impact tests to prevent the risk of accidental damage.

6.2.2.7 Initial shots and changing research aim

After aiming the weapon and mount system, some initial shots were made against stone targets at 0°, 15° and 30° angles of incidence to examine what the impact marks would like and potentially develop any additional recording strategies as required. What became apparent is that, in significant contrast to blocks shot by Wynne, the Crosland Stone blocks appeared to be almost completely resistant to the impact, leaving only surface smears of lead surrounding a central infusion of stone grains and lead. Furthermore the resulting bullets were completely unlike those from the majority of Wynne's impacts. Where the Grinshill stone impacts had split into large fragments, in this experiment the resulting bullet from the initial shot (shot 1) at a 0° angle of incidence produced 16.3g of recoverable fragments (≈50% of pre-firing mass of 32.4g) in forty recovered pieces, with the largest fragment weighing only 1.9g. A further impact on the reverse of the same stone block produced the same overall effect with no indication

As it was clear that the stone surfaces and bullets were not producing results that could be of short-term success for the experiment, a new research objective was developed from the impact marks produced. On inspection, the marks consisted of two visible components; the centre of the scar where the surface was extremely loose but apparently bound together by infused lead, and the outer ring of stone with surface striations and lead smearing (Figure 53). With light contact, it was possible to dislodge the lead-infused skin on top of the central area of pulverised stone, which in turn was able to be crumbled away with limited abrasive contact. At a two-dimensional level this resembled scars identified on archaeological sites, with a spalled area surrounding an inner scar, albeit with a much shallower profile when examine in depth.

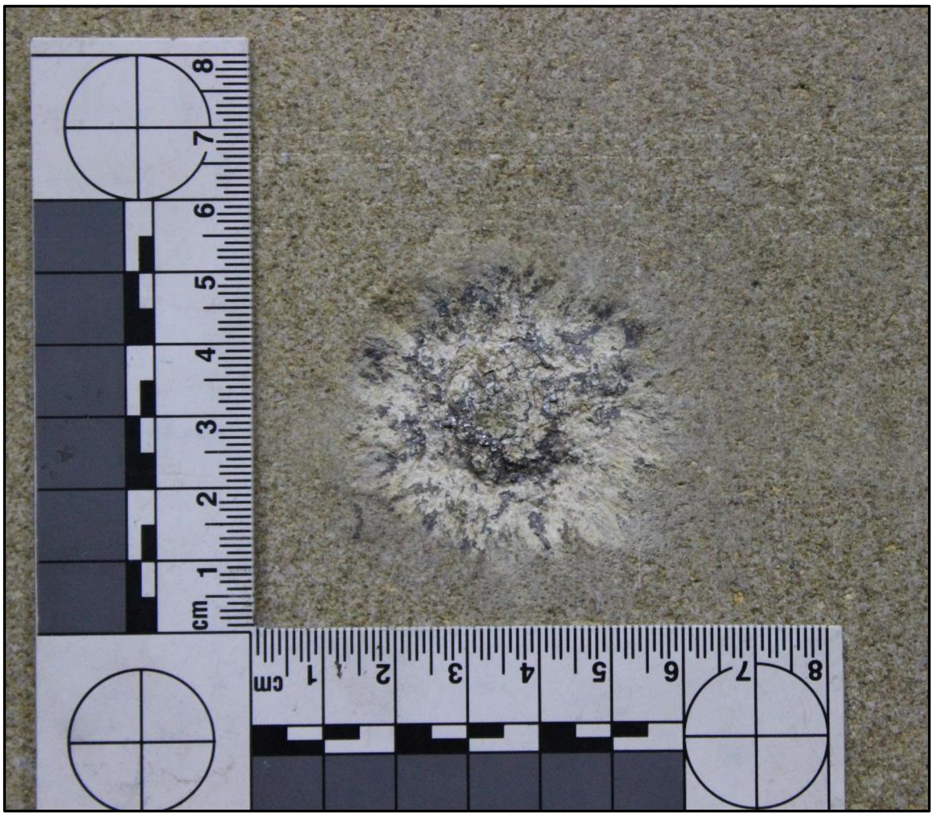

Figure 53: A freshly formed impact mark created during ballistic trials at the Yorkshire Shooting Centre

Exploring the characteristics of this mark, which was unlike anything recorded in past stone-impacts by Wynne (2012) or Green (2010), set the priority for the remaining research time on the range. The new aims for the experiment were thus:

- Establish the relationship between impact velocity and the size and appearance of the resulting impact marks formed on Crosland Hill stone blocks. This was to test whether Green (2010)’s assertion of increasing size with increasing velocity applies to non-penetrative impacts.
- Examine resulting bullet fragments for any indication of a reciprocal correlation in core-fragment size for the size of the impact mark and impact velocity. This again was a test of whether Green (2010)’s assertion that identifying a relationship between impact velocity and resulting bullet condition applied to the core or central fragment of the bullet from which the deformed fragments detach radially.
- Evaluate the development of the impact marks when exposed to weathering processes to identify whether these marks are likely to remain superficial, or have the potential to develop into features that resemble archaeological scars over extended time-frames.

To achieve these aims the decision was taken, based on the resistance of the stone blocks to the initial impacts, to expand the data set to include one orthogonal impact on each side of the block at each of the different propellant quantities (80gr and 120gr) to provide a sample of impacts that were directly comparable within each velocity set, but also between the sets for the stone type and bullet size.

6.2.2.8 Experimental results

Using the new aims and methodology, a total of 30 impact marks (15 at each velocity range) were created on 15 stone blocks of the Crosland Hill stone type. The bullets were of the same bore and fired from the same position and weapon in the same manner. Each scar was recorded photographically, and bullet fragments collected between shots. The examination and discussion of these results is presented below.

6.2.2.9 Impact mark results

The measured diameter values for each impacted block and propellant charge are presented below in Table 12 and Table 13, together with the mean diameter in each axis, and the standard deviation of the measured scars from the population average. Difference between the axes is shown as a single value to reflect deviation from ‘circular’ values, rather than as an absolute difference using a single axis as a reference value, with percentage representing the additional diameter increase of the longest axis over the shortest. A plot of all the measured impacts in presented in Figure 54.

80gr Propellant Charge (mean vel. 304m/s)

Block #	Impact diameter (mm)		Difference	
	X-axis	Y-axis	Total (mm)	% of diam.
D	27	27	0	0.0
E	32	35	3	9.4
F	36	35	1	2.9
G	29	28	1	3.6
H	30	31	1	3.3
J	31	32	1	3.2
K	44	41	3	7.3
L	40	38	2	5.3
M	42	43	1	2.4
N	45	43	2	4.7
P	42	42	0	0.0
Q	44	41	3	7.3
R	45	44	1	2.3
S	30	30	0	0.0
T	44	43	1	2.3
Mean	37.4	36.9	1.3	3.6
Std. dev.	6.6	5.9	1.0	2.7

Table 12: Measured impact diameters for shots fired with 80gr propellant

120gr Propellant Charge (mean vel. 368m/s)

Block #	Impact diameter (mm)		Difference	
	X-axis	Y-axis	Total (mm)	% of diam.
D	45	46	1	2.2
E	39	39	0	0.0
F	44	49	5	11.4
G	44	40	4	10.0
H	42	36	6	16.7
J	46	45	1	2.2
K	46	47	1	2.2
L	49	47	2	4.3
M	50	50	0	0.0
N	48	47	1	2.1
P	39	36	3	8.3
Q	48	46	2	4.3
R	50	47	3	6.4
S	51	45	6	13.3
T	45	45	0	0.0
Mean	45.7	44.3	2.5	5.6
Std. dev.	3.6	4.3	2.0	5.1

Table 13: Measured impact diameters for shots fired with 120gr propellant

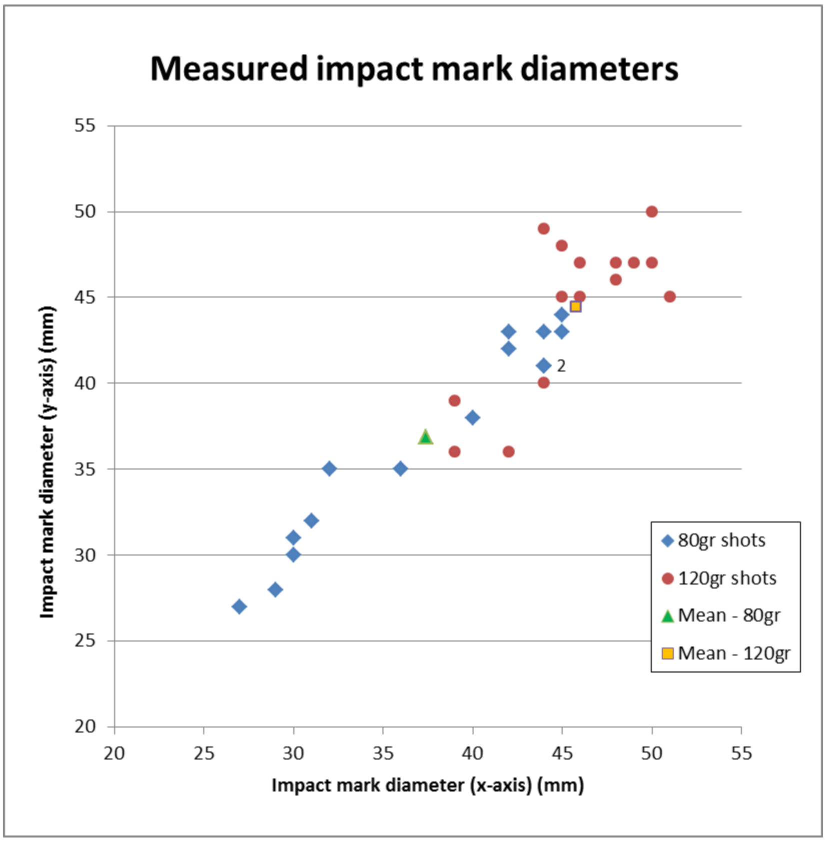

Figure 54: Plot of measured diameters for all impacts produced during experiments at the Yorkshire Shooting Centre, Mirfield (2019)

Perhaps the most striking initial observation is that the impact diameter values for the two sets of marks overlap each other i.e. the largest 80gr-fired impact marks are larger than the smallest marks produced by the 120gr-fired set. This is in apparent contrast to results presented by Green (2010) that indicate increased impact mark size with velocity, as here impacts for the smaller propellant charge (80gr) produced a number of marks of greater overall diameter than those of the larger charge (120gr). Although this may simply be the result of natural variation in the results, which in itself may have significant consequences for the investigation of archaeological scars, there are a number of reasons that this outcome could prove to be the result of experimental error.

The primary candidate for causing this variation is impact velocity inconsistency. Due to the practical issues of the range set-up, it was not possible to record the individual impact velocities of each shot. While test shots were carried out to establish the mean muzzle velocity for each of the propellant charges in question, it is possible that the variation in the performance of the gunpowder used was greater than that established through 5-6 test shots. Muzzle velocity (and by extension impact velocity) may have increased as a result of fouling of the firearm after multiple shots reducing the windage between the bullet and the barrel, and thus improving the acceleration of the bullet. The weapon barrel was cleaned more than once during the experiment after several shots had been fired, however the quantity of shots fired, and the point during the firing at each time this occurred was not recorded due to oversight. The trend in the mean diameter of the resulting marks with progression of shots is illustrated in Figure 55, with the alphabetical order of the blocks indicating progressive number of shots made during the experimentation (80gr shots were systematically fired before 120gr shots for the same block). Despite fluctuation, the trend lines for both propellant charges indicate a steady increase in the average impact diameter over the course of the trial, which would seem to indicate an increase in muzzle velocity during the course of the day.

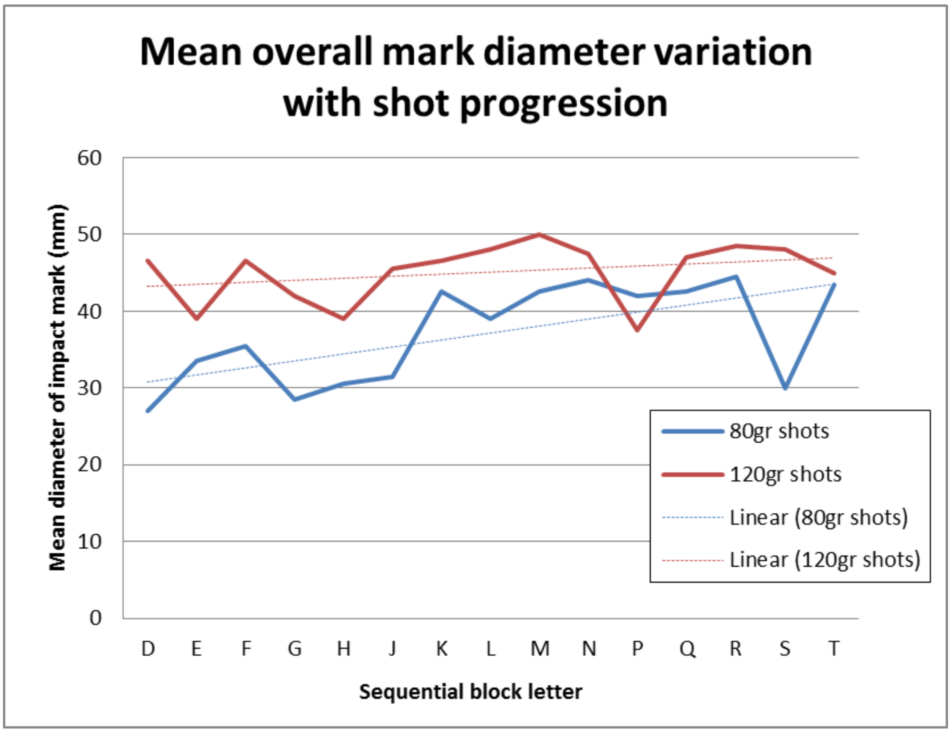

Figure 55: Impact diameter variation with shot progression

The possibility of propellant measurement or loading error also cannot be completely discounted. Although frequent checks were made to ensure propellant charge and bullet were recorded against each shot, the consistency of the measuring and loading of each cartridge was carried out in parallel with the recording and replacing of the target block between each shot, and consequently any creeping errors in the process may have gone unnoticed. Only one candidate for an incorrect loading order for the cartridges can be identified in the instance of block P, where the 80gr-fired impact measured larger in overall diameter than the 120gr-fired impact on the same block. This is not a certainty however as the measurements for both impacts fall within the range of largest and smallest marks for both sets of impacts, and no other block impact pair shows this reversal of the expected size order. Other considered reasons for the overlap in impact mark diameter ranges, including possible variation in the impacted surface consistency, are unlikely to account for all of the instances observed.

The overall variation between measured diameters of the impact marks is consistent with the expectation that a spherical bullet impacting onto an unyielding, flat surface at an orthogonal angle would deform equally about the point of contact, producing a circular or near circular impact mark. In reality the consistency of the shape of the bullet after firing, and the natural variance in the surface structure of the stone would influence the overall impact mark’s shape.

While the mean impact size in both axes increases with increasing impact velocity, as would be expected based on Green (2010), what the data also indicates is that the range of the difference between measured axes also increases with impact velocity across a single set of marks. This is indicated in the greatest difference between measured axes for impacts. For both sets of marks there were three impacts that measured equally in the horizontal and vertical axes (20% of sample impacts), however the greatest variance in the 80gr-fired bullets was measured at 3mm (+9.4% of the narrowest axis of the mark), and at 6mm (+16.7% diameter) for the 120gr-fired bullets. This indicates that while the higher velocity impacts are as likely to be ‘circular’ as the lower velocity impacts, those that vary may do so to a proportionally greater degree.

By contrast the variation in overall diameters between marks within each group shows the opposite trend. The 120gr-fired marks show a greater consistency in the overall diameter between the largest and smallest marks than was measured across the examples from the 80gr-fired set. This may indicate that at higher velocities there is less variability in the impact result than for lower velocity impacts, though the influence behind this is not clear. It is also possible that the data across these two sets is skewed by the possible impact velocity issue addressed above.

6.2.2.10 Impacted bullet results

Despite the high fragmentation of the bullets observed in the initial impacts, recovery of as many of the fragments of each bullet as possible was carried out following each impact, with particular attention paid to locating the central/core fragment of the bullet that showed evidence of the point of contact and from which all of the other bullet fragments detached. Table 14and Table 15 below show the mass and mean diameter of each bullet prior to firing, the impact details for each bullet (block imp-acted and propellant charge), the total mass of the recovered fragments, and the mass and dimensions of the core fragments where recovered (greyed tabled entries indicate that the bullet core fragment was not located after impact).

Bullet	**Pre-firing**		**Shot/impact details**		**Total recovered bullet**		**Bullet core fragment**				
	Mass (g)	**Mean diam. (mm)**					**Mass (g)**	**% original**	**Dimensions (mm)**		
			Block	**Charge (gr)**	**Mass (g)**	**% original**			**Length**	**Width**	**Thickness**
6	32.0	17.5	H	80	22.3	69.7	3.5	10.9	21.6	16.2	3.7
7	32.5	17.7	F	80	20.2	62.2					
8	32.1	17.6	E	80	24.4	76.0	2.2	6.9	19.6	12.7	3.0
9	32.4	17.7	G	80	25.0	77.2	2.6	8.0	14.8	12.3	3.3
10	32.4	17.6	D	80	25.1	77.5	7.6	23.5	29.5	22.1	3.6
21	32.5	17.7	N	80	22.7	69.8	2.5	7.7	24.8	16.2	2.6
22	32.4	17.5	M	80	26.1	80.6	2.1	6.5	20.1	14.1	2.0
23	32.4	17.6	K	80	23.0	71.0	1.8	5.6	13.2	12.4	2.8
24	32.4	17.6	L	80	27.7	85.5	2.5	7.7	20.3	15.6	2.6
25	32.5	17.6	J	80	28.1	86.5	3.7	11.4	24.7	15.8	3.1
28	32.4	17.7	P	80	27.0	83.3	1.2	3.7	14.7	9.1	2.8
29	31.9	17.6	R	80	24.7	77.4	2.1	6.6	19.5	13.2	2.7
33	32.2	17.6	S	80	21.9	68.0	2.8	8.7	16.3	13.8	3.3
34	31.9	17.5	T	80	24.4	76.5	2.1	6.6	17.5	16.2	2.5
35	31.9	17.5	Q	80	24.5	76.8	2.8	8.8	25.8	20.3	2.8
Mean:	**32.3**	**17.6**	**-**	**-**	**24.5**	**75.9**	**2.8**	**8.7**	**20.2**	**15.0**	**2.9**
St. dev.	**0.2**	**0.1**	**-**	**-**	**2.1**	**6.5**	**1.5**	**4.5**	**4.6**	**3.2**	**0.4**

Table 14: Record of experimental bullets and recovered fragments for shots fired with 80gr of propellant

Bullet	Pre-firing		Shot/impact details		Total recovered bullet		Bullet core fragment				
	Mass (g)	Mean diam. (mm)	Block	Charge (gr)	Mass (g)	% original	Mass (g)	% original	Dimensions (mm)		
									Length	Width	Thickness
11	32.5	17.6	D	120	15.3	47.1	2.0	6.2	20.1	14.2	2.6
12	32.5	17.7	E	120	21.5	66.2	1.8	5.5	17.7	12.0	2.7
13	32.5	17.7	H	120	24.6	75.7					
14	31.9	17.6	F	120	22.2	69.6	2.5	7.8	17.9	13.7	2.7
15	32.4	17.6	G	120	21.2	65.4	1.8	5.6	23.2	14.6	2.0
16	32.4	17.6	J	120	16.5	50.9	1.1	3.4	17.0	9.7	2.4
17	31.9	17.5	K	120	18.8	58.9					
18	31.9	17.5	L	120	19.2	60.2					
19	32.3	17.6	N	120	23.7	73.4					
20	32.1	17.6	M	120	23.0	71.7	1.1	3.4	12.3	11.1	2.8
26	31.9	17.5	Q	120	21.1	66.1	1.4	4.4	17.2	13.3	2.5
27	32.0	17.5	T	120	23.2	72.5	1.2	3.8	11.8	10.4	2.9
30	31.9	17.5	R	120	22.6	70.8	1.7	5.3	16.0	15.0	2.8
31	31.9	17.5	P	120	19.5	61.1	2.3	7.2	19.0	16.8	2.6
32	31.9	17.5	S	120	25.1	78.7	1.3	4.1	14.7	12.5	2.2
Mean:	**32.1**	**17.6**	-	-	**21.2**	**65.9**	**1.7**	**5.2**	**17.0**	**13.0**	**2.6**
St. dev.	**0.3**	**0.0**	-	-	**2.7**	**8.6**	**0.5**	**1.4**	**3.1**	**2.0**	**0.3**

Table 15: Record of experimental bullets and recovered fragments for shots fired with 120gr of propellant

Examination of the bullet fragments and the data presented in the table above does not indicate any clear trend between the impact velocity range of the two sets of impacts and the resulting dimensions of the bullet core fragment. While the higher velocity impacts typically produced smaller and thinner core fragment as would be expected from observations made by Green (2010) and Haag and Jason (2012) for bullet fragmentation with increased impact velocity, there are several fragments in both sets that overlap the division. When comparing the mean values for length, width and thickness for either group, these each fall within one standard deviation of the mean of the other, indicating that the majority of the population in both sets significantly overlaps. This indicates that the relationship between core fragment dimensions and the impact velocity range is not necessarily predictable.

Comparing the data for the average impact diameter for each shot and the resulting dimensions of the bullet core fragment produced a statistically significant negative-correlation for the thickness of the bullet and the mean diameter of the impact for the 80gr-fired shots (Figure 56). Although this correlation is still possibly due to random chance owing to the small sample size, the implication is that as the degree of contact deformation increases along the lateral axes, the bullet core-fragment at the centre of the disc becomes thinner due to the lead of the bullet being stretched out further. This seems intuitive, as there is a finite volume of lead within the bullet and thus if it is stretched into a wider disc upon impact, the volume distribution of the lead requires that the overall disc be thinner. However the same correlation could not be found for the 120gr-fired bullets fragments and impact marks, suggesting that there may be some change in the deformation behaviour of the bullets for the higher energy impacts from those at the lower impact velocity. The mechanism behind is not apparent from the present data and may require more detailed future investigation of the impact fragmentation behaviour of spherical lead bullets on stone surfaces before this can be properly understood.

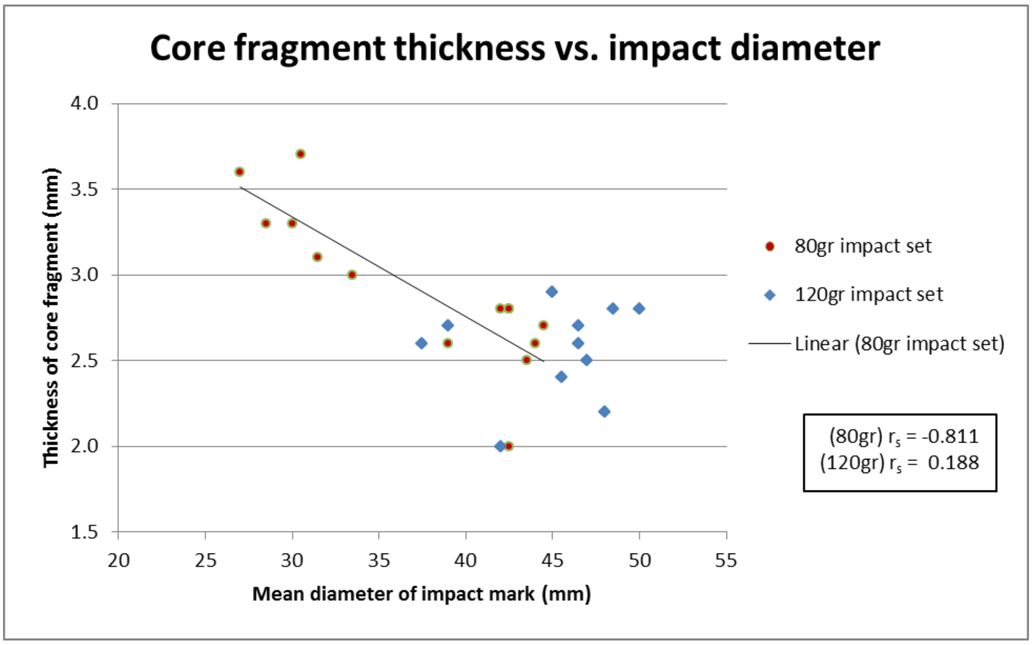

Figure 56: Comparison of bullet core fragment thickness with mean impact diameter. Only the 80gr-fired set shows a statistically significant negative correlation (r_s = -0.811)

The mass of the bullet core fragments again shows a general trend for smaller mass fragments for greater impact velocities, i.e. greater fragmentation with greater impact velocity. However as with core fragment size, a statistically significant (negative) correlation between the size of the impact mark and the mass of the core bullet fragment could only be found for the 80gr-fired shots, although the 120gr-fired impacts did produce a negative correlation also, though not a statistically significant one (Figure 57). The core fragment from impact D80 produced the only fragment with a mass larger than 4g owing to the retention of a large portion of the outer section of the impacted bullet-disc, and also corresponds to the mark with the smallest overall size. Assuming that, as has been observed elsewhere and in this experiment, the impact mark size relates to the impact velocity of the bullet, this suggests that the true impact velocity of shot D80 may be much lower than for other shots in the same series, and may fall closer to the fragmentation limit of the bullet.

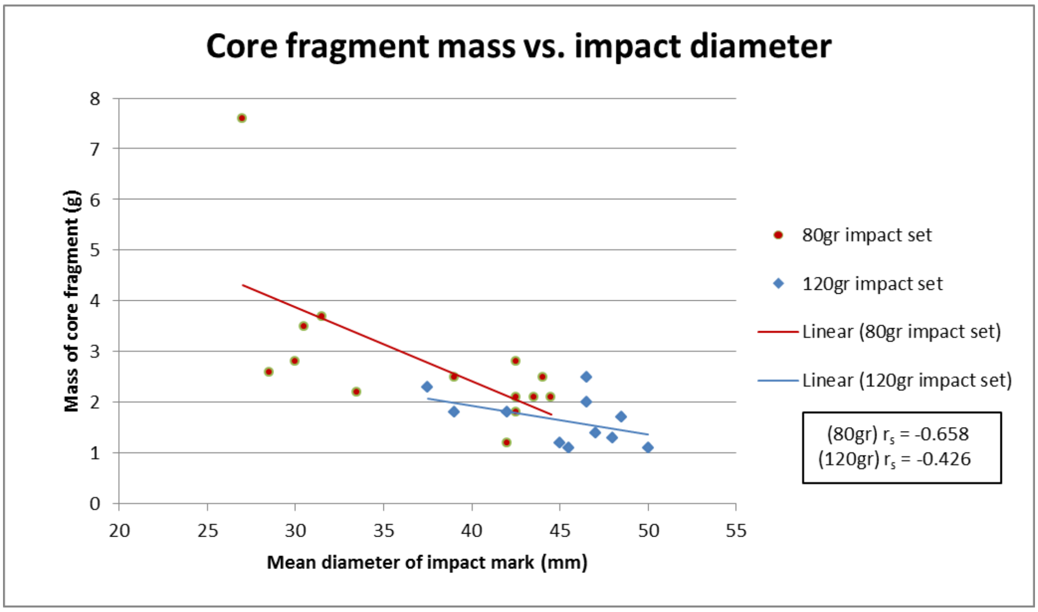

Figure 57: Comparison of bullet core fragment mass with mean impact diameter. Both sets show a negative correlation, however only the 80gr-set is statistically significant

6.2.2.11 Impact scar profiles

The majority of the impacted blocks are currently undergoing a long-term weathering exposure experiment to assess how these marks compare after a multi-year period of exposure to the elements. Originally the plan for these stones included profile measurement of the developing impact scars after six months of weather exposure using the contour gauge method. However during measurement it was noted that the impact marks still contained a significant quantity of loose/weak surface grains that were becoming dislodged by contact with the contour gauge pins. In an effort to limit the influence of recording processes on the overall development of the impacts, the recording of these blocks was limited to two examples of impacts from each set of impacts (80gr and 120gr).

As the four measured impacts had already been subjected to contact surface-loss through measurement, the decision was taken to assess the true extent of the depth of the loose surface material and find the internal 'hard' surface of the scars. To this end all four impacts were subjected to washing with a pressurised water jet to remove loose surface grains from within the impact scar. These impacts were photographed again after washing (and being allowed to dry) for visual comparison, and profile-measured once again for the same marked surface points of the stone block. Images presented below for comparison show impact mark F120 immediately after formation (Figure 58), after six months of weather exposure prior to initial profile measurement, and after measurement and pressure washing without further weather exposure (Figure 59). Table 16 provides a summary of the mean profile measurements for each scar on the examined blocks, detailed measurement data for each individual axis of the scar profiles can be found and in Appendix B.

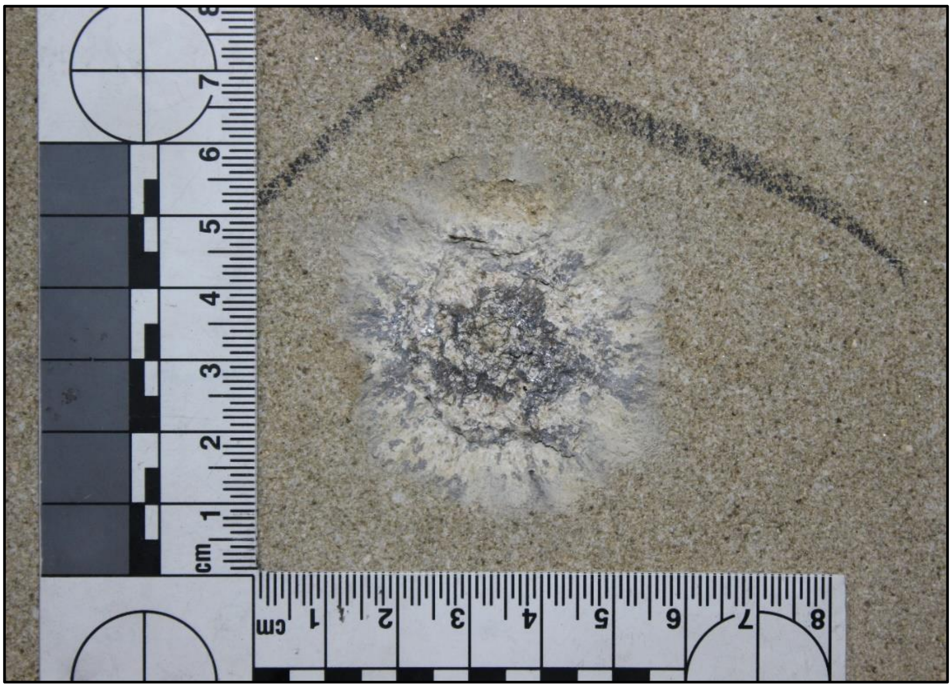

Figure 58: Impact mark F120 immediately after formation

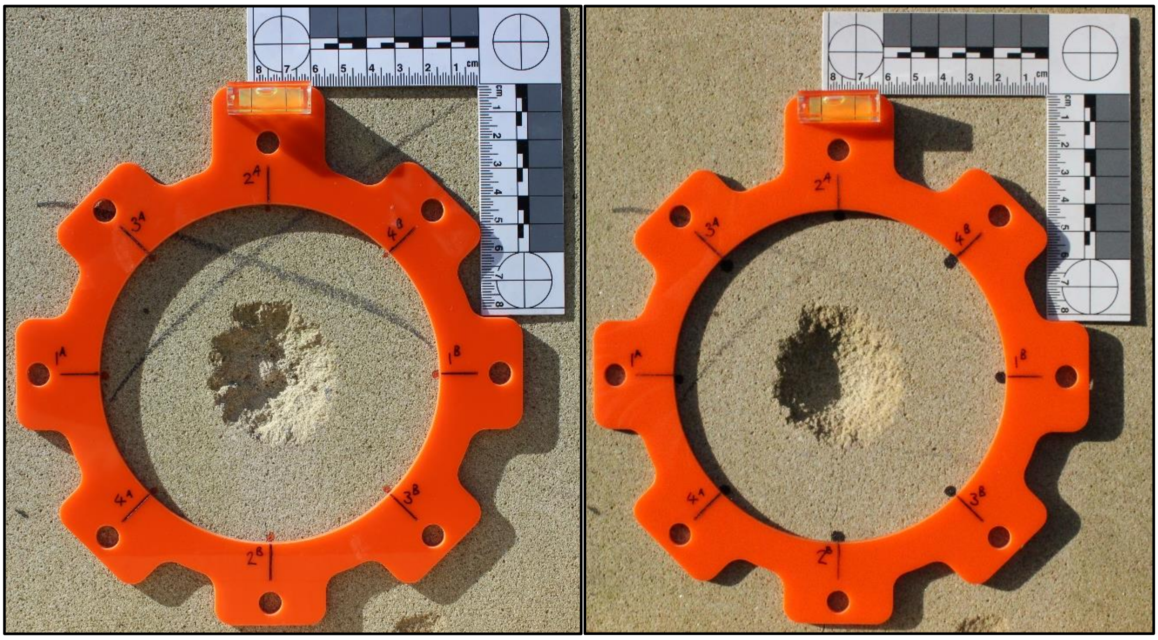

Figure 59: Impact F120 after six months of weather exposure (left) and following washing with a pressurised hose (right)

Scar no.	Mean diameter (mm)	Mean depth (mm)	Diameter to depth ratio (:1)	X-axis centre off-set (mm)	Mean spalling depth (mm)	Mean width of spalling (mm)
D80	25	2	16.3	5	-	-
D80 (washed)	27	4	6.7	3	2	6
F80	36	3	11.1	-6	1	5
F80 (washed)	38	6	6.3	-1	4	9
D120	43	6	7.3	1	3	9
D120 (washed)	44	8	5.5	-1	3	8
F120	46	8	6.0	-5	4	11
F120 (washed)	48	10	4.9	-1	5	11

Table 16: Mean values of measured characteristics of scars on blocks D and F before and after washing

Visual evaluation of the scars before and after washing shows a distinctive change in the overall shape of the scars. While the pre-washed scars appear generally shallow and relatively flat in their internal form, after washing the removal of the loose surface reveals that the ‘solid’ base of these features penetrate much deeper into the surface at the centre, and produce an overall cupped-shape comparable with the general appearance of archaeological impact scars. The washed experimental scars also present a rough internal texture in contrast to archaeological scars, which might be expected to weather into smoother surfaces over time (Figure 60). It is also worth noting that the central portions of the experimental scars show a colour change in the stone surface akin to that observed for numerous archaeological examples. It is unclear whether this represents a colour change in the outer layer as a result of case-hardening with the inner scar penetrating into the unhardened layer beneath the outer skin, however such a colour change was not apparent in the experimental impacts created on freshly-cut stone by Wynne (2012).

Figure 60: Internal surface texture of scar F120 (left) compared with scar E29 from Moreton Corbet Castle (right)

Comparison of measured cross-sections and traced profiles for these scars outlines the degree of change between the pre-washing and post-washing profiles (Table 17, Figure 61 and Figure 62). The washed scars are between 1-2mm wider than their pre-wash measurements and 2-3mm deeper (+/- 0.5mm margin of error). In terms of proportion, the width increase for the scars is less substantial than the overall increase in depth, indicating that surrounding block surface adjacent to the impact scar is relatively resistant and does not retain significant sections of loose or fragmented material susceptible to dislodging with the pressure-hose. It is worth noting also that the degree of change in the measurement-defined spalled area across the 120gr scars is low, which would imply that the majority of the profile change occurs with the removal of the pulverised stone grains retained primarily in the central portion of the scar, however this is not readily apparent from a visual comparison of the cross sections presented in the diagrams below. The lead-infused mark and shallower portions of loose surface material within the 'spalled' volume (visible in the photo of the freshly-formed impact mark above) washed out gradually from the scars within the first six months of exposure to weather, primarily through rainfall washing the grains from the surface. This is not per se a formation of the scar through weathering in this instance, but the action of weathering in removal of the already pulverised material lodged in the scar's volume, though it is unclear if the reason for the retention of this material is the infusing of bullet material acting as a binding agent between the grains, or some form of surface tension. The remnant of the central portion of the material can be seen above as a central peak of pulverised stone that corresponds to the lead mark in the pre-washed scar image. Unfortunately this feature could not be recorded with the contour gauge as the gauge's pins dislodged this along with other loose grains upon pressing into the scar shape. Future recording of developing scars would benefit from the use of laser-scanning so as to avoid abrasive contact with the loose surface material.

Scar no.	Mean diameter (mm)	Mean penetration (mm)	Diameter to depth ratio (:1)	X-axis centre off-set (mm)	Mean spalling depth (mm)	Mean width of spalling (mm)
D80	25	2	16.3	5	-	-
D80 (washed)	27	4	6.7	3	2	6
Value Change	*2*	*2*	*-9.6*	*-2*	*2*	*6*
% Change	*8.0*	*100.0*	*-58.9*	*-40.0*	*n/a*	*n/a*
F80	36	3	11.1	-6	1	5
F80 (washed)	38	6	6.3	-1	4	9
Value Change	*2*	*3*	*-4.8*	*5*	*3*	*4*
% Change	*5.6*	*100.0*	*-43.2*	*-83.3*	*300.0*	*80.0*
D120	43	6	7.3	1	3	9
D120 (washed)	44	8	5.5	-1	3	8
Value Change	*1*	*2*	*-1.8*	*-2*	*0*	*-1*
% Change	*2.3*	*33.3*	*-24.7*	*-200.0*	*0.0*	*-11.1*
F120	46	8	6.0	-5	4	11
F120 (washed)	48	10	4.9	-1	5	11
Value Change	*2*	*2*	*-1.1*	*4*	*1*	*0*
% Change	*4.3*	*25.0*	*-18.3*	*-80.0*	*25.0*	*0.0*

Table 17: Data comparison of scar metrics between pre-wash and post-wash conditions

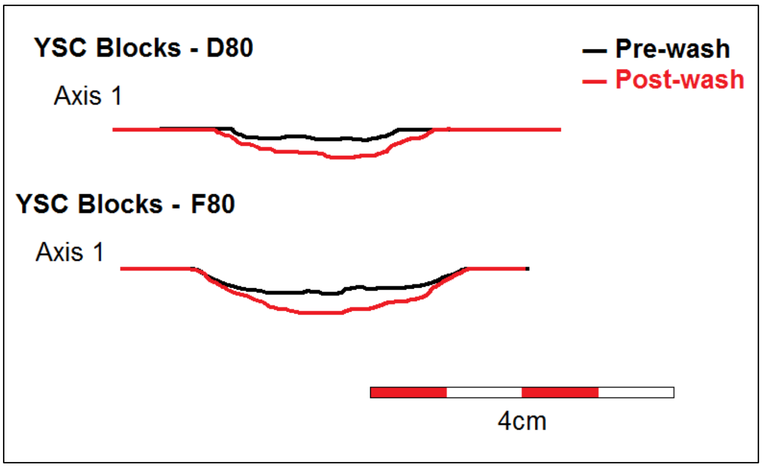

Figure 61: Traced horizontal cross-sectional profile comparison for 80gr impact scars before and after pressure washing

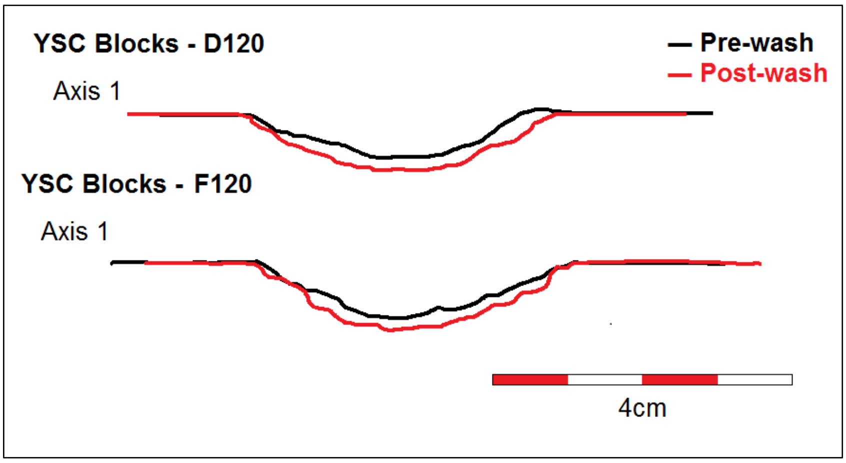

Figure 62: Traced horizontal cross-sectional profile comparison of 120gr impact scars before and after pressure washing

Scar no.	Horizontal diameter (mm)	Vertical diameter (mm)
D80 (formation)	27	27
D80 (washed)	28	27
Variance	*1*	*0*
F80 (formation)	36	35
F80 (washed)	35	37
Variance	*-1*	*2*
D120 (formation)	45	46
D120 (washed)	42	43
Variance	*-3*	*-3*
F120 (formation)	44	49
F120 (washed)	44	51
Variance	*0*	*2*

Table 18: Comparison of recorded diameter values for scars on blocks D and F immediately after impact, and after pressure washing

Comparing the 2D diameter measurements of the scars at formation with the 3D diameter measurements after washing (Table 18), it is apparent that a number of the former return greater values for the same scar, contrary to what might be expected through loss of surface material during pressure-washing. This difference is due to the measurement approaches used, as the 2D measurements took into account the surface marking of the stone by the lead-smear of the musket ball and light abrasion from its disintegration. By contrast the 3D measurements cannot record these elements as they are too thin to be perceptible in a cross-sectional measurement, and following pressure washing are no longer visible on the surface of the stone. A combined form of 3D Laser scanning together with orthogonal imaging would better allow an examination of how the marked area relates to the developing depth-profile of the scar over time in any future investigation.

6.2.2.12 Discussion of results

The outcome of the YSC trials was not what had been expected from initial planning. The response of the stone to impact stands in contrast to what had been observed in previous experiments by Green (2010) and Wynne (2012), and limited the opportunity to examine the variances in internal scar cross-sectional profile shape from changing impact variables, largely because the scars possess little shape beyond the surface mark. Observation of the scars after a six-month exposure to weathering and being subjected to pressure-washing suggests that much of that difference is in fact the presence of fragmented or pulverised stone material lodged in the base of the impact mark that is then ejected over a relatively short period of time. The degree to which this observed behaviour is common to other case-hardened sedimentary stone surfaces, or potentially a property of the much higher compressive strength of Yorkstone over Grinshill Stone, requires further investigation.

The variation in the resulting marks observed for the two impact groups highlights potential problems for scar analysis to make any exact statements about impact variables, as the likely degree of variation in bullet performance for seventeenth century small-arms is likely to be much greater than that caused through using standardised bullets and largely consistent impact velocities. What is clear from the results is that general trends are visible for the relationships between velocity and initial impact mark size, but being able to quantify the relationship is more difficult due to overlapping mark-size values between the data groups.

Perhaps the most interesting observation is that the bullet fragmentation does not behave in a linear manner in relation to the resulting fragments. This may indicate that there is an upper-limit for bullet deformation with increased impact velocity, and may in turn mean that there is an upper limit for scar size for a bullet of a given calibre beyond an impact energy threshold. If this is the case, then it is possible that impacts from shots fired at extremely close range would overlap entirely with scars formed by impacts at that energy limit.

How this factors in to the weathering of the surface into the appearance of a present day scar is unclear, as indeed is the issue of scar development from an impact mark. This issue is probably the most crucial for future study of impact scars, as without knowing how scars relate to the marks caused by the impact itself, we cannot identify with certainty which on the resulting scar profile attributes are products of the impact process, and which are wholly artefacts of weathering. Continued investigation of archaeological impact scars may shed some light on this issue, as identifying visible profile attributes for scars with limited impact variables, i.e. where the range, angle or bullet size can be pinned down with certainty based on landscape, terrain or historical accounts, may show that weathering in fact enhances these features, or that the resulting form persists despite erosion.

6.3 Conclusions

This chapter has explored previous investigative work in the realm of bullet impacts on hard surfaces that relate to early modern conflict archaeology as well as the evidence these provide that informs investigation of early modern siege sites with bullet impact scars. What is apparent from this exploration is that there is a dearth of experimental studies relating to this phenomenon, and those that do exist have limitations in their usefulness for siege archaeology owing to problems with methodologies or the specifics of what was being investigated.

This chapter has also presented the results of experimental archaeological investigations as part of this study that aimed to reproduce impact scars under controlled conditions, with the intention of replicating what can be seen archaeologically. What these experiments have shown is that the formation of an impact scar is not a straightforward cause and effect from the impact of the bullet, and that there is some evolutionary process for the transition of the initial impact marks into the scars seen on structures.

Two key issues arise from the above. The first is the need for more ballistics experiments and impact datasets from which to build upon understanding of impact scar formation. This will need to address two aspects of previous studies; the refinement a methodology and experimental set-up that can overcome the challenges to recording key variables for each experiment, and a broader exploration of different variable influences such as bullet size and angle of incidence. Impact mark size-overlap between the two firing groups in the 2019 experiment cannot be fully accounted for under the methodology due to problems with recording impact velocity in the range environment using the Doppler radar. Addressing these problems is necessary to properly assess whether the difference reflect natural variation, or whether with a more rigorous method for producing precise impact velocities the results can be separated more clearly.

The second issue is the lack of understanding of how impact marks develop across an array of stone surface types. It remains to be seen whether the experimentally created impact marks will develop into features resembling archaeological impact scars after sufficient exposure to weathering processes, and how the impact result and weathering process varies between different sedimentary stone types used in structures at siege sites presents a significant challenge for developing a base knowledge for developing archaeological analytical techniques.

7. Moreton Corbet: A siege site case study

Figure 63: Photograph of Moreton Corbet Castle ruins and adjacent St. Bartholomew's Church. Image taken by Mick Krupa. ©Shropshire Council

7.1 Introduction

From August 2014 to March 2020 the siege location of Moreton Corbet was surveyed by the author and a team of volunteer detectorists for evidence of the Civil War sieges using an adapted methodology from that used at Edgehill (Foard, 2012). In addition to the recovery of metal artefacts from the plough-zone, a detailed survey of the impact scar evidence on the castle ruins and neighbouring church was undertaken using the methodology for investigating impact scars discussed in chapter 5 evidence outlined above. This site was chosen as in addition to a broad array of impact evidence across multiple structures, the surrounding landscape is largely undeveloped, and thus offered an opportunity to develop a combined methodology for the examination of impact scar evidence together with the unstratified scatter of metal artefacts in the plough zone that is the core evidence for interpretation of action in battlefields contexts (Pollard and Oliver, 2002, Foard, 2012, Schürger, 2015). Although this is not the first instance of a metal detector survey of a siege location, it is the first time the distribution of artefacts has been considered in relation to impact evidence on the contemporary structures within the landscape.

7.2 Historical overview of Moreton Corbet

Moreton Corbet Castle lies in the village of Moreton Corbet in the marcher county of Shropshire, situated approximately 12km north-east of the county town of Shrewsbury, and 7.5km south-east of the town of Wem in north Shropshire. The castle lies at the south-eastern end of the adjacent village, and to the south of the church of St. Bartholomew. The castle is relatively unusual as it combines elements of the modified medieval fortifications with the ornate Elizabethan south range. For this reason it has received some scholarly interest for its architectural style as well its heritage aspect.

Figure 64: Map showing the present-day landscape around Moreton Corbet Castle. OS VectorMap® Local 1:10,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

The historical background of the Moreton Corbet Castle's development into a late-sixteenth century country house from an earlier medieval fortification has been well discussed elsewhere (Remfry, 1999, Harwood, 2006) and will only be outlined here in limited detail. The oldest surviving elements of the medieval castle date to approximately the beginning of the thirteenth century, though most of this structure was significantly modernised in the 1560s by Sir Andrew Corbet, including the gatehouse and east range, though only the front face of the gatehouse and the garderobes of the east range survive (Harwood, 2006, pp. 37-40). Following Sir Andrew's death in 1578, his son Robert Corbet took to redeveloping the southern portion of the east range and constructing a grand, three-storey Elizabethan country house on the southern side of the castle, but died in 1583 before the work was completed (Harwood, 2006, pp. 37). The house was apparently not occupied by the successive lord, Richard Corbet, and probably until the early seventeenth century when it was inherited by his brother Sir Vincent Corbet of Acton Reynald. An inventory of the castle after Vincent's death in 1623 shows it was both habitable and well-furnished (Harwood, 2006, pp. 43), indicating that the construction work had been completed even if the complete design had not.

The castle was active as a Royalist and later as a Parliamentary garrison during the Civil Wars and attacked multiple times, however it ceased to be used as a residence during the conflict with the current lord, Sir Vincent Corbet, residing in the family's house at Acton Reynald between campaigning and acting as governor of the Royalist garrisons at Moreton Corbet and High Ercall (Remfry, 1999, pp. 25-27). Sir Vincent died in London during the Commonwealth after being heavily fined for his involvement in the Royalist army. Whether the castle was an active residence after this period is unclear, as although repairs were undertaken as evidenced by a date of 1667 on a fireplace in the south range, by 1680 the Corbet family were living at the Acton Reynald house (Harwood, 2006, pp. 44-45). An often repeated assertion that the house was razed during the Civil Wars (Historic England, List Entry 1366802, Bracher and Emmett, 2000, pp. 83) is certainly incorrect as evidenced by later occupation and subsequent sketches and paintings of the castle that show it largely intact well into the eighteenth century (Harwood, 2006). The castle gradually fell into increasing states of ruin following abandonment, and various paintings and sketches from the eighteenth and nineteenth centuries, and photography from the early twentieth century show the gradual loss of the roof and collapse of walls on the southern range. The site itself appears to have been used as a farmyard and livestock enclosure from examination of early twentieth century photography and sketches held in the Shropshire Archives, and western most of the five-light windows on the south face of the southern range was remade as a brick arch as a carriageway into the ruins prior to the twentieth century, though later 'restored' sometime around 1977 without the stone mullions or transoms.

The present-day ruin is a grade one listed structure managed by English Heritage, and stands within a scheduled area encompassing the castle ground and moat. The adjacent landscape comprises of large arable fields to the east and south, permanent pasture to the south-west, later Victorian and twentieth century farm buildings to the west across the road, and the village of Moreton Corbet and twelfth century church of St Bartholomew the north. The castle and much of the adjacent landscape remains under the ownership of the Corbet family, but is managed through English Heritage guardianship, and by the Acton Reynald Estate.

7.2.1 Role in the Civil Wars

In territorial terms, Shropshire was predominantly Royalist at the outset of the Civil Wars (Gaunt, 1987, pp. 140), with two thirds of the county's MPs siding with the king against Parliament (Bracher and Emmett, 2000, pp. 21). The lord of Moreton Corbet Castle itself, first baronet Sir Vincent Corbet, had declared his loyalty to the King prior to the onset of hostilities in 1641, earning him the reward of his knighthood and baronetcy in that year (Bracher and Emmett, 2000, pp. 21). Following the Battle of Edgehill (1642) the war in Shropshire began to take the form of territorial control through minor garrisons, with skirmishing and siege actions as the predominant form of warfare (Bracher and Emmett, 2000, pp. 27, Worton, 2016, pp. 213). Although no major battles of the Civil Wars occurred in Shropshire, Worton (2016) identifies six actions that might be considered as 'small battles' as several meet the deployed force-size criteria to be classified as battles as used by Foard and Morris (2012, pp. 6), but none of which particularly fit the formula of a set-piece engagement and instead arguably reflect large skirmish actions (Worton, 2016, pp. 204-205). The war in Shropshire can thus be characterised predominantly as a struggle for territorial control through raiding, skirmish and siege actions.

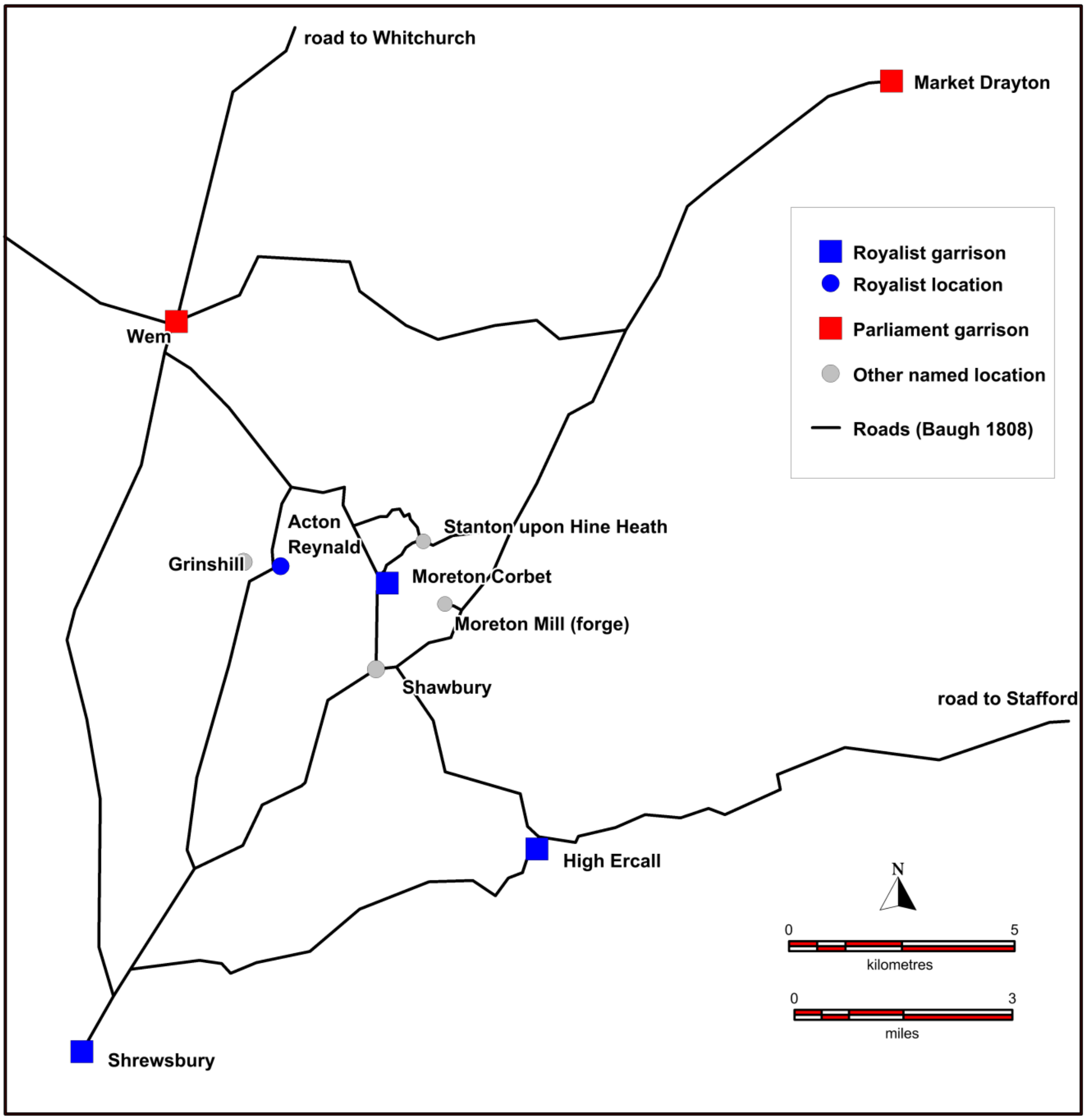

Figure 65 - Overview of the location of Moreton Corbet in relation to key locations and historic roads in Shropshire during the civil war

Moreton Corbet Castle was for much of the war situated between the Royalist garrison of Shrewsbury, and the Parliamentarian garrison at Wem which had been captured and garrisoned in mid-late 1643 and served as the major base of Parliamentarian actions in the county thereafter (Worton, 2016). As a result Moreton Corbet served as one of a number of satellite garrisons used to both screen against territorial intrusion for the major garrisons (Worton, 2016, pp. 215). The exact timeline of garrisoning of Moreton Corbet Castle is unclear, it was likely garrisoned properly by Sir Vincent Corbet until after the capture of Wem in 1643 (Worton, Pers. comm., Bracher and Emmett, 2000, pp. 83), as there would have been little reason to do so prior to the Parliamentarian military presence in the county, though Remfry suggests it was garrisoned from the outbreak of war as Sir Vincent began raising his regiment of dragoons and may well have been a suitable candidate as a barracks for 800 or so soldiers and horses (Remfry, 1999, pp. 24-25).

Although there are no accounts for a siege action in early 1644, there is some evidence of an change of garrison in Jan-Feb 1644 in the form of a letter from Vincent Corbet requesting a prisoner exchange for troops taken prisoner at Moreton Corbet (Worton, Pers. comm., Remfry, 1999, pp. 26). If Moreton Corbet was captured by Parliament at this time, it had returned to Royalist control by early March 1644 following regional setbacks for Parliament (Worton, 2016, pp. 215). The castle remained a Royalist garrison until shortly after the fall of Montgomery in 1644. When Sir Vincent's Dragoons were sent to support the unsuccessful effort to retake that town, the garrison at Moreton Corbet Castle was attacked by a Parliamentary force at night on 8th September 1644.

7.2.2 The Second Siege of Moreton Corbet – 8th September 1644

There are limited surviving accounts of the storming action that comprises the Second Siege of Moreton Corbet, probably due to the small scale of the action and potential number of participants likely to keep a written record of the event when compared with large engagements such as Edgehill or Naseby. A transcription of text from the contemporary sources for this siege can be found in Appendix C. As there are only two accounts that have been identified by the author, both from the Parliamentarian side, it has not been necessary to produce a concurrence of sources in the form used for examination of the Battle of Edgehill (Foard, 2012).

The castle was attacked on the night of 8th September 1644 by soldiers from the Wem garrison under Col. Wilhelm Reinking, and a detachment of foot and horse from four regiments of Sir William Brereton's Cheshire forces stationed at Wem (Worton, 2016, pp. 123). The newsletter 'Burning Bush Not Consumed' published by Vicars gives an account that conveys the use of surprise and confusion tactics by the Parliamentary force, using drummers and calls of orders by Reinking to regiments not present to instil the fear in the defenders that a much larger force had fallen on the castle, and that overwhelming defeat was imminent. After scaling the earthwork defences on ladders and surprising the sentries, a small force of c.10 Parliamentarian soldiers including Reinking tried to force entry to the castle through a small door with no success. Reinking then proceeded with about half of the initial assault detail to force the defenders off of another work, and under fire from the now alerted garrison, forced entry through a window after a barrage of grenades thrown through, and breaking a mullion to enable access. The garrison, at risk of being overrun by the attacking forces and already trying to defence a breach by the assault into the castle itself, surrendered rather than continue fighting. Ultimately it transpired that the garrisoned force of about eighty soldiers, as well as thirty horses, ammunition and gunpowder, officers, colours and the governor, had surrendered to a force probably no larger than a hundred and fifty.

The degree to which the subterfuge is true or colourful exaggeration is unclear. Reinking was also involved in the taking of Shrewsbury, again apparently through surprise and subterfuge tactics in breaching the defences without alarm in February 1645, though his accounts clashed with those of Sir Thomas Myton in accounts given to Parliament over which of the men had won the victory, possibly in the hope of being appointed governor of the town (Bracher and Emmett, 2000, pp. 35-36, Worton, 2016). The account of the action given in the periodical 'The Weekly Report' emphasises that previous accounts of the action has been filled with "peradventure" and claims to give the most factual recounting, leaving out the discussions of subterfuge, but agreeing with the account given in 'Burning Bush' regarding the method and progression of the attack and the outcome in regards the captured soldiers and supplies. The castle was subsequently garrisoned by Parliament, and references to its demolition or burning as a result of the attack appear to be a romantic fabrication by later scholars (Harwood, 2006).

7.2.2.1 Further actions

There is no strong evidence for any further action at Moreton Corbet castle following capture in September 1644. Abandoning the castle as a garrison was discussed in January 1645 by the committee at Wem, however following the fall of Shrewsbury to Parliament in February of that year, it seems the site continued to be garrisoned, likely until after the surrender of the Royalist garrison a short distance away at High Ercall, in March 1646 (Worton, pers. comm.). The history of the village of Myddle by Gough (1875) mentions the brother of a resident of Myddle named Elizabeth Fenwicke [sic], who:

> “*was a Collonell in the Parliament Army, a comely proper gentleman. Hee was somewhile Governor of a small Garrison in the Castle att Moreton Corbett, which hee fortyfyed with a mudde wall, and there manfully withstood a sharpe assault of his enimyes.*”

This is likely inaccurate, and the reliability of this information is questionable due to both the lack of detail, and the source being at best a third hand account written almost half a century after the conflict. It is possible fortifications were enhanced after the castle’s capture by Parliament in September 1644, though no other account of a Royalist assault on the garrison exists, and the Royalist presence in the county was certainly on the back-foot by the end of 1644. The possibility still remains however and the degree to which unsuccessful attacks on garrisons survive into the historical record is an issue that may require further examination before a complete understanding of the archaeological signature at siege sites can be fully understood.

7.3 Reconstructing the historic landscape

Without an understanding of the nature of the historic terrain and landscape at the time of the engagement, it is impossible to fully appreciate how an action was fought in the past from the present-day landscape alone, or how the archaeological evidence relates to that action. This process is at the core of battlefield investigation and underpins reinterpretation of past battles using the unstratified archaeology (Foard, 2012, Schürger, 2015, Pollard). For siege sites this includes not only an understanding of the terrain surrounding the site, but also of the fortified location itself including prepared defences, structures and routes of access. For the investigation of urban sieges this will undoubtedly require significant research and possibly excavation to identify the contemporary street layout and stratigraphy of the often-demolished defences. For smaller, rurally situated siege sites, landscape regression is likely to be easier as the surrounding landscape is typically less developed with less fragmentation of the archaeological evidence.

For Moreton Corbet landscape regression is dependent on surviving descriptions of the castle from the late-sixteenth and early-seventeenth centuries, and on maps from the early-nineteenth century. Sketches and paintings of the castle and neighbouring church provide a number of clues to the contemporary form of the castle at the time of the Civil Wars, as well as the post-occupation degradation of the site (Harwood, 2006), while the form and extent of the formal gardens to the south of the structure can be extrapolated from 1920s aerial photography, as well as an archaeological survey of the surviving earthwork features in the late 1980s (Wilson-North, 1989) prior to loss through ploughing as the surrounding landscape became predominantly used for arable crops.

7.3.1 The castle and location of the earthwork fortifications

The remains of the castle are associated with three stages of development: the twelfth century stone castle, the c.1560s redevelopment of the castle into a residence by Andrew Corbet, and the c.1580 construction of the three-storey Elizabethan southern range. At the time of the civil war the form of the castle was predominantly dictated by work to incorporate the older elements of the site with the newer three-storey southern range. The form and appearance of the structure is well documented in sketches and diagrams from the period before and after ruination began, and a detailed chronological-phase plan diagram of the site is available from the English Heritage webpage for Moreton Corbet.

The form of the fortifications used to protect the garrison is the key issue in understanding the historic terrain for Moreton Corbet. The defences were considerable enough that ladders were required to scale them in the assault during the second siege (Worton, 2016, pp. 227). They were almost certainly built during the occupation of the site by the Royalist garrison, probably before early 1644, and included 'flankers' presumably to protect the faces of the castle from being blind spots to defence from the structure i.e. across the flank. Flanker is not however a terminology to describe the form of an earthwork, and rather describes its function. Civil War generally mirrored the Dutch style of fortification used during the Thirty Years War, using a ditch and rampart, typically with a parapet constructed on top of the rampart to shelter the defenders from incoming fire, and to add to the height to the overall bank of the defences (Duffy, 1979).

The need for earthen defences at Moreton Corbet is evident from the nature of the castle. While the ashlar-faced structure would provide adequate shelter for billeted troops, and a solid position against any small-arms fire, the Elizabethan range was built in the manner of a country house rather than as a military structure. Consequently there are numerous blind spots from the windows against the base of the structure, such as the recesses between column bases that also offer cover from flanking fire. The threat of artillery bombardment would also have been a genuine concern, even for smaller garrisons and fortified locations, though as the siege of Hopton Castle (1644) shows this was not always effective at bringing about capitulation without also resorting to storming (Bracher and Emmett, 2000, pp. 79-80).

Identifying the position and composition of the defensive perimeter at Moreton Corbet is hindered by the lack of any surviving remains. Without surviving earthworks, any modelling of the defences at Moreton Corbet relies on applying contemporary military theory with an examination of the landscape for their practical application (Louth, 2016, pp. 70), allowing for pragmatism in what was built and where. There is a probable candidate for the location of the defences, and a possible clue to earthwork remnants at Moreton Corbet prior to the late twentieth century. A rapid survey of the surviving traces of the formal gardens at Moreton Corbet in the late 1980s by Wilson-North identified a formal garden enclosed by a raised square platform, with "bastions" on the surviving corners (Wilson-North, 1989). Curiously despite Moreton Corbet's military history, Wilson-North overlooked the possibility that the trace earthworks were in any way related to this past, and attributed the form wholly to an ornate garden attached to the southern range speculating the bastions to be the possible location of summer houses without any further consideration given to their presence (Wilson-North, 1989, pp. 226). A transcription of the map from the gardens survey is shown in Figure 66 below. The details of this survey are largely corroborated by the 1929 RAF orthogonal aerial photography of the landscape in the area of the castle and around Shawbury. Although the castle lies towards the edge of frame, the castle and garden area is entirely within the image, however sporadic snow cover possibly due to combined melting and drifting (the images were taken in the late afternoon on 28th February 1929) makes some of the relief features harder to interpret.

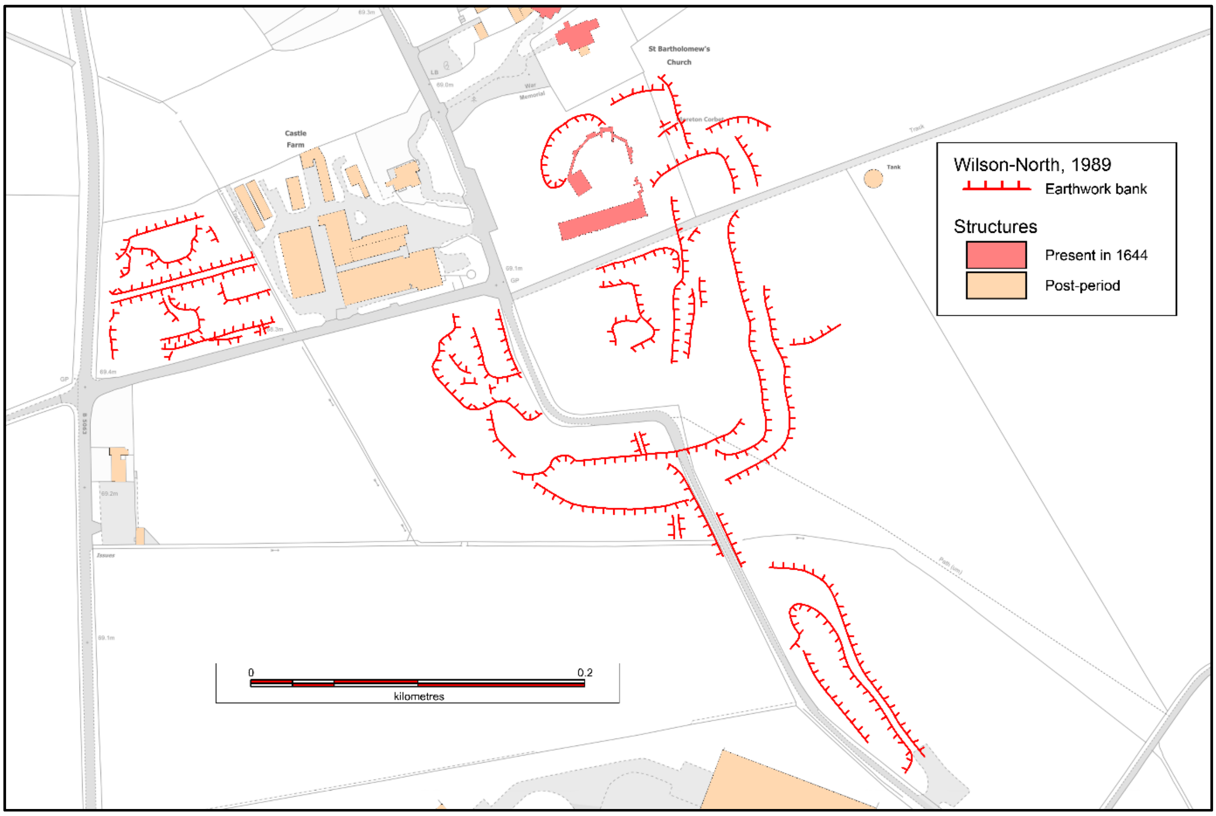

Figure 66: Transcription of the features from the Wilson-North (1989) garden survey at Moreton Corbet Castle. OS MasterMap® Topography Layer 1:1,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

The raised garden platform would have offered both a practical and pragmatic location for defensive fortification to have been built, being both raised above the low-lying wet landscape, offering potentially good fields of fire and visibility against attacking forces, but also extending to cover the least defensible sides of the castle (east and south) where the straight edges of the structure provide considerable blind-spots to defence from the building alone. This does not necessarily correspond to the likely direction of approach of the castle however, as the roads located to the north and west sides of the castle also pass through the village and its enclosures, as well as likely the associated service buildings, providing good ground and potential cover for an attacking force. After the capture of Wem by Parliament in 1643, the source of the greatest local threat to the Royalist garrison would also have been located in that direction. This side is also afforded the best cover from the village and the church, as well as enclosures within the village. The significance of the village enclosures as cover for an attacking force may be overstated however, as a watercolour of the church by (Williams, 1788) shows the boundary between the castle and the church to be a simple wooden fence rather than the present-day stone wall.

If the defences incorporated the entirety of the garden platform, a sizeable garrison would have been required to adequately defend the perimeter. If Moreton Corbet had been used as the base from which Sir Vincent Corbet's 860 strong dragoon regiment operated (Remfry, 1999, pp. 25), this would have provided ample garrison for the circuit to include the gardens and possibly encompass the service buildings, and indeed may have been necessary to provide accommodation for the number of men and horses entailed in such a force. This would also have proven a defensive liability in the event of a reduced garrison, as evidenced potentially by the successes of the attackers in September 1644 in being able to surmount the defensive works without apparently significant resistance. Figure 67 below shows the speculated location of earthwork defences at the site, based off of the earthwork evidence in Wilson-North (1989).

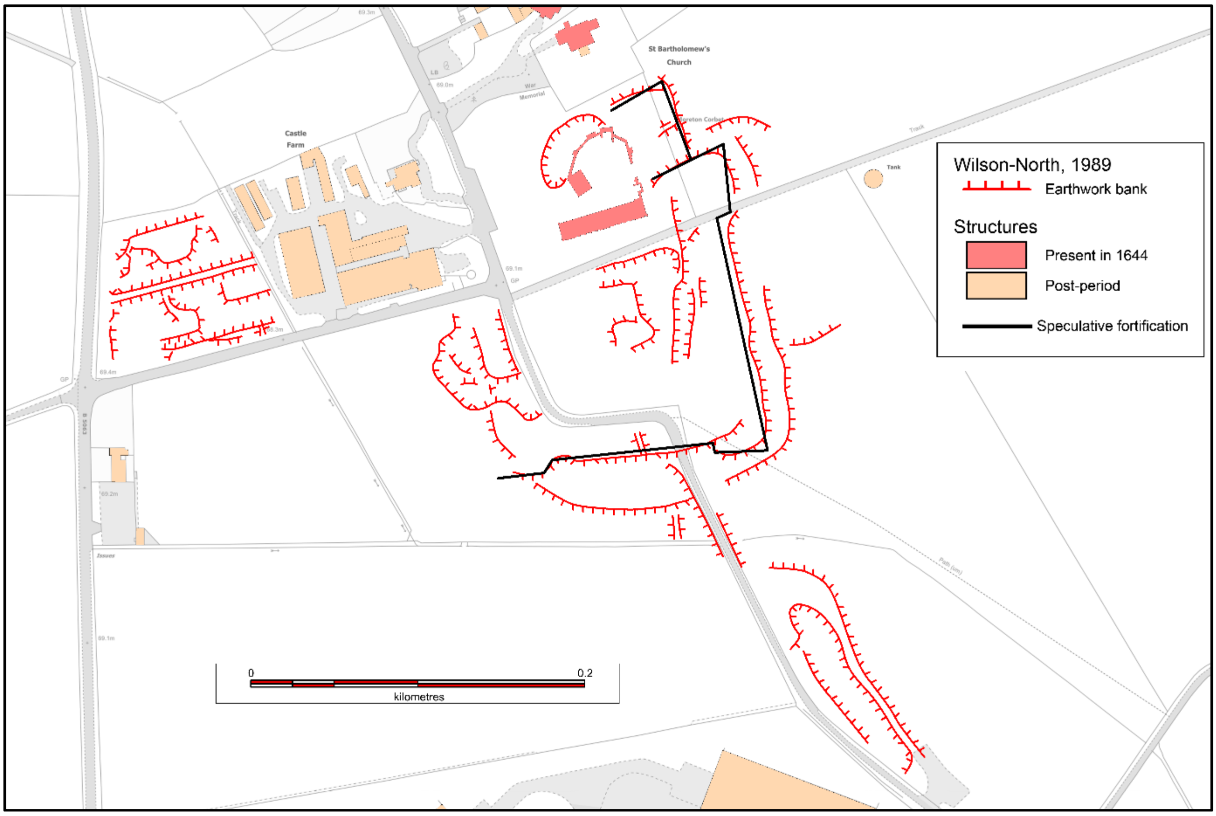

Figure 67: Projection of speculated defences from earthwork evidence mapped in Wilson-North (1989). OS MasterMap® Topography Layer 1:1,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

There is no surviving evidence of the service buildings that were built for the new house, though it seems likely based on the location of the gardens and the ornamental pond that aligns with the house and gardens to the east, that these buildings were somewhere around the location of the present Castle Farm site, or possibly spanning the road north into the village in the area of the present day visitor parking for the English Heritage site. Farm buildings immediately west of the castle that appear in the 1848 township map held at Shropshire Archives are no longer extant by the time of publication of the first edition OS maps, which may further complicate the search for service buildings to the west of the southern range, as well as the archaeological survival of any defence earthwork remains occurring on the west side of the castle.

The remains of the moat at the north of the medieval remnant of the castle suggests that this feature was left intact by any defensive fortification of the site, though to what extent this may have been modified for defence as an entrenchment or an additional barrier against assault is not evident. There is also no evidence that the castle building itself was modified in a defensive capacity by the garrison, and previous suggestion of a possible gun port and spotting hole (Foard and Morris, 2012, pp. 132) has been identified as a fireplace flue from an internal examination of the opening, and from later drawings and plans of the castle.

7.3.2 Surrounding landscape

The changing land-use of the fields surrounding Moreton Corbet has been examined in detail by Rowe (2019) as part of investigation into the condition of artefacts in the plough zone, and will not be discussed in further detail here save for where it influences survey activity or relates to reconstructing the contemporary landscape of Moreton Corbet at the time of the siege. The extent of the enclosed landscape surrounding Moreton Corbet Castle in the 1640s is unclear, and although an accompanying map of pre-existing enclosures is alluded to in the act for Moreton Corbet (1797), this map is not present in the Shropshire Archives.

The earliest identified map relating to the surrounding landscape of the castle is a 1748 map of the estate of the late Corbet Kynaston. The key observations from this map are that the boundaries to the west, south and east are significantly different from later maps. Rowe (2019) identified that much of the land to the north-east, east and south the castle is low lying and was likely marshy prior to drainage, further indicated by field names such as “moor” and “deepmoor”. It is likely then that the field boundaries changed to their broadly contemporary alignment after drainage ditches were cut prior to the mid-nineteenth century, and indeed the boundaries today are largely determined by the present locations of drainage channels. The Kynaston map field boundaries and associated names are shown in Figure 68.

Figure 68: Translated approximate location of field boundaries and associated name as denoted on the Kynaston map (1748). OS MasterMap® Topography Layer 1:1,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

St. Bartholomew's church has undergone limited change since the Civil War period, with significant external alterations including an upper extension of the tower in 1769, and the southern squire's pew annex and repair of the chancel walls in 1778 (Historic England, List Entry 1307235). The land to the north of the church is marked on the estate map as "gleabe" (meaning church land), and incorporates the location of the rectory as well as a large section of the present adjacent pasture field (Field 1434) that remains under church ownership. The former rectory is largely centred around a probably sixteenth century structure with numerous surviving seventeenth century elements, though the exact form of this building in the 1640s is unclear (Historic England, List Entry 1178013) The meadow to the west of the glebe, although truncated to the south for the church access road in the present landscape, appears largely unchanged from the eighteenth century. The village beyond this from the castle contains a number of areas marked as yards, presumably associated with working farms, though today only Moreton Corbet Farm is an active alongside Castle Farm. The timber-framed house referred to as "Corbet Lodge" on present maps is the only other contemporary structure in the village, and dates to approximately 1600 (Historic England, List Entry 1055400).

The formal gardens survey by Wilson-North (1989) indicates the castle was previously accessed from the Roman road by a causeway running through the present-day location of Castle Farm and the scheduled area to the west of the castle, and north of the modern road from the west. Although the causeway is not shown on any maps relating to Moreton Corbet, the estate map shows an unexpected turn in the field boundary of "Castle Court", adjacent to the Roman road. This would approximate to the location of the end of the causeway, however no above ground evidence remains of this location and it is not identifiable in later maps.

The present-day road to the south of the castle is not also contemporary to the Civil Wars, evidenced by its bisecting of the formal gardens of the castle. It is not shown as a road/path on the Kynaston estate map (1748) and no roads other than the Roman road to Shawbury and the road to Stanton to the north-east are shown on Baugh's map of Shropshire (1808). The route may have existed in the form of a route of access as its location is mirrored in part by field entry points on the estate map boundaries, later becoming an enclosed road after low-lying areas of the landscape were sufficiently drained prior to the mid-nineteenth century.

7.3.3 1640s landscape

The image of the Moreton Corbet landscape drawn from map regression and landscape investigation is one of a largely open landscape to the east and south with marshy ground and meadows beyond the limits of the formal garden platform. To the north and west the roads form a boundary to the extent of the village, with enclosures between the church and village houses spread either side of the road running north connecting to the Stanton road. Buildings associated with the castle appear to be located to largely in the area to the immediate west, probably to the side of the causeway linking the castle to the roman road, and possibly surrounding the junction of these access routes to the castle grounds. Figure 69 provides a simplified overview of the projected landscape at Moreton Corbet at the time of the Civil Wars, together with an approximate outline of the castle structure prior to ruin, and the speculative defences (black lines) derived from Wilson-North's survey (red lines).

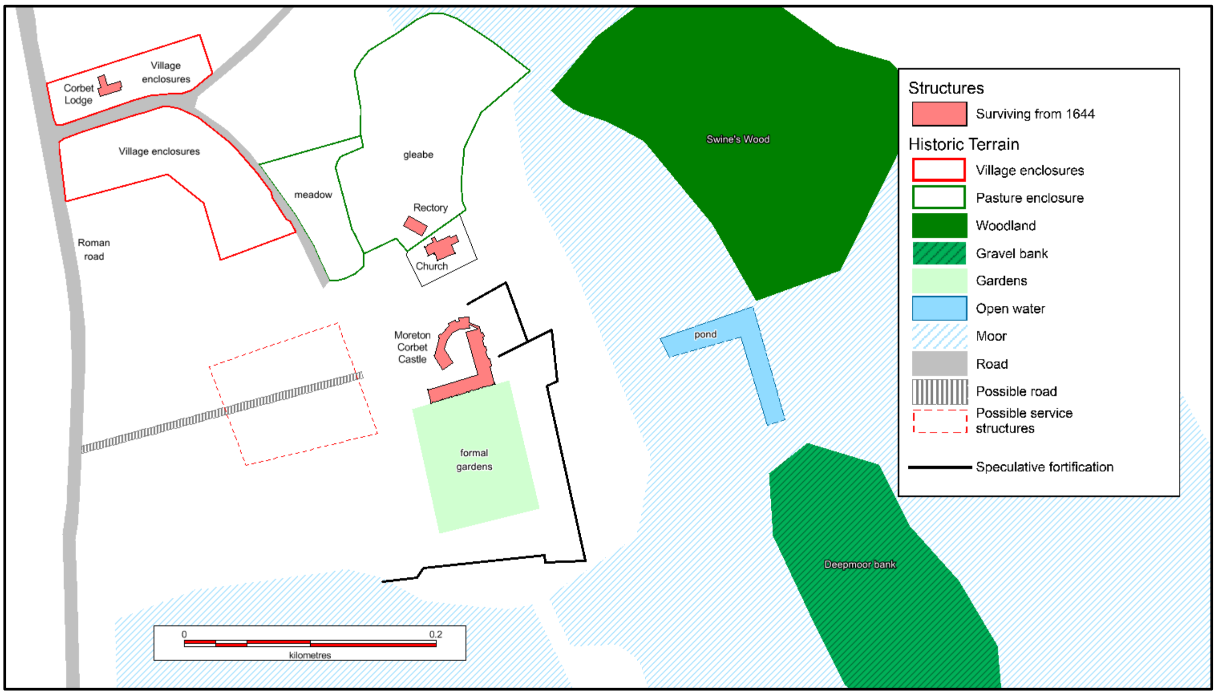

Figure 69: Overview of the probable or identifiable elements of the surrounding landscape of Moreton Corbet Castle in 1644

7.4 Metal detector survey

The survey of the plough-zone metal artefacts from the sieges of Moreton Corbet was carried out between 2014 and 2019 according to the methodology for transect detecting of battlefields set out in Foard (2012, pp. 40). Transect metal detector survey has been proven to be the most statistically representative method of examining the distribution density of finds on early modern fields of conflict (Foard, 2012, Schürger, 2015). As the principal artefacts being sought for interpretation of the actions at the site were lead projectiles, detecting was limited to non-ferrous discrimination, as the additional cost to the survey of retrieval, conservation and analysis of ferrous objects could not be justified.

While the composition of the team and the assortment of detector devices in use changed over the course of the survey, the majority of the survey work was undertaken by a core team of six detectorists. In order to reduce bias in the recovery rate as a result of signal selection based on individual detecting experience, detectorists were instructed to recover all non-ferrous signals they encountered. Management of the forward progression rate of the team proved difficult when experienced detectorists were working alongside those with less experience, and a majority of the team management time during 2.5m transect survey was spent trying to prevent straying across transects, owing frequently to misalignment between the transects and the lines in the fledgling crop. Each incidence of straying was corrected rapidly, to ensure the correct coverage for each transect, and no siege related finds were made during straying incidents. Future surveys at 2.5m transect intensity may require additional measures within the survey method to ensure detectorists do not lose position after digging a signal, though careful examination and counting of marker flags by the detectorist when resuming the transect can often resolve this issue.

Transect positions and find locations were recorded using a mapping grade (accurate to within 1-2m) handheld GPS unit (Trimble GeoXT GeoExplorer 2008 Series). The base level of accuracy of point logging for the unit was typically to within 1.6m of the internal receiver; however for the majority of the survey location signal from a geostationary satellite-based augmentation system (SBAS) satellite provided real-time corrections to the GPS signal, allowing 60-80cm accuracy except for instances of obstruction of line-of-sight to the SBAS satellite. Additional GPS devices were not available to record the speed of survey of individual detectorists, and the degree to which variance in the individual rates of progress of detectorists could not be wholly accounted for during the survey. The surveyed area is shown in Figure 70.

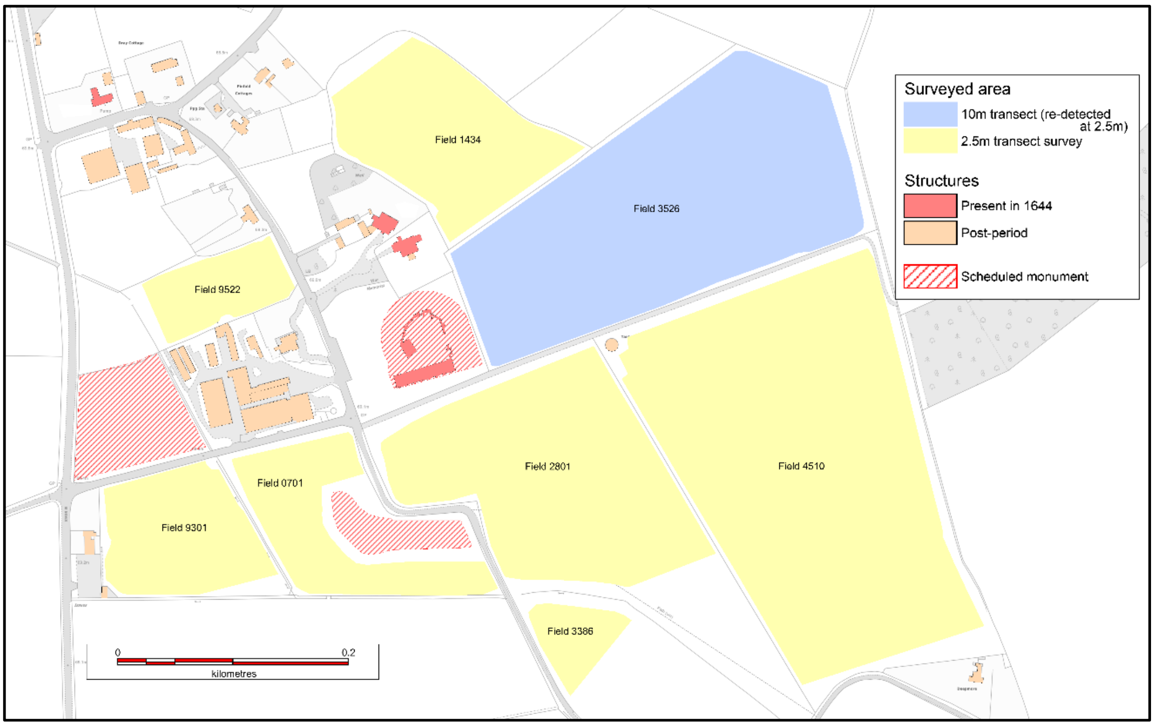

Figure 70: Metal detector survey coverage at Moreton Corbet. OS MasterMap® Topography Layer 1:1,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

Initial surveying began in the field immediately to the east of the castle (3526), with transects running a roughly north-south axis at 10m intervals as per the Edgehill base survey (Foard, 2012). Results from this survey indicated a significant quantity of lead debris in the first 100m extending away from the castle grounds boundary, containing significant quantities of melted lead and charred inclusions. None of this lead was able to be identified for its previous use or form, and recovery of these fragments significantly slowed progress in the first few transects. The decision was taken following this first survey to continue to bag and collect smaller fragments of less than 100mm x 125mm (the size of the finds bags) without initialling by the finder, with larger pieces being placed in the junk bags along with modern rubbish and large ferrous items. The retention of smaller items was to avoid potential loss of bullet fragments or small lead finds misidentified in the field by individual detectorists, and to pass the filtering of lead scrap from artefacts to the cleaning process where a better assessment could be made.

The initial survey also raised the issue of surface conditions for detecting at Moreton Corbet on arable fields. The Edgehill survey identified that the ideal conditions for detecting on arable fields are typically immediately after the crop has been cut and before soil turning, as this provides the best signal quality owing to good conductivity of the soil and evenness of the ground after settling out of the soil over the growing season (Foard, 2012, pp. 153-154). At Moreton Corbet the crop cycle turnaround was sufficiently short that it was largely impracticable to survey during the timespan between harvesting and soil tillage. In addition to this the soil was typically turned in late summer, producing both dry and loose ground conditions with a highly uneven surface, the least productive combination of conditions for detecting object signals in the topsoil (Foard, 2012, pp. 154). Surveying on arable fields was instead limited to a window occurring approximately one to two months after sowing of winter wheat in October and November, as the recently germinated wheat was sufficiently hardy to tolerate survey activity (trampling and being turned by shovel), while the soil was sufficiently damp to produce workable detector signals despite retaining some of the loose quality as a result of being tilled.

The method of soil turning at Moreton Corbet may also have an influence on the depth of signal penetration and the movement of topsoil artefacts. Rather than deep ploughing, the soil is ploughed to a depth of 25cm every year and broken (without turning) using a vertical plough every four years down to 35cm depth to break up subsoil compaction (Rowe, 2019, pp. 176). It was noted that the detectorists rarely recovered object signals more than 10cm deep on the arable fields, and virtually nothing below the compacted soil layer at c.25cm. It is reasonable to expect that as the landscape was largely pasture until the twentieth century, a significant portion of unstratified archaeology may have sunk below the reach of the shallow ploughing method used here. As the soil is not being turned during the vertical subsoiling process, finds from c.25-35cm may also have sunk further into the topsoil Putting them beyond the signal detection range of most hand-held VLF detectors. Trial investigation of the issue of recovery and depth on arable fields at Lutzen showed that signal recovery is predominantly concentrated within the first 10cm depth from the surface on arable fields, with more than 70% of the metal artefacts recovered from the spit-trench found from 10cm down to 80cm (Schürger, 2015, pp. 122). Using this figure as a baseline, and assuming approximately 80% coverage of the surveyable area when using 2.5m transects (Foard, 2012, pp. 155), the total finds recovered from arable fields would be expected to be approximately 24% of the total small artefact finds from the landscape on arable fields and those pastures previously ploughed since the turn of the millennium. The percentages of finds in the three permanent pasture fields is likely to be significantly lower owing to artefacts not being periodically brought back to the surface through ploughing.

Initial bullet recovery from the east field at 10m transects produced just eighteen bullets for a surveyed area of 2.3 hectares, a recovery density of approximately 7.6 bullets per hectare. If this were extended to the targeted survey area of the site, taking into consideration the reduced rate of recovery on pasture and likely reduction of bullets with increasing distance from the castle, this gave an estimated projected total of between 80 and 130 bullets. This was considered too small a data set from which to make meaningful assessments of the archaeology, or to use as a basis to develop a methodology for investigating siege sites using transect survey on a small siegefield.

Subsequent surveying was intensified to 2.5m transects, giving the greatest degree of surface sampling of the surveyed area with the least overlap in the coverage of the swing of the detector coil between detectorists. This degree of intensity was maintained for the remainder of the surveyed area, including a redetect of the initial field (once completed at 10m intensity) with transects running perpendicular to the original survey (i.e. east-west). This survey intensity proved challenging but achievable for the planned survey area, however due to external factors to this study, several significant time intervals between surveying occurred in 2016 and 2018, and attrition of members from the detecting team precluded the survey from maintaining the consistency achieved at Edgehill and Lutzen through consistency of detecting team members.

7.4.1 Artefact distributions

A total of 1320 artefacts of all types were recovered as part of the Moreton Corbet survey, of which 268 are bullets or bullet fragments of early modern period projectiles. In addition to this a further 7 objects are of certain military origin, including 5 powder box caps from musketeers’ bandoliers, and one priming-powder flask nozzle. A further two that have possible origin to military activity in the period of the Civil Wars have been identified as sprues from a gang mould for bullets. Similar items have been identified in excavations at other siege sites such as Beeston Castle (Ellis, 1993), however the sprues identified at Moreton Corbet are much smaller, being of an estimated bullet size of 60 bore for one found within the formal gardens landscape, and of smaller than 100 bore for the other found in the southern most surveyed field (3386). The remaining items span in date from the Roman occupation to the twentieth century, though by far the largest category of non-bullet finds is that of scrap lead debris in various forms. Although these have not been analysed in detail, they range in forms from melted lumps to twisted pieces of flashing, as well as a small number of rolled or crushed sections of sheet lead.

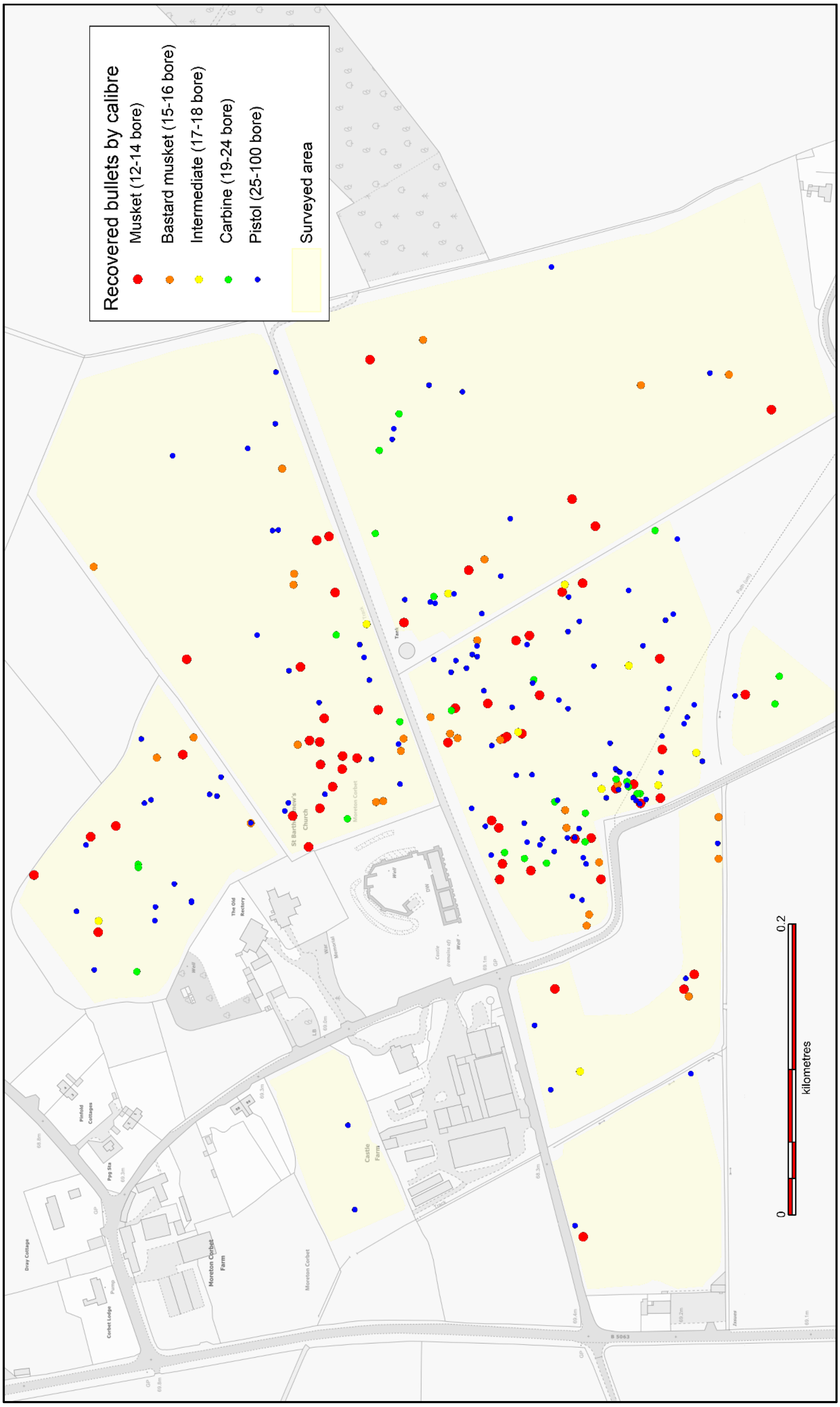

Figure 71: Distribution of bullets recovered through metal detector survey by weight-derived bore. OS MasterMap® Topography Layer 1:1,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

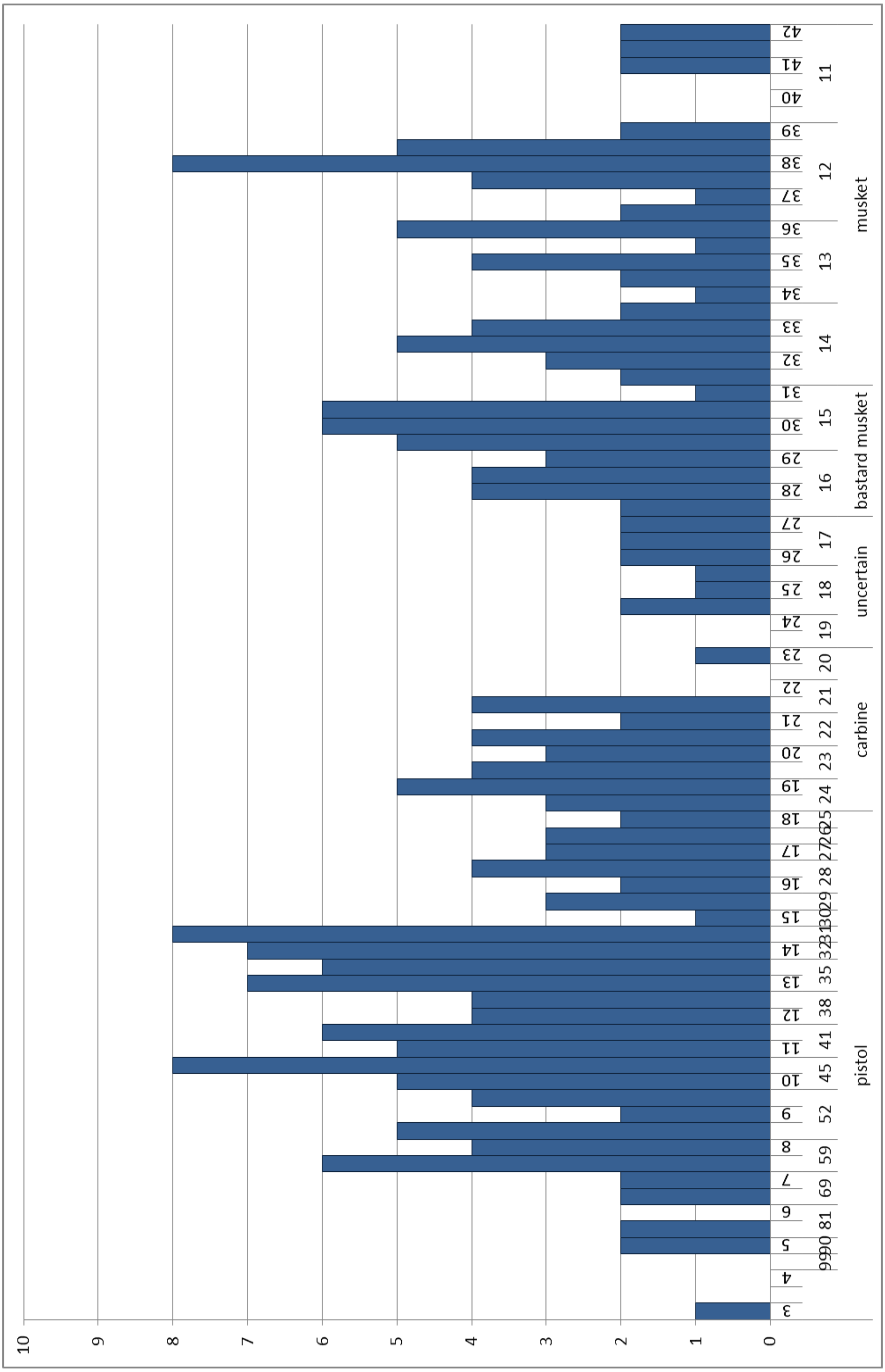

Figure 72: Graph of calibre of all "ball" bullets identified from Moreton Corbet at 0.5g intervals, including those distorted by impact or firing. Weapon bore ranges derived from those used by Foard (2012)

Figure 72 shows the calibre distribution by mass of 'ball' bullets, including those identified as ball bullets with significant impact distortion. Due to the sparsity of the data, masses are grouped by 0.5g intervals rather than the 0.25g intervals used for Edgehill (Foard, 2012). The boundaries for weapons categories e.g. pistol, carbine, etc., are the same as those given by (Foard, 2012) for Edgehill. The calibre distribution shows a number of major peaks centred around 12 and 14 bore for muskets, 15 bore for bastard muskets, 23-24 bore for carbines and a density of pistol-calibre ranges between 31-59 bore (14.5g-7.5g respectively).

The high quantity of smaller shot and the variability in the totals bullet calibres towards the larger bores have a number of possible interpretations. As this was an arguably less important garrison during the conflict, it is likely the troops permanently stationed here for defence would not have been equipped as well or as uniformly as musketeers and cavalry regularly deployed by field armies in the Civil War, who in turn had issue with weapon supply in at least the early conflict (Foard, 2012, pp. 156). Comparison of the Moreton Corbet calibre graph with other siege locations published by Foard and Morris is problematic, as significant variation in the calibre distributions of these sites most likely reflects difference in the collection methodologies and surveyed areas between sites. These approaches include intensive grid-survey and non-archaeological detecting of the siegefield (Grafton Regis and Basing House respectively), and excavation from within or adjacent to the fortified site (Sandal Castle and Beeston Castle) (Foard and Morris, 2012, pp. 136-140). As at Moreton Corbet the majority of the detecting area falls beyond the speculative location of the defended position, the mix of bullets will probably more closely reflect the calibre of weapons being fired outward by the defenders, though bullets closer to the fortified site have a greater probability of being from attacking fire towards the defences.

Another explanation of the high small-calibre concentrations is the likelihood as discussed above of Moreton Corbet being largely garrisoned by Sir Vincent Corbet's dragoons during periods when not on campaign. During the September 1644 siege it is clear that the majority of this force was engaged with retaking Montgomery from Parliament (Worton, 2016), and as such might not be expected to heavily contribute to the bullet assemblage for the second siege. The remaining garrison however was probably a mix of musket equipped foot and carbine equipped dragoons, possibly with a mix of weapons calibres depending on the quality of supply, and the degree of necessity for the best quality weapons to follow the field forces rather than garrisons.

At Edgehill the issue of contamination of the bullet assemblage by later period sport-shooting was deemed not to be significant owing to the low frequency of occurrence, and that the majority of those bullets would fall into 28-bore or smaller, while the vast majority of bullets recovered were within military firearm calibres (Foard, 2012). For Moreton Corbet nearly half of all ball bullets (or impact-distorted balls) fall into 24-bore or smaller, and as such the potential proportion of contamination from later periods could be much higher. That the land retained by the Acton Reynald estate continues to be used for recreational shooting today implies that the likelihood of contamination from early modern recreational use is quite high, and may be greater for siege locations where the siegefield forms part of an active estate. More investigation of the issues of background noise from leisure shooting may be necessary before an assessment of the likely scale of this problem can be ascertained.

The quality of the bullets from Moreton Corbet was extremely variable, ranging from those with good overall condition and visible surface detail in the corrosion layer, to bullets with significant concretions and surface loss. The influences on the condition of a sample of the bullets from Moreton Corbet are explored in Rowe (2019). How concretion and surface loss influence the overall mass-calculated calibre distribution of the bullets is unclear, though the thickness of the surface corrosion layer typically appears to be very small in bullets examined for corrosion depth (measured in micrometres) (Rowe, 2019, pp. 187), and may have minimal influence on mass measurements when rounded to the nearest half-gram. Assessing the impact and firing detail on many bullets was also impaired by the frequent presence of significant surface loss or corrosion pitting in the bullet surface, likely due to mechanical damage from abrasion in the soil triggering surface patina loss and acceleration corrosion (Rowe, 2019). Increased corrosion in areas of pitting may have led to many of the small rotational impacts incurred in ground-impact from contact with small stones or sand grains in the soil (Parkman, 2017) being misidentified as corrosion damage to the bullet. A detailed reinvestigation of the corrosion features on bullets in the assemblage may be able to better identify differences between impact-led corrosion weakness, and corrosion led surface loss.

7.4.1.1 Bullet scatter evidence

Unlike for battlefield contexts, where areas of bullet calibre densities can indicate infantry or cavalry action, there is little expectation that similar distribution evidence would be seen in the scatter at Moreton Corbet based on troop-type deployment, as once defending the fortified position, all soldiers effectively become infantry using whatever firearm they happen to be equipped with. What might be expected from calibre distribution are densities of pistol and low-calibre shot radiating away from the defences in the locations where an assault was made and defended at close enough distance to warrant using pistols, though how frequently garrison soldiers were likely to be armed with a long-barrelled firearm is uncertain, and probably only applies to dismounted cavalry troopers.

What instead is likely to occur are bands of shot in the vicinity of the defences that have struck earthworks or the ground short of the target, combined with clusters of impact scars, and in return see channels of bullet scatters radiating out from the fortified location as evidence of counter fire. For sieges where the besiegers dug lines of circumvallation, scatters of bullets from sallies and raids might be expected might be expected between bands of bullets indicating mutual exchanges of small-arms fire, and possibly scatters of hail-shot also radiating out from the defended location, however at Moreton Corbet there is no reason to think that such a protracted siege occurred for either siege event, and there has been no evidence of defensive artillery in the archaeology.

Three probable scatter densities were identified in the scatter distribution: to the south, to the east, and to the southeast. A possible fourth scatter density may be present in the northern pasture field (1434) extending past the church. Although the total number of bullets recovered from this field was relatively low, the ratio of bullets to other finds recovered from the field during detecting was the highest for any field covered by the survey. This may reflect an enhanced signal quality for field 1434 due to its recent land-use history, as it had been under plough as recently as the turn of the millennium, potentially drawing finds close to the surface, before returning to pasture thus giving good surface compaction of the soil, and better conditions for signal conductivity.

7.4.1.2 Impacted bullets and fragments

A small percentage of the total siege finds recovered included flattened bullets and edge-fragments of impacted bullets that could feasibly relate to surface impacts on stone. Bullet core fragments show a focal point of the radial striations that relate to the point of impact, while the smaller fragments from the radial edges of the bullet all feature distinct striation patterns and a curvature away from the striated face. Similar impacted bullets have been found in battlefield assemblages and may represent bullets striking larger stones in a ploughed surface. No part of the metal detector survey area approached any closer than 25m (castle site boundary) to the nearest set of impact scars, so it is improbable that these are rebounds from impact upon a structure. A small correlation between fragmented bullets and the base of the garden platform (and hypothesised location of the defences) may indicate an archaeological signature for earthworks from unstratified artefacts in the form of fragmented bullets, possibly hitting some component of the fortifications. Examination of plough zone artefacts from other siege locations in the vicinity of known historic earthworks may shed further light on this apparent relationship.

7.5 Impact scar survey

Surveying of the impact scars at Moreton Corbet was carried out using the techniques and approaches outlined in Chapter 5. An initial visual and photographic survey was carried out in 2013 to assess the extent of the impact evidence and record the general locations of scarring, followed by a more detailed photographic recording of scar distributions and measurement of scar heights between 2015 and 2020. The detailed photogrammetry was combined with manual cross-sectional profile recording of scars that were within accessible reach of a self-supporting step-ladder.

This is not the first study to examine the impact scar evidence at Moreton Corbet, as the site was subjected to limited investigation and presentation of the impact evidence by Foard and Morris (2012). Beyond a general description of the scar distribution around the castle ruins and on the church, the study also produced a broad plan of the site illustrating the general location of scar clusters, although detail within the published plan is not discernible from the scale. The limited investigation did not extend to presentation of elevation diagrams of scar distribution, nor any explanation of the methodology used in identifying which surface marks were considered impact evidence. From the building plan diagram, it is clear when compared to the recording undertaken in the present study that a small number of marks have been labelled as impact scars that have been discounted by the present study, and conversely several scars that have been identified in this research were overlooked previously.

7.5.1 Survey results

In total 101 small-arms impact scars were identified with certainty on the ruins of the castle, with a further 19 marks that were possible impacts but did not exhibit enough of the characteristic features to be labelled impact scars with certainty. An additional total of 49 small-arms impact scars were identified on the walls of St. Bartholomew’s Church, with a further 8 noted as possible impacts but without sufficient certainty for positive identification, and 2 marks that showed evidence of being impact scars but for which the remains were sufficiently compromised by post-period activity that this could not be established with certainty. The ‘compromised scars’ contrast from the ‘possible scar’ marks in that, while the latter group are those that appear unaltered on the surface and simply lack clear definition or some key features for positive identification, the former are marks where the evidence is strong, but has been altered, modified or removed by later development/restorative work. Figure 60 shows a plan diagram illustrating wall-facings that carry impact scars at the site on both the castle and the church.

Of the 150 identified small-arms scars on the castle and the church, 111 were subjected to cross-sectional profile recording. Profile recording was carried out using the 0.8mm-pin contour gauge and graph-paper trace method as outlined in Chapter 5, as the practical considerations for the available laser-scanning technology would result in 50% fewer scars not being examined. The contour gauge recording process was modified for Moreton Corbet based on insights gained from the trial recording undertaken at Ashby, Tong and High Ercall. At Moreton Corbet scar-recording fieldwork was carried out as part of a two-person team of the author and a volunteer. By dividing the set-up process prior to recording, and the transitional process between scar cross-sections, such as adjusting the recording sheet within the support frame between traces, this reduced significantly the time lost in switching between taking profiles and tracing them on to the paper, and adjusting the recording set-up for the next trace or scar. The total set-up and recording time for a complete scar measurement was thus reduced from twelve minutes per scar in the trial recordings, to six minutes per scar, doubling fieldwork productivity. The total fieldwork time spent recording scars at Moreton Corbet is estimated at approximately 11h using the contour gauge method. It is estimated that for the same quantity of scars to be recorded using the NextEngine laser scanner, this would require at least 37h of fieldwork, not including time required for re-scanning due to errors, moving and setting up an AC generator to power the unit, or potential difficulties encountered setting the scanner close enough to the wall for each scar.

In addition to profile-recording, further contextual data was also recorded for a small number of impact scars that might develop scar-shape understanding and interpretation. This included the slope angle of a section of dressed stone where a scar occurred on the angled surface adjacent to scars on the upright walls, and for some scars the trigonometric distance from the centre of the scar to protruding parts of the structure to examine the maximum possible angles of incidence to the impact point.

7.5.2 Significant scar groups

There are several clustered groupings of scars on the castle, three notably large clusters on the east wall of the castle, and several smaller groupings on the southern wall of the Elizabethan range. In addition to these, the south wall of the church south aisle and tower bear a number of impacts likely reflect fire from the castle against attackers approaching from the churchyard. Figure 74 and Figure 75 show elevations of the scar locations on the eastern wall of the south range of castle, and a cluster of ten impacts on the southern wall of the southern range. Figure 76 is a scar diameter distribution graph for the internal diameter of profile-measured scars across both the church and the castle.

Several scars present opportunities for specific investigation of spatial context and cross-sectional profile, the locations of these are highlighted in Figure 73, and are discussed below.

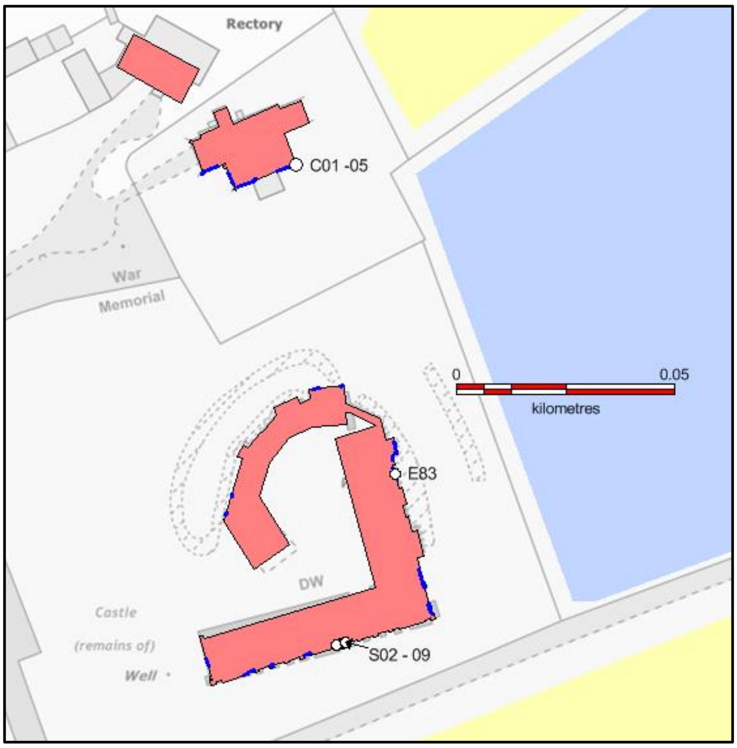

Figure 73: Location of scarred areas and exceptional scars at Moreton Corbet. OS MasterMap® Topography Layer 1:1,000 © Ordnance Survey EDINA Digimap Ordnance Survey Service

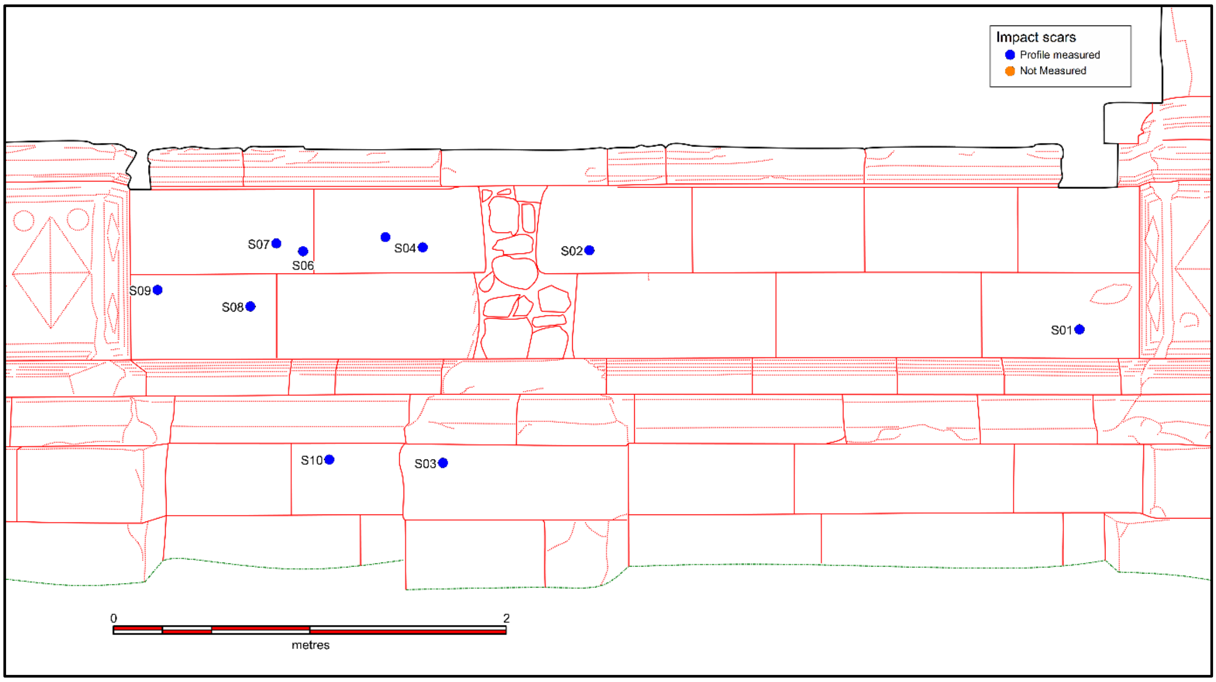

Figure 74: Scar plot elevation of southern wall of the south range of Moreton Corbet Castle

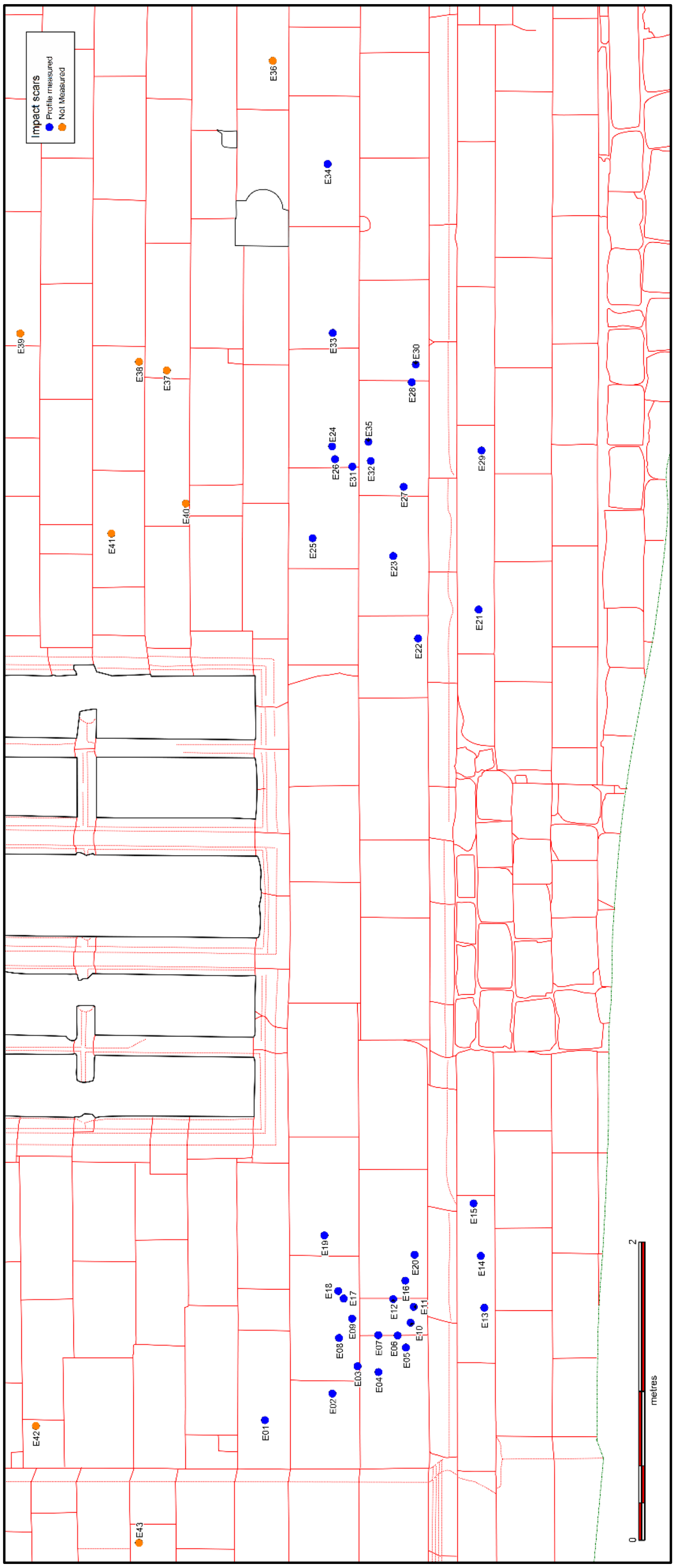

Figure 75: Scar plot elevation of eastern wall of the south range of Moreton Corbet Castle

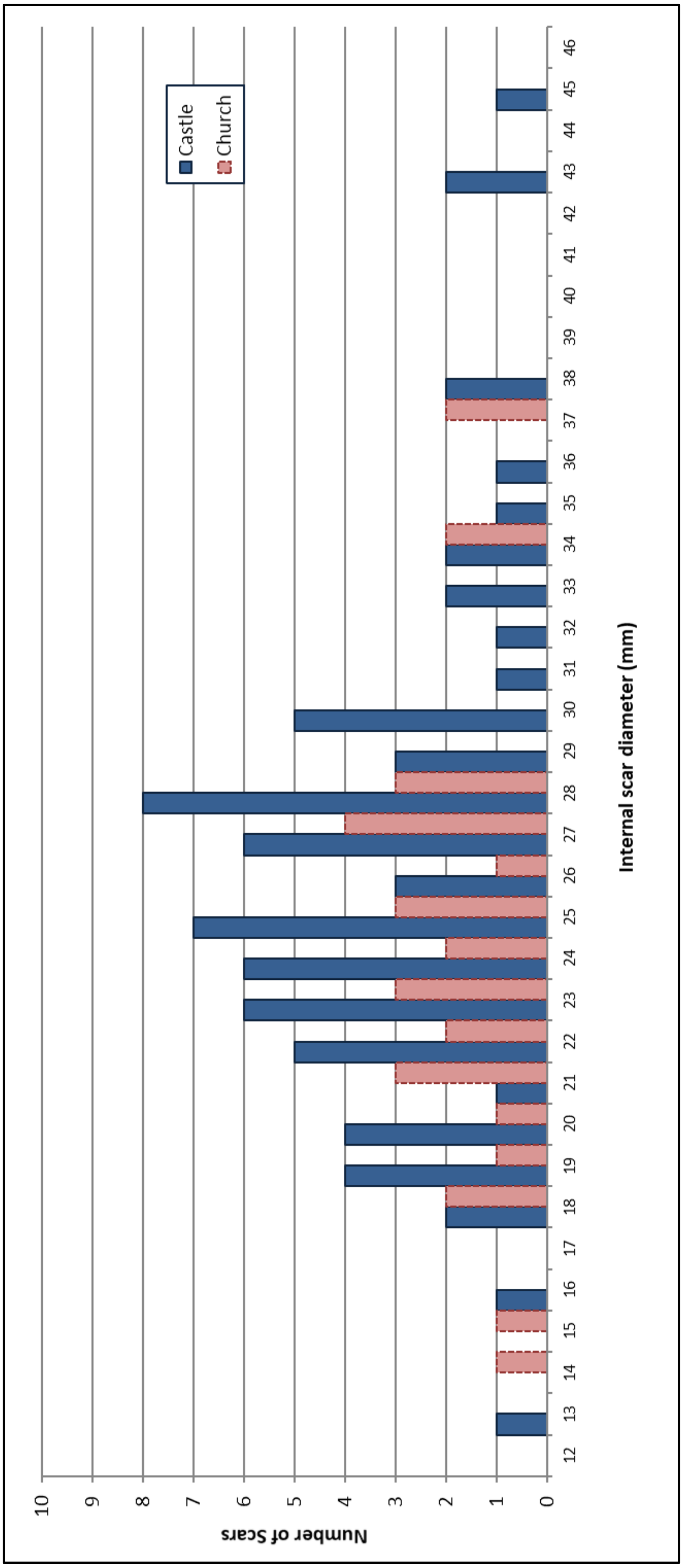

Figure 76: Scar size distribution graph for profile-measured scar internal diameter values

7.5.2.1 Castle scars S02, S04 and S09

Impact scars S02, S04 and S09 occur just to the east of the base of what was the central five-light window on the southern range. This section of wall survives only up to a low height of approximately 2.2m along a 12m section of the southern range. To the immediate east (right) of the window bay when viewed, a small cluster of impact scars occur along a 4m section of the wall, show in elevation in Figure 74. Located within this span is the remains of a column base, of which elsewhere on the southern range are adorned with a cuboid monolith with a diamond carved face, measuring approximately 60cm width, 90cm height and 45cm depth. Scar S02 and S04 occur on the recessed wall in close proximity to the former location of this block on opposite sides, while scar S09 occurs close to a similar block on the corner of the central-window bay.

That these scars occur centrally along the southern range on the side of the castle dominated by the formal gardens and orchard with few surrounding clusters of scars, it is reasonable to suspect that these scars may be related to one another in origin. Examination of the cross-sectional profiles shows that the scars in this section (that have not suffered from significant surface loss within the scar owing to fracturing) are also very similar in internal diameter and depth of penetration, varying to only a small degree from the mean for this group (Table 19).

Scar no.	Internal scar diameter (mm)	Variance from mean (mm)	Total scar depth (mm)	Variance from mean (mm)
S01	27	0	14	-2
S02	28	1	17	1
S03	25	-2	14	-2
S04	24	-3	15	-1
S05	25	-2	14	-2
S06	*Profile measurement unreliable due to severe surface fracturing*			
S07	32	5	19	3
S08	24	-3	14	-2
S09	24	-3	17	1
S10	30	3	16	0
Mean	27	0	16	0

Table 19: Internal diameter and total depth values for scars S01 – S10, and variation from mean value for this cluster

If these scars were indeed fired from the same position by an individual or a group of individuals, the proximity of the column base provides a clue to the origin, as this would have significantly limited the maximum angle of incidence for each of the scars. By measuring the remains of the base, and using other column bases as a measurement guide, it is possible to infer the position of the block, and make an estimation of the maximum angle of incidence from each direction. Figure 77 below shows the plotted arcs of maximum angle of incidence for each of these three scars out to a distance of 100m from the castle. The area of overlap is shown in Figure 77 out to a distance of 200m, plotted against the historic terrain, hypothesised location of the defences, and the distribution of finds related to the garrison and the sieges.

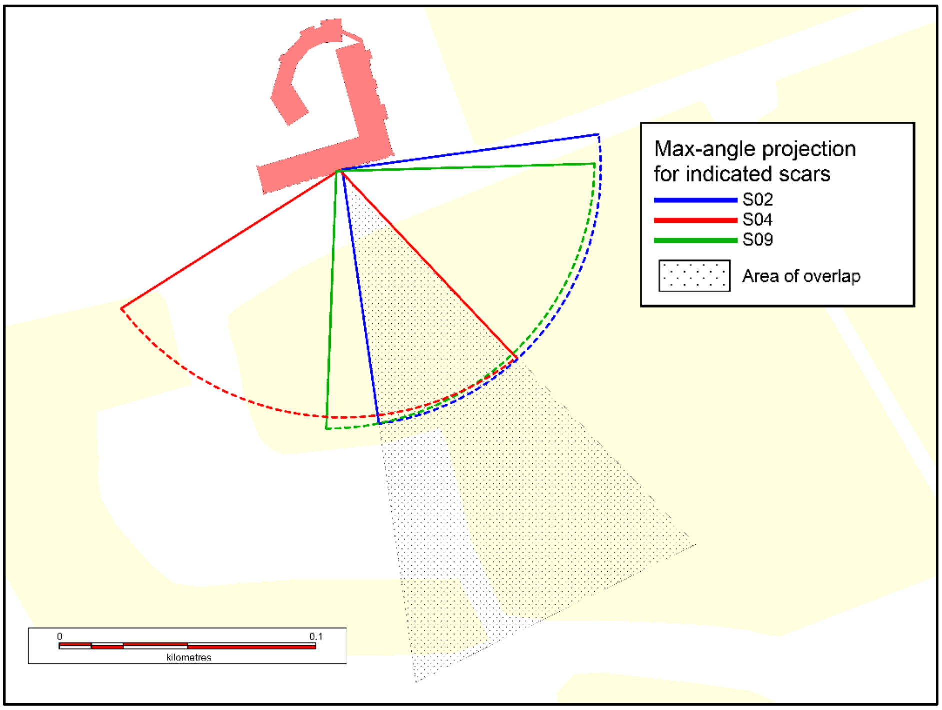

Figure 77: Maximum angle arcs for scars S02, S04 and S09 with area covered by overlap

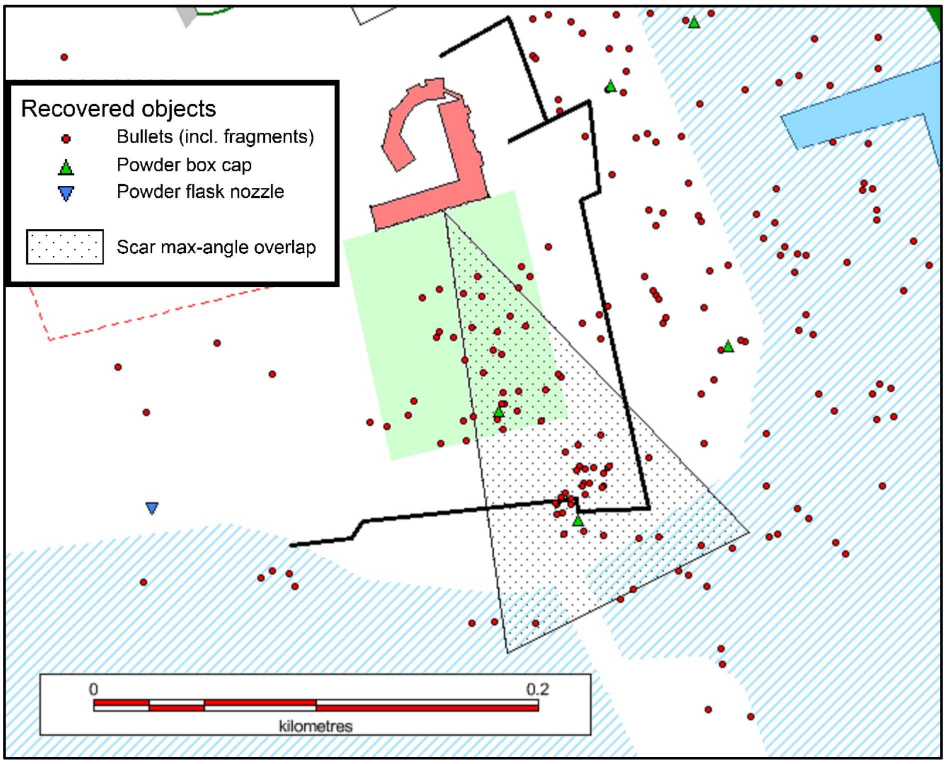

Figure 78: Maximum scar angle of origin overlap plotted against siege-related finds and historic terrain

The overlap immediately and strikingly shows a correlation with a significant quantity of bullets within the survey area of the south field and two of the five powder box caps recovered from the survey. This area is also flanked by areas of low density of siege related finds, recovered by the survey, though the area to the immediate east also has a low recovery rate for all finds, and may be a product of the ploughing of the garden platform in the late twentieth century increasing the depth of finds in this location.

If the scars and finds do relate to an attack from this direction, it raises several questions. If the defence hypothesis of having used the garden platform is correct, does this reflect the successful capture of the outer earthworks by an assaulting force, and repeated volleys of defensive fire from the direction of the house? The scars are characteristic of scar distribution for backdrop impacts, rather than having been targeted at the house, suggesting that once within the garden area, the attackers had another possible defended position to overcome before reaching the house. Although the lack of higher surviving elevations makes it difficult to assess with certainty whether these scars are incidental impacts or fall-shorts from attacking window positions, the low frequency of impacts, their position towards the base of a section of wall with no windows immediately above it (prior to ruin of the structure), and the lack of impacts in proximity to the actual locations of the windows, suggests that it is more likely that these are indeed ‘backdrop’ impacts at a ground target.

If the defences did not include the gardens, then this would seem to be an illogical choice for the direction from which to assault the house, as although the southern range possesses two small doorways, it also have the greatest window coverage, and the longest run of level ground over which the defenders could give fire, on the assumption that the orchard had been cleared as an obstruction. If the orchard had not been cleared, was this poor defensive preparation, or was it retained due to lying within the defensive circuit and thus not a problem whilst the site was adequately garrisoned? Confirmation or otherwise of the defence location hypothesis could provide an answer to these questions about the defensive strategy and preparation of the site against assault in relation to the gardens,

7.5.2.2 Castle scar E83

Impact scar E83 is located on an angled section of stonework northern-section of the east face of the castle (Figure 79). This scar stands out for individual investigation due to the angled surface on which it occurs, in contrast to the surrounding scars which all occur on upright sections of the wall surface. For the majority of impact scars it is the lateral angle of incidence of the impacting shot that is being sought from analysis, in order to attempt to reconstruct the probable location of the shooter, with the vertical angle of impact expected to show little deviation from a horizontal path except for instances of significant elevation of shot.

Figure 79: Impact scar E83 located on backwards-sloping wall surface on Moreton Corbet Castle

For this scar the angle of incidence to the impact point is effectively determined by the angle of the backward slope of the stonework. The surface measures a 140° angle relative to the vertical wall, which by extension would lead a bullet travelling horizontally to strike the surface at a 40° angle of incidence from the orthogonal (Figure 80). Drawing from theory for frangible-surface behaviour under angled impacts (Haag, 2005), the expected cross-sectional profile for this scar in vertical axis (in this instance measured across the sloped axis) should show an elongation of the scar towards the top edge as the bullet draws out the material along the direction of travel from the point of initial contact. Conversely the deepest point of the scar should be located towards the bottom edge indicating the initial contact point and direction of impact. The diameter of the scar should also show elongation along the axis of travel compared to the perpendicular (horizontal) axis.

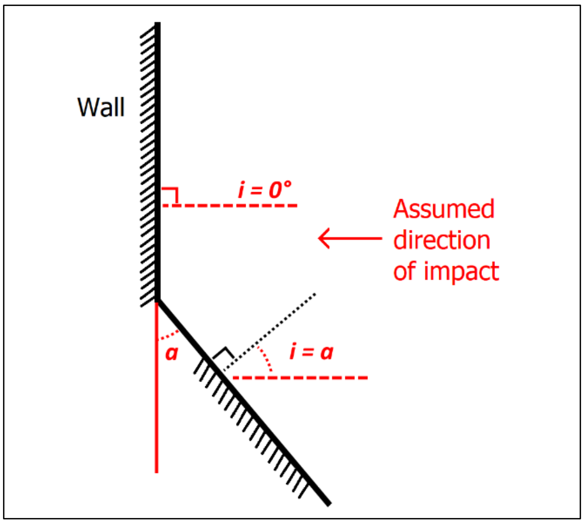

Figure 80: Diagram showing the expected angle of incidence deviation from orthogonal for the sloped east wall position of scar E83. The wall is shown in vertical cross-section, with angle (a) measured to be 40 degrees

The results from the cross-sectional measurement of this scar do not conclusively reflect this hypothesis. The measured deepest point of penetration into the stone in the 'vertical' axis shows a slight (2mm) offset towards the top of the scar, not significant enough to show a clear bias in the offset, but surprisingly also contrary to what would be expected from the theoretical model for an angled impact. The total diameter in this axis is 10mm longer than in the horizontal axis, with the elongation also reflected in the internal diameter measurement taken at two-thirds of the penetrative depth into the stone.

There are several possible explanations as to why an expected offset of the deepest point is not observed in this scar despite the expected vertical axis elongation. The first is that the vertical angle of incidence of the impact is not what has been hypothesised. Although the impact is unlikely to have struck the surface perfectly horizontally at a 40° angle of incidence, to achieve an orthogonal impact on the angled surface the shot would have to have been fired from a point well above the present ground level (there is no evidence of prior structures in this location) or have arced far enough into the air from an elevated shot to strike at a sufficient angle on a downward trajectory, by which point the likelihood of such a shot occurring close to or targeted at the defences becomes much less likely. Alternatively the angle of incidence could have a significant horizontal component to the direction of travel that effectively cancels the offset due to heavy offset along another axis, though the measurement data in the diagonal axes does not indicate that this is likely and supports the vertical axis as being the source of the greatest directional component.

Another possibility is that the theoretical model for angled impacts on frangible surfaces does not reflect the outcome of seventeenth century ballistic impacts, as models drawn from modern ballistics may not accurately reflect the behaviour projectile shapes and velocities of early modern firearms on sandstone surfaces. This seems less likely and indeed the ballistic trials carried out by Wynne (2012) indicate that angled impacts on sandstone do reflect this pattern on unweathered sandstone. There also remains the possibility that the scar's shape does reflect this, but that the limitations of two-dimensional cross-section measurement preclude identifying that component of the geometry. Visual examination of the trace of the vertical axis profile suggests this is not the case (Figure 81), however as this is the first such study of scar geometry to identify these properties, future developments in recording and analytical methodologies will be able to better explore this issue.

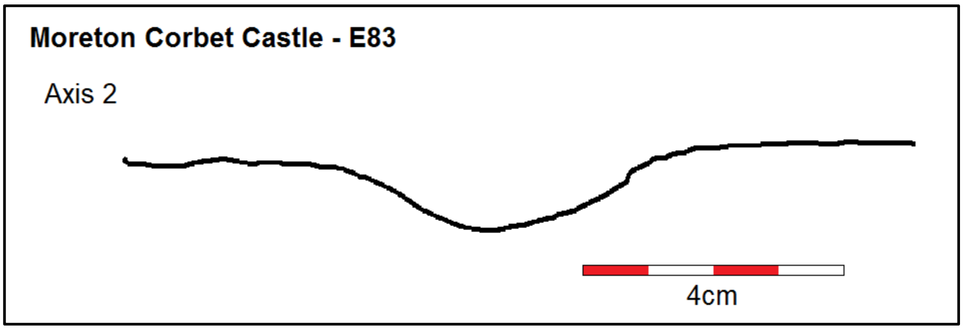

Figure 81: Digital profile-trace of vertical profile axis for scar E83. Left to right of the digital traces reflects the scar's depth profile from top to bottom of the axis

The final and most probable reason for the lack of off-set in the scar however is that the internal surface has been eroded predominantly in the direction of the bottom of the scar due to its location. The scar occurs on an upward-tilted surface, and is more greatly exposed to the downward movement of precipitation and surface run-off of rainwater over the point of impact. This increased deterioration of the stonework as a result to enhanced relative exposure to weathering is seen elsewhere on this sloped section of the eastern wall, and elsewhere on related features around the ruins of the castle and the adjacent church. This would indicate that examining similarly upturned surfaces for the evidence of the angle of incidence in the vertical component of the scar is unlikely to produce a reliable result where the scar is not sufficiently sheltered so as to prevent direct exposure to rain fall, and needs to be found in scars with a horizontal component instead.

7.5.3 Church Scars from the Castle

The array of impact scars on the southern side of St. Bartholomew’s church provides a site-specific opportunity for impact-scar origin assessment. The implied origin of the shots that formed these impacts is the fortified site of the castle, though the corresponding facing surfaces of the castle gatehouse and flanking walls bear far fewer identified reciprocal impacts. The distance between the opposing impacted surfaces on the castle and church is approximately 50m, and thus well within the typical engagement range for smoothbore firearms making the likelihood that these represent an exchange of fire of soldiers in close proximity to these positions much more likely.

The likely position of the target however is unclear, as while the scars on the eastern end of the wall range in a band from 1.8m to 2.9m in height, the ground level from the church to the castle gently slopes downhill only by about 1m. A possible explanation is that the defenders may have been firing upwards from a sunken position within the castle moat, possibly incorporated into the defences around the garrisoned site, at attackers relatively close to their position with overshots striking the church behind. Alternatively, the attackers may have been utilising a no longer extant feature, such as at the original church-yard boundary, as improvised cover that absorbed the missed shots at lower height levels leaving only those that cleared both the boundary and the attackers to impact the church wall. Examination of the present churchyard wall for possible re-used stone in its construction showed no visible impact scars, though the rough surface of the stone pieces used my preclude the formation of an identifiable scar. Figure 82 below shows a height-profile of the land between the church and the castle gate.

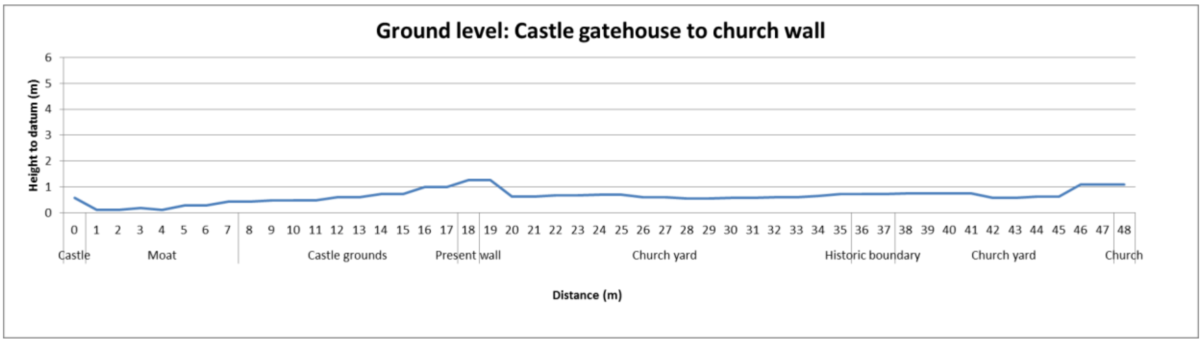

Figure 82: Height-profile of the ground between Moreton Corbet Castle and St Bartholomew's Church. Height values taken from 2m DTM Lidar data

7.5.3.1 Church scars C01 – C05

On the church southern wall of the south aisle, 26 identified impact scars indicate a possible volley of fire from the direction of the castle towards targets presumably within the grounds of the church (Figure 83). These are seemingly related as they have a close vertical distribution, and correspond approximately to the presence of another nine scars at the west end of the same southern facing, six of which are in an equivalent height range on the structure. The spread is interrupted by the later squire's pew built for the Corbet family in the eighteenth century, within which there is a possible impact scar located on what is now an internal wall surface.

Figure 83: Grouping of scars on eastern end of the south aisle exterior wall bearing measured scars C01-26. Scars are indicated by red circles for clarity, red diamonds indicate scars C01-05 on the angled buttress. This wall faces towards Moreton Corbet Castle

Five of the 35 scars occurring on this facing of the church are located on a 45° angled buttress at the eastern corner of the wall. If these scars are from a common source, the expectation would be that the buttress impacts must have occurred at an angle of incidence to the impacted surface of 45° relative to the angle of incidence of those on the adjacent wall e.g. if the wall impacts struck from the left at a 10° angle, the buttress impacts will have struck from the right at a 35° angle. This should be reflected in the overall scar profiles as an elongation along the horizontal axis relative to the vertical, however if the wall impacts also occurred at a non-orthogonal angle, an elongation would be expected in the horizontal axis for these scars also and the direction of impact indicated by a deepest-point offset as per Haag (2005). The horizontal axis offset of the deepest point from the centre of the scar for each of these scars is shown in Table 20.

Scar no.	Total scar diameter (mm)	Offset deepest point from centre (mm)	Internal scar diameter at 2/3 depth (mm)	Offset from internal diameter centre (mm)
C01	64	1	21	0
C02	73	-12	22	-2
C03	73	-2	28	1
C04	34	0	13	1
C05	67	-2	26	-1

Table 20: Horizontal axis diameter and deepest-point offset values for scars C01-05. Positive values in the offset indicate a bias towards the right of the measurement frame i.e. in the direction of the castle

The lack of a consistent offset for the scars is surprising given the strong evidence for an angled impact. Examination of the offset values for neighbouring scars also failed to produce a trend in the centre-offset values that might indicate these originated from a similar location, or a trend in the opposite direction for other scars along this wall that might indicate they are the angled impacts. This may be a product of the properties of the Grinshill stone used in the church, however failure to identify clear offsets in identified scars with almost certain instances of angled impacts suggests that determining direction of impact using the deepest point method may not be possible for weathered scars.

7.5.3.2 Internal scar

A single internally situated mark on the former external wall of the southern aisle of the church now lies within the Corbet squire’s pew. It is not clear how this mark has been treated over time, and whether it have been plastered over at some point in the past. The mark in question was recorded in 3D profile to assess how it compares with other marks along the same wall.

Figure 84: Internal scar in the squire's pew at St. Bartholomew's Church, Moreton Corbet. The scar shows the same internal cup-shape as seen elsewhere, and lighter stone in the base of the scar in comparison to the case-hardened patina on the block surface

The key variance is the depth. While the scar shares some visual similarity with the external scars (Figure 84), the measured scars on the external wall average at 15.3mm depth, while the internal scar penetrates the surface only to 8mm depth, and shows no evidence of spalling, wearing of the edges due to weathering, or radial fracturing. This scar may be a suitable candidate for lead residue testing, however as it only became sheltered from weathering during the eighteenth century, the time exposed may have been sufficient to remove any lead residue on the adjacent surface.

7.6 Impacted bullet trial survey

In addition to investigation of the impact scars and survey of the surrounding landscape, a trial series of excavations was undertaken to locate evidence of projectile fragments relating to the impact scars on the structure. Impacted bullets have been recovered through excavation at other sites of siege actions (Ellis, 1993, Roberts, 2002), but as yet no recovery of bullet fragments has been undertaken in proximity to surviving impact scars and thus no attempt has been made to identify the relationship between impacted bullets and archaeological scars.

The proposed methodology for recovering these fragments was two-part. As the target objects being sought were predominantly lead fragments, the site would be examined using very low-frequency (VLF) metal detection in ferrous-discrimination mode to locate non-ferrous signals, and identify potential concentrations of fragments in proximity to scars. With signal densities identified, a sample location for a test pit would be marked out and all signals within that area down to the base of the turf would be recovered, and if not modern rubbish, recorded. Following this the turf level was to be removed and the ground within the test pit area re-detected for further signals using a pulse induction (PI) metal detector to locate signals finds of all metals. Each signal would then be recovered and recorded down to a maximum 10cm depth. Once all objects had been recovered, a 10cm spit was removed from across the surface and same process repeated, with the vertical and horizontal position of each artefact being recorded at each stage to enable the three-dimensional spatial relationship of the recovered bullet fragments to be examined.

As the castle lies within a scheduled ancient monument, permission had to be sought from the Department for Culture, Media and Sport for scheduled monument consent (SMC) to enable the trial exploration methodology above to go ahead. The permission granted in 2014 restricted excavation of four test pits of no more than 2m x 2m to the topsoil component of the site, with a prohibition of exploration of any stratigraphy encountered, or the recovery of any detected finds outside of the context of an active test pit. This decision to limit the extent of the survey depth proved to be the most significant limitation on the attempt to recover bullet fragments, as the likelihood of the presence of fragmented bullet above any post-period site decay or demolition stratigraphy was anticipated to be very low, and without being able to reach these for recovery, it would be impossible to establish and link between the archaeology in the ground and the scars on the walls

7.6.1 The survey

Initial detecting of the area to the east of the castle ruins began in December 2014, with a second survey date in June 2016 prior to the expiration of the SMC licence. The initial detecting of the topsoil within the kept grounds indicated a sparse distribution of non-ferrous signals, with density much less than one signal per square metre over the majority of the site adjacent to the scars. Consequently the initial suggestion of targeting the test pits at locations with high concentrations of signals was impractical, as no location offered more than three signals within the maximum 2m square. The strongest signal source detected was a linear feature approximately 4m east of the northern section of the ruined east wall of the castle, which corresponded strongly with the known location of the boundary fence surrounding the castle, identified on first edition OS maps. The test pits were therefore located based on proximity to identified scars clusters at a distance that observational data drawn from Wynne (2012) indicated might contain rebounded fragments of impacted bullets.

Recovered finds denoted by signals in the topsoil were limited entirely to modern rubbish relating to tourism activity, and included aluminium screw caps from alcoholic beverages, and a zip-fastener tab. No object that was not identified to be from this modern heritage visitation was located in the turf level in any of the three test pit locations. Spit removal and detecting each of the test pits proved equally fruitless, with signals identified within the pits down to 20cm depth containing further tourist litter as well as occasional galvanised nails, I hypothesised to relate to two rounds of boundary fence movement since the mid-late twentieth century.

Test pit 1 was terminated after 20cm of topsoil removal below the turf layer when it encountered the upper surface of stratigraphy for what appears to be a demolition layer relating to clearing the castle site. This top surface of this layer contained numerous fragments of charred organic material, fire-cracked rock, and three lead fragments identical to the form and composition of those found in high quantity during detecting of the adjacent field earlier that year.

Test pit 2 to the south of the castle was terminated after a single 10cm spit below the turf level upon encountering a compacted, stony layer, possibly relating to a previous footpath around the castle that has now become turf covered. This layer contained a number of fragments of red sandstone and other small pebbles, with no metal artefacts that were not positively identified as modern litter.

Test pit 3 in 2016 was placed at 1m from the base of the southern-most concentration of scars on the eastern wall as the best hope for finding any bullet fragments adjacent to a wall where the structure was still largely intact, and thus less likely to feature a demolition layer. Despite the hope attached to this pit, it too was terminated after 30cm depth below the turf level after encountering the upper surface of another compacted layer containing charcoal and fire-cracked rock fragments. Finds from this pit included three galvanised nails and two pieces of unidentified iron bars from the upper 10cm spit, again possibly also related to the movement of the old boundary fence, with no artefacts located below the first 10cm spit after removal of the turf. Based on the stratigraphy issues encountered in the previous test pits, and the proximity of the end of the scheduling consent time period, the decision was taken not to dig a fourth test pit within the castle grounds.

7.6.2 Discussion

The lack of success with recovering any bullet fragments from the Moreton Corbet site was disappointing, as the indication had been that the quantity of scars would give a decent probability of success with the limited scope to explore the site. The inability to detect concentrations of fragments in the initial detecting phase likely owes to the depth of the fragments, as no non-litter metal objects were recovered from the top 20-30cm of the ground below the upper surface of the turf. As the typical penetration of a detector is between 15-30cm dependent on ideal soil conditions, there is little chance that the detectors would penetrate deep enough to encounter these signals without removal of the turf and topsoil layers. Even if this had occurred at least once during the initial detecting, as the requirements to only recover signals through test pits was imposed, the probability of encountering that instance would have been very low unless it was in proximity to numerous other signals.

The overall reason for failure to recover the impacted fragments however was the restriction placed upon exploration of the stratigraphy by the SMC licence, as each time the demolition layer was encountered, this represented a stratigraphic barrier to recovery. As the siege(s) of 1644 predate and clearance of decayed structural elements of the site, any bullet fragments are most likely to occur in levels below the depth of demolition activity or other post-period site-use stratigraphy. As bullet fragments have been recovered from other excavations at siege sites where impact scars are not present, such as Beeston Castle (Ellis, 1993), the presence of fragments would be expected at Moreton Corbet if the stratigraphy could be excavated beyond the topsoil component.

Further investigation of this issue at Moreton Corbet Castle should incorporate a full trench excavation, extending away from the walls, to explore the rebound extend and distribution of these bullet fragments as a primary aim, but also to allow recording of the stratigraphy at the site and test for evidence for civil war defensive earthworks that may require amendments to the extent of the scheduled area. Until a methodology can be developed from practical recovery of fragments in an archaeological context, it is vital that future excavation at this site or other siege locations in future by required to incorporate a metal-detector scanning and spit-removal methodology to allow three-dimensional spatial recording of fragment locations as part of the excavation process, to prevent further loss of the archaeology during non-targeted, trench-based excavations.

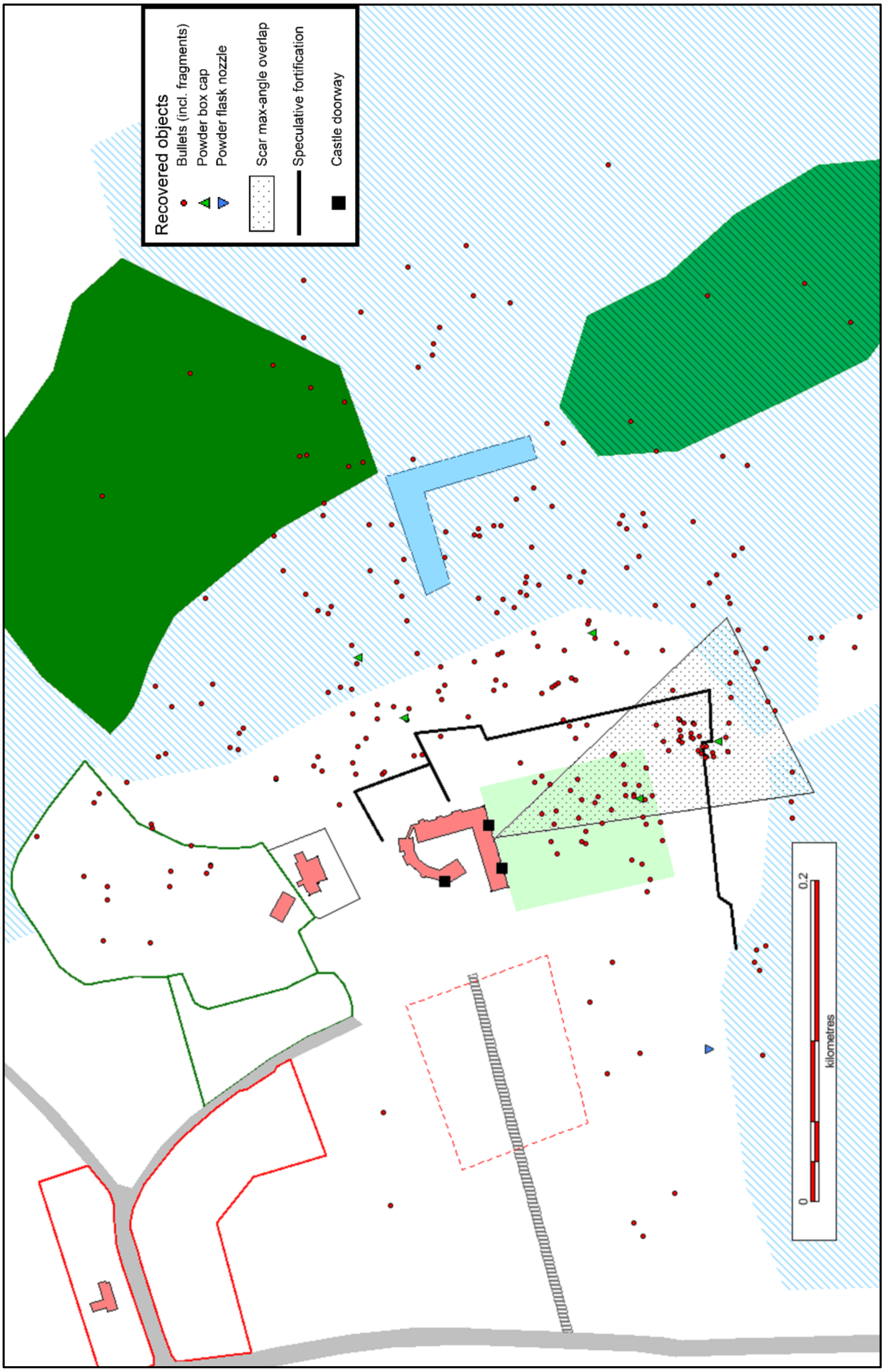

Figure 85: Location of doorways on the castle exterior sown with probable siege-related find locations, historic terrain and probable shot-origin locations for the scars located on the southern wall of the castle

7.7 Interpretation of the evidence

Relating the archaeological evidence to specific elements of the second siege at Moreton Corbet is problematic owing to uncertainty about the presence of occupationally deposited items, the activity of the site in repelling undocumented attacks of raids, and the extend and intensity of any prior or later sieges for which there is limited or no documented account. Archaeological confirmation of the hypothesised fortification location is also necessary to underpin any interpretation of the evidence.

Impact scar evidence on the east wall is the most compelling for evidence of an assault against the defences, as the concentrations are in relatively tight clusters and occurring at sufficient height on the structure that, if considering only the present landscape, do not reflect attack against a target at ground level except for the southern-most cluster. The scar clusters also correspond with the greatest distribution of musket and bastard musket calibre bullets within the landscape which represent calibre least likely to be the result of identified background noise signatures from recreational shooting (Foard, 2012, pp. 70). Additional to these are the hammered slugs located on the site, manufactured by striking a bullet with a hammer to form an elongated box shape, compromising ballistics flight properties with short-range stopping power (Foard, 2008, pp. 121-122), these also likely reflect certain military use over later leisure shooting, for which accuracy was more likely the intended goal of bullet use.

The locations of the power box caps and the powder flask nozzle are important clues to evidence of attack as these are typically lost when in use and in the location of the soldier using them (Foard, 2012, pp. 47-48). That four of the caps and the nozzle all occur in locations beyond the projected defensive position is enticing for hypothesising that these were deposited by soldiers engaged in an attack on this side of the defences. Nevertheless the possibility exists that these were also dropped by garrison soldiers atop earthworks that have since demolished and ploughed downslope into the adjacent fields. The remaining single cap lies within the location of the formal gardens, in line with the southern most of these and amidst a musket and bastard musket bullet scatter that appears to extend from the southern range across the gardens. While an attack across the gardens would increase the distance across which the assaulting force would have to cover before reaching the structure, if the defence location hypothesis is incorrect, the garden platform would undoubtedly have provided significant dead ground from the view of the castle for an approach on foot. If the garrison were at a reduce size, it is also conceivable that these works would have been abandoned in favour of a position closer to the house, to avoid stretching the garrison soldiers too sparsely.

Attempting to tie the accounts of the second siege to evidence within the landscape is problematic without a certainty over where the earthworks were located. The assault required scaling of the outer rampart with a ladder, possibly placing that somewhere along the garden platform. If the platform was the extent of the defensive circuit, then while it may seem an odd choice of location from which to launch an assault on the house, the reduced garrison may have left this circuit of the earthworks with a limited number of defenders, and at one o’clock in the morning the size of the sentry was possibly small enough to make this feasible. There are only three doorways on the structure’s external walls, excluding the castle’s main gate, that could have been the subject of Reinking's initial attempt at entry (Figure 85), and an examination of contemporary drawings and sketches in Harwood (2006) would seem to confirm that no additional doorways existed in the now lost sections of the east wall. Given the typical height of the windows on the structure in relation to the ground level, the forced window entry is an improbable scenario, leaving the doorways as the best candidates for the breach of the structure by the assailants. The presence of numerous small clusters of impact scars on the southern face of the structure may be an archaeological signature for a small group of attackers moving through the location of the garden platform towards the castle, which if Reinking's' team, would probably have culminated in entry through one of the doors on the south range. All of this, combined with the strong correlation for a bullet distribution crossing the garden feature that corresponds to a limited array of impact scarring on the castle, presents an enticing supposition of a night approach over a poorly manned defensive circuit located on the perimeter of the garden platform, combined with exchanges of fire on the approach, leading to entry through one of the two doorways by the attackers.

Future investigation and re-examination of the artefactual evidence may produce an entirely different hypothesis for the action, and indeed there is no certainty that this evidence does not conform to the first siege action, of which we presently know entirely nothing save for the reference to prisoners taken (Worton, 2016). However as this is the first such study of the unstratified archaeology and historical terrain reconstruction in combination with examination of impact scar evidence for a siege site of the Wars of the Three Kingdoms it is entirely expected that further siege studies will change this interpretation in light of new understanding of the archaeology.

7.8 Recommendations for further investigation

Detailed 3D scanning of the scar evidence at Moreton Corbet Castle and on St. Bartholomew's church is recommended with urgency. While these are both listed structures, it is clear that restoration work to protect the structural integrity of the church has had negative influences on one impact scars discussed that occur on the corner buttress (C03), and similar damage may occur in future without proper recognition of these archaeological features, or sufficient protection from incidental damage during renovation work. On the castle the issue of decay through weathering is ever present and good quality digital models made now could mitigate for the potential loss of detail into the future, at which point more detailed analysis may be possible than was able to be achieved by this study.

Expansion of the detector survey to complete the partially detected and undetected fields south of the garden platform would enhance distribution analysis of finds outside the projected location of the fortifications. Similarly elements of the south-eastern end of the field to the immediate south are now under plough having previously been left fallow, and would allow an examination of the extent of the bullet scatter density moving away from the fortified site, as would surveying of the fields beyond the Corbet Estate to the north-east. Redetection of the field immediately east of the castle under better surface conditions may be necessary to properly appreciate the patterns in the scatter of bullets in this direction counter to the large scar clusters identified on the east wall.

The site would benefit from geophysical survey of the area of the suspected earthworks to attempt to establish the provenance of these features from the 1989 gardens survey, however the issue may only be properly settled through excavation of the feature in the location of the southern field where ploughing has already removed the surface trace, but is unlikely to have penetrated deep enough to completely destroy the stratigraphy of the feature. Excavation here may also shed light on the nature of the scheduled remains on the south-western corner of the garden platform as to whether these are indeed garden earthworks, or potentially the remains of Civil War fortifications.

Recommendations for future attempts to locate impacted bullet scatters would include exploration of the stratigraphy below the demolition layer, and trial trenching extending up to 2m either side of impact scar clusters, and up to 15m away at a right angle from the impacted surface, both to ensure the likelihood of success in recovery of the sought evidence, but also to assess the rebound range of the fragments from an archaeological context. Confirming the maximum distance of rebound archaeologically should inform any changes to the extent of the scheduled monument areas underlying extant structures and ruins where sieges have occurred in the historic past. Similarly excavation strategies at the castle for future archaeological survey, or ahead of conservation needs such as structural underpinning of the ruins to avoid future collapse, must include a strategy for the proper recording of the individual bullet fragments and their context that accounts for the failures of the trial study as a result of limitations imposed on the investigation.

8. Conclusions

This study has aimed to establish a methodology for the investigation of siege sites of the early modern period. While the categorisation of battles is relatively well established for the period, and the field of battlefield archaeology has had over a decade of methodological development since the first largescale battlefield investigations of early modern actions, siege investigation has remained relatively undeveloped beyond stratigraphic and landscape archaeological approaches. The limited application of battlefield survey methodology has thus far failed to establish a methodology suited to siege studies specifically, in part due to the additional challenges surrounding the investigation of siege sites in terms of scale, landscape development challenges, and interpretation of multi-layered patterns within the unstratified evidence.

Settling the issue of what archaeologically constitutes a siege is an important advance, as it allows sites to be examined on the basis of common cultural processes that lead to the deposition of the material culture. While significant variance in the scale and conduct of historic siege actions remains, the underlying patterns in the archaeology are likely to been seen across a multitude of siegefield investigations as more sites are studied. Although large-garrison siege locations often have limited scope for this investigation, the understanding of how sieges were fought at smaller and often less strategically significant garrisons during the Wars of the Three Kingdoms, a key period of pragmatic military development in British history, will certainly have ramifications for how the evidence at urban siege sites is viewed. This study has also identified the benefits of this approach in terms of the available resource, with an identifiably large quantity of small siege sites that have low levels of surrounding development and would be well suited to small-scale yet intensive metal detector surveys, and examination of contemporary upstanding or ruined structures. This could allow for detailed studies of these conflict sites to be carried out in much shorter timescales than is typically required when locating and surveying early modern battlefields.

Though small-arms impact evidence at sites has previously been identified as an opportunity for siege archaeology, this evidence has not previously been explored for their potential for siege study. Sites such as Old Wardour present opportunities to examine existing assumptions about small-arms accuracy and range if the unstratified archaeology of outgoing fire can be accessed and examined, whereas structures such as St. Bartholomew’s church at Tong offer the possibility of testing forensic models for firearms impacts on early-modern impacts (though admittedly difficult to access).

One of the most important outcomes of this study for impact scar investigation however is the development of a recording methodology for these in a site-scale investigation. Scars have been shown to be vulnerable to weathering damage and loss as stone surfaces erode over time, and thus the need to record them is both one of data collection and preservation against future decay. While digital scanning with laser devices remains the ideal approach to recording these features, the development of a methodology for a low-cost, high-productivity method of examining and recording scars enables rapid investigation and recording scars to be carried out at a site without having to tackle the accessibility and logistical practicality issues associated with professional scanning equipment. This also allows repeat recording to be undertaken with greater frequency to produce comparable records of scars over both short and long time periods as desired, providing a further dataset for how scars continue to develop through weathering, and the developing risks to loss as stone surfaces degrade over time.

Further investigation into the underlying reasons for variation in scar appearances between sites and across individual structures may yet identify further information about the impact process that formed the scar in the past, though the complexities of weathering and variability in early modern ballistic performance would need to be approached in parallel before scars are likely to give up details about individual impact variables. The experimental impact studies undertaken above emphasise the need for further studies and larger datasets for small-arms impacts on stone surfaces to be undertaken to better identify and explain the variability in the impact-response of stone surfaces and the fragmentation process of bullets, particularly for expanding on what bullet fragments can tell us about sites where the scars are no longer extant.

Finally, the case study investigation Moreton Corbet has shown that there is opportunity for the interpretation of siege actions with limited surviving contemporary accounts through the exploration of the archaeology. The limited quantity of recovered finds from the metal detector survey reflects the scale of the site and historic siege action, but also identifies the potential risk to the archaeology through non-archaeological removal of the unstratified metal artefacts. While the immediate vicinity of defended sites may often be scheduled, the outlying siegefield and greatest concentrations of archaeological evidence for siege actions are typically not protected against this unrecorded removal and are arguably at even greater risk due to their attractiveness as locations for non-archaeological detecting as identifiable conflict locations within the landscape, anchored around the defended site. The benefit of small-scale sites for intensive detector-survey also serves as a threat that a site could be effectively erased archaeologically through low intensity detecting over a sustained period of repeated activity.

Further investigation of siege locations is needed to explore several outstanding questions about the nature of the archaeological evidence at besieged locations, and the relationship of the archaeology to the siege action. At Moreton Corbet as an example, there are opportunities for identifying and exploring the archaeological signature of the defensive perimeter of the garrison through geophysical survey and trial excavation in the active field systems beyond the scheduled monument areas. Positively identifying the location of the former defences would serve both to test the hypotheses presented above in interpreting the siege the site, but also allow exploration through the detector-survey results to see whether there is an identifiable scatter signature the corresponds with the former presence of earthwork defences, and if so, could this signature be used to identify areas on other sites where earthworks are no longer extant? Another obvious next step would be for a more intrusive excavation licence within the castle monument to locate and examine the impacted projectiles in proximity to impact scars. Without this it will be impossible to properly examine an archaeological fragmented-bullet dataset together with the associated impact scar evidence, but it will also be impossible to properly develop protection strategies for the archaeology at siege sites elsewhere if the form of the evidence cannot first be established in an archaeological setting. The distance, distribution and vulnerability of the impacted bullet fragment evidence is almost entirely unexplored outside of the by-product of ballistic experiments, and the development of a functional methodology for appropriate recovery and recording in future excavation strategies at sites with siege evidence cannot be achieved without first establishing an exemplar investigation.

Siege investigations have the potential to expand our understanding of historic conflicts and the cultural processes of warfare for the early modern period. However, this archaeology is vulnerable from a number of different risk sources. Without additional, properly supported studies of the evidence to allow both for investigation methodologies to be developed, and appropriate strategies of protection and conservation to be devised, this cultural resource is at much at risk from failure to engage with the issues as it is from active loss through non-archaeological activities and decay through time.

Appendix A: Site condition assessments

Siege Location	Total Number of Sieges	Present Site Character	Development Level Score	Contemporary Structures Score	Potential Surveyable Area Score	Total Assessment Score
Abbotsbury	1	Rural	2	2	3	7
Abingdon	2	Urban	1	2	1	4
Albrighton Hussey	1	Rural	3	2	3	8
Apley Castle	1	Urban	2	2	1	5
Appleby Castle	2	Rural	2	1	2	5
Arundel Castle	3	Rural	1	2	1	4
Ashbourne	1	Rural	2	1	1	4
Ashby de la Zouche	1	Urban	1	2	1	4
Aston Hall	1	Urban	1	2	1	4
Aylesbury	1	Urban	0	2	0	2
Banbury	2	Urban	0	2	0	2
Barnstaple	1	Urban	0	0	0	0
Barthomley church	1	Rural	3	2	3	8
Basing house	3	Urban	1	2	2	5
Bath	1	Urban	0	1	0	1
Beeston Castle	2	Rural	3	1	2	6
Belvoir Castle	1	Rural	3	1	3	7
Berkeley Castle	1	Rural	2	2	3	7
Beverstone	1	Rural	3	2	3	8
Bewcastle	1	Rural	3	2	3	8
Bickleigh Castle	1	Rural	3	1	3	7
Biddulph	1	Rural	3	1	3	7
Blechingdon House	1	Rural	3	2	2	7
Boarstall House	2	Rural	3	2	3	8
Bolingbroke Castle	1	Rural	2	1	2	5
Bolsover Castle	1	Rural	1	2	1	4
Bolton	2	Urban	0	0	0	0
Bradford	1	Urban	0	1	0	1
Bramber	1	Rural	2	1	1	4
Brampton Bryan	1	Rural	2	2	3	7
Bridgnorth	1	Urban	1	1	1	3
Bridgwater	1	Urban	1	1	1	3
Bristol	2	Urban	0	1	0	1
Broncroft Castle	1	Rural	3	1	3	7
Brougham	1	Rural	3	1	3	7
Buckland Abbey	1	Rural	3	1	3	7
Burghley House	1	Rural	3	1	2	6
Burton Stather	1	Rural	1	2	1	4
Canon Frome	1	Rural	3	2	3	8
Carlisle	4	Urban	0	1	1	2
Cartington Castle	1	Rural	3	1	3	7
Castle Bolton	1	Rural	3	2	3	8
Caus Castle	1	Rural	3	0	3	6
Cawood Castle	1	Rural	1	1	1	3
Chester	1	Urban	0	2	0	2
Chichester	1	Urban	0	2	1	3

Siege Location	Total Number of Sieges	Present Site Character	Development Level Score	Contemporary Structures Score	Potential Surveyable Area Score	Total Assessment Score
Chideock	1	Rural	2	2	2	6
Christchurch	1	Urban	1	2	0	3
Cirencester	1	Urban	1	2	0	3
Clitheroe Castle	1	Urban	1	2	1	4
Cockermouth Castle	1	Urban	1	2	1	4
Colchester	1	Urban	0	2	0	2
Compton Wynyates	1	Rural	3	2	2	7
Corfe Castle	2	Rural	2	2	2	6
Coventry	1	Urban	0	1	0	1
Crowland	2	Rural	1	2	1	4
Dartmouth	2	Coastal	1	2	1	4
Deal Castle	1	Coastal	0	3	0	3
Devizes	2	Urban	1	2	1	4
Donnington Castle	2	Rural	3	1	2	6
Dover Castle	1	Coastal	2	3	1	6
Dudley Castle	2	Urban	0	1	0	1
Dunster Castle	1	Rural	2	2	2	6
Eccleshall	1	Rural	3	1	2	6
Evesham	1	Urban	1	2	1	4
Exeter	3	Urban	0	2	0	2
Faringdon	1	Urban	1	2	2	5
Farnham	1	Urban	1	2	2	5
Gainsborough	1	Urban	0	1	1	2
Gloucester	1	Urban	1	2	1	4
Goodrich Castle	1	Rural	3	1	3	7
Grafton Regis	1	Rural	3	2	3	8
Great Fulford	1	Rural	3	0	3	6
Greenhalgh Castle	1	Rural	3	1	3	7
Greenlands House	1	Rural	3	1	3	7
Greystoke Castle	1	Rural	3	0	3	6
Hawkesley Hall	1	Urban	0	0	1	1
Helmsley Castle	1	Rural	2	1	2	5
Hereford	4	Urban	1	2	1	4
High Ercall	3	Rural	3	2	3	8
Highworth	1	Urban	0	2	0	2
Hillesden	1	Rural	3	2	3	8
Holme House	1	Coastal	1	1	0	2
Hopton Castle	1	Rural	3	1	3	7
Hornby Castle	1	Rural	3	1	2	6
Houghton Tower	1	Rural	3	1	3	7
Houndshill	1	Rural	3	1	3	7
Howley House	1	Rural	1	0	1	2
Hull	2	Coastal	0	0	0	0
King's Lynn	1	Urban	1	2	0	3
Kings Mill	1	Rural	3	1	1	5
Knaresborough	1	Urban	1	1	0	2
Lacock House	1	Rural	2	1	3	6
Lancaster	2	Urban	1	2	1	4
Lathom House	2	Rural	2	1	3	6

Siege Location	Total Number of Sieges	Present Site Character	Development Level Score	Contemporary Structures Score	Potential Surveyable Area Score	Total Assessment Score
Leeds	1	Urban	0	0	0	0
Leicester	2	Urban	0	2	0	2
Lichfield	3	Urban	1	2	1	4
Lilleshall Abbey	1	Rural	2	1	2	5
Lincoln	1	Urban	0	2	0	2
Lindisfarne	1	Coastal	2	2	3	7
Liverpool	1	Urban	0	0	0	0
Ludlow	1	Urban	1	2	1	4
Lyme Regis	1	Urban	0	2	0	2
Madresfield	1	Rural	2	1	2	5
Manchester	1	Urban	0	0	0	0
Market Drayton	1	Urban	1	2	1	4
Marlborough	1	Urban	1	2	0	3
Moreton Corbet	1	Rural	3	2	3	8
Morpeth Castle	1	Urban	1	2	0	3
Mulgrave Castle	1	Rural	3	1	0	4
Newark	3	Urban	1	1	2	4
Newcastle	1	Urban	0	0	0	0
Newnham	1	Rural	2	2	2	6
North Luffenham	1	Rural	2	2	3	7
Norwell	1	Rural	3	1	3	7
Nottingham	1	Urban	0	2	0	2
Nunney Castle	1	Rural	2	2	2	6
Oswestry	1	Urban	0	2	0	2
Oxford	3	Urban	1	2	1	4
Paynsley Hall	1	Rural	3	0	3	6
Pembridge Castle	1	Rural	3	2	3	8
Pendennis Castle	1	Coastal	1	1	1	3
Plymouth	1	Coastal	0	0	0	0
Pontefract Castle	3	Urban	0	1	1	2
Poole	1	Coastal	0	0	0	0
Portland	1	Coastal	0	0	0	0
Portsmouth	1	Coastal	0	0	0	0
Powderham Castle	2	Coastal	2	1	3	6
Preston	1	Urban	0	0	0	0
Raby Castle	1	Rural	3	1	3	7
Reading	1	Urban	0	0	0	0
Restormel Castle	1	Rural	3	1	3	7
Rose Castle	1	Rural	3	1	3	7
Rushall	1	Urban	2	2	1	5
Salcombe Castle	1	Coastal	0	1	0	1
Saltash	1	Coastal	0	2	0	2
Saltram House	1	Coastal	3	1	3	7
Sandal Castle	1	Urban	1	1	2	4
Scaleby Castle	2	Rural	3	1	3	7
Scarborough	1	Coastal	0	1	1	2
Sheffield	1	Urban	0	0	0	0
Shelford House	1	Rural	3	1	3	7
Sherborne Castle	4	Rural	2	1	2	5

Siege Location	Total Number of Sieges	Present Site Character	Development Level Score	Contemporary Structures Score	Potential Surveyable Area Score	Total Assessment Score
Shirburn House	1	Rural	2	2	2	6
Shrawardine Castle	1	Rural	2	1	3	6
Shrewsbury	1	Urban	0	2	0	2
Skipton Castle	1	Urban	1	2	0	3
Sleaford	1	Urban	1	2	0	3
South Kelsey Hall	1	Rural	3	0	3	6
South Wingfield	1	Rural	3	2	2	7
Southampton	1	Coastal	0	0	0	0
Southsea	1	Coastal	1	1	0	2
Stafford Castle	1	Rural	1	1	2	4
Stansted House	1	Rural	2	1	2	5
Staveley	1	Urban	1	2	1	4
Stokesay	1	Rural	3	2	2	7
Sudeley Castle	1	Rural	2	2	3	7
Swarkestone	1	Rural	2	1	3	6
Taunton	2	Urban	0	1	0	1
Thornhill	1	Urban	1	2	1	4
Thurgarton priory	1	Rural	2	2	2	6
Thurland Castle	1	Rural	3	1	3	7
Tickhill Castle	1	Rural	1	2	2	5
Tissington	1	Rural	2	2	3	7
Tiverton	1	Urban	0	1	0	1
Tong	1	Rural	2	2	2	6
Topsham	1	Coastal	0	1	0	1
Tutbury Castle	1	Rural	2	2	3	7
Tynemouth	2	Coastal	1	1	1	3
Upnor Castle	1	Coastal	1	0	0	1
Wakefield	1	Urban	0	2	0	2
Wallingford	1	Urban	1	1	1	3
Walmer Castle	1	Coastal	1	3	2	6
Warblington	1	Coastal	2	2	0	4
Wardour Castle	1	Rural	3	1	2	6
Wareham	3	Urban	1	2	1	4
Warwick	1	Urban	1	2	0	3
Welbeck Abbey	1	Rural	1	1	2	4
Wem	1	Urban	1	2	0	3
Westbury on Severn	1	Rural	2	2	3	7
Weymouth	1	Urban	0	1	0	1
Wigan	1	Urban	0	1	0	1
Wilne Ferry	1	Rural	1	0	1	2
Winchester	3	Urban	1	2	1	4
Winwick	1	Rural	1	2	1	4
Woodcroft Castle	1	Rural	3	1	3	7
Woodstock	1	Rural	1	2	1	4
Wootton Lodge	1	Rural	3	1	2	6
Worcester	1	Urban	1	2	1	4
Wormleighton	1	Rural	3	2	3	8
Wythenshawe Hall	1	Urban	2	3	2	7
Yate Court	1	Rural	3	2	3	8
York	1	Urban	0	2	0	2

Appendix B: Experimental scar profile-measurement values (Blocks F & D)

Scar record	Cross-sectional measurement axis	Total scar diameter (mm)	Penetration depth (mm)	X-axis centre off-set (mm)	Spalling depth - side A (mm)	Spalling depth - side B (mm)	Spalling width - side A (mm)	Spalling width - side B (mm)
D80 (Pre-wash)	Horizontal (1)	25	2	5	*Could not be detected in cross-sectional measurement*			
	Vertical (2)	23	2	7				
	Top-left diagonal (3)	26	1	5				
	Bottom-left diagonal (4)	24	1	5				
	Mean Value	25	2	5				
D80 (Post-wash)	Horizontal (1)	28	4	3		2		6
	Vertical (2)	27	4	8	2		6	
	Top-left diagonal (3)	27	4	5				
	Bottom-left diagonal (4)	25	4	-2				
	Mean Value	27	4	4	2		6	
D120 (Pre-wash)	Horizontal (1)	42	6	1	3	3	9	9
	Vertical (2)	44	6	-1	4	3	10	10
	Top-left diagonal (3)	44	6	-1	2	1	7	7
	Bottom-left diagonal (4)	46	6	2	3	3	10	11
	Mean Value	44	6	0	3		9	
D120 (Post-wash)	Horizontal (1)	42	8	-1		4		10
	Vertical (2)	43	8	1	3		6	
	Top-left diagonal (3)	44	8	-1	6	2	13	6
	Bottom-left diagonal (4)	46	8	3	2	1	6	4
	Mean Value	44	8	1	3		8	
F80 (Pre-wash)	Horizontal (1)	34	3	-6	1		3	
	Vertical (2)	34	3	7		1		3
	Top-left diagonal (3)	36	3	8	1	1	6	4
	Bottom-left diagonal (4)	40	4	-6	2	2	5	7
	Mean Value	36	3	1	1		5	
F80 (Post-wash)	Horizontal (1)	35	6	-1	3	5	7	8
	Vertical (2)	37	6	1	3	4	6	11
	Top-left diagonal (3)	37	6	-1	3	3	8	7
	Bottom-left diagonal (4)	43	6	-2	3	4	9	12
	Mean Value	38	6	-1	4		9	
F120 (Pre-wash)	Horizontal (1)	42	8	-5	4	5	10	12
	Vertical (2)	50	9	3	4	4	11	12
	Top-left diagonal (3)	45	7	2	4	3	12	11
	Bottom-left diagonal (4)	48	7	-2	3	1	10	7
	Mean Value	46	8	-1	4		11	
F120 (Post-wash)	Horizontal (1)	44	9	-1	6	5	10	11
	Vertical (2)	51	10	5	7	4	18	9
	Top-left diagonal (3)	47	10	-1	7	4	13	8
	Bottom-left diagonal (4)	49	10	-2	3	4	9	9
	Mean Value	48	10	0	5		11	

Appendix C: Contemporary source text for the second siege of Moreton Corbet

The Weekly Account – Parliamentarian chronicle (Anonymous, 1644)

"The excellent fine Stratagem of Warre which was used at the takeing of Mourton Corbet Castle is very observable, but because I have seen it sundrie wayes related (some of them peradventure being only upon beare reports) I will here informe you what was written therof to the Parliament, under the hands of Mr Machworth, Mr Lloyd, Mr Glyn, and diverse other Gentlemen of quality at Wem, wherein they certified that seventy foot, and as many horse marched from thence to Corbet castle under the command of Major Rinking an experienced souldier, who geting within Musket shot before they were discovered; the Major passed over the dicke with ladders, got into the Flankers, from whence they beat the maintainers into the house, afterwards took another Flanker, with only foure Musketteers, after entred through a crib doore, and in short time became Master of the Castle, took Major Bridgman governour thereof Captaine Maurice, I. Ensgine, I. quartermaster, two horse collours, thirty good horse, eightie common souldiers, six barrells of powder, and great store of provision, and other things which they had plundred from the Countrie."

Burning Bush Not Consumed – Pro-Parliamentarian newsletter (Vicars, 1646)

"About the 10 of this instant September, wee had certain information by Letters from Wem, that the vigilant and active Committee there resident, having intelligence of the drawing out of the forces in Shrewsbury, toward Ludlow, (as was then conceived) but afterward they understood those forces marched toward Sir Thomas Middleton, they sent out under the Command of Leivtenant Colonell Rinking (a very good Souldier) a party of foot and horse to surprise Morton-Corbet-Castle, and sent unto the Lord Calven to meet them with a party from Stoke, and upon a Saturday night about one or two of the clock they came before the Castle, every man being assig•ed the place where hee should fall on. Now they being come thither, it being but about four miles from Wem, and they finding the People in great security, ordered the businesse thus: First, the Commander gave the Word, which was Will and Tom, with order that if any asked who they were, to answer, Will, and if the other answered not, Tom, they should give fire; this being done, hee sent Drums at a fields distance from the house, with order to beat a march as soon as ever the assault began, which they did accordingly, and therby made the Enemy think that there had been a great strength, when as, indeed, it was no such matter; Then presently the Leivtenant Colonell calling aloud to bring up such a Regiment to such a place, and such a Regiment to another place, (this much daunted the hearts of the Enemy at the hearing there of) and then hee sent some to discover the Centery, with an order to tell the Centery that they were friends, and to hold him in discourse untill they had notice; which service was so well performed on all parts that before the Centinell knew who wee were, our Ladders were mounted and wee in possession of one of their works, and then the Enemy took the alarum, and our men plyed the work most stoutly: The Leivtenant Colonell endevoured with but ten men to have forced a little door, wherein not prevailing, hee marched along over the tops of the works with but four men, and with these, fell upon them that were in another work, and forced them with one volley to betake them to the House, where, out of the windows and holes they within shot fiercely at us, till wee by throwing in among them some hand Granadoes, they quitted those places, which gave way

to our men to break a stone pillar of a window, where the Leivtenant Colonell entred, and his four men entred, and after them (immediately after) many more; but before these were come in, the Enemy being at least 80 foot and 30 horse, and fearfully supposing (by reason of the noise of the Drums, afore-mentioned, and the Leivtenant Colonels calling together of so many Regiments) supposing therefore, I say, that a greater force of ours followed those five then entred into the Castle, they all instantly cryed out for quarter, which these five granted them, and by that time the rest of our Forces were come up and had entred the Castle and so possessed themselves firmly of it, and in it Major Bridgeman, Captain Maurice, one Leivtenant, one Sergeant, one Quartermaster, one Ensigne, two Horse Colours, at least 80 Souldiers and 30 good Horses, 6 barrells of powder, with much other provisions. The House was so strongly fortified, that my Lord Calven, and the Leivtenant Colonell, who behaved themselves most bravely in this action, said it might have been maintained against a great strength; for, had it been day-work, they should not have attempted it. In all this so resolute and even desperate service, wee lost but one man, and had only some few wounded." P25-26

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