

Guidance on Recording Lead Bullets from Early Modern Battlefields

Lead bullets are by far the commonest of finds from battlefields, siege sites and other fields of conflict of the early modern period. In England such finds will most commonly be from sites of the Civil War (1640-1651), although the information will also be relevant for finds from fields of conflict and other military sites from the mid 15th to 18th centuries, and indeed for finds of non military bullets, prior to the introduction of conical bullets for rifled weapons in the 19th century. Brief reference is also made to other specifically firearm related artefacts that may be encountered on fields of conflict, but the guidance does not extend to the various non firearm related artefacts deposited during military action which may be recovered from early modern fields of conflict.¹ Neither does this document provide information on survey and recording methods in the field, but guidance on the latter is available on the battle archaeology pages at: <http://www.battlefieldstrust.com/resource-centre/>

The present document is based on PhD research which considers material from various European sites of the 17th century,² but it also draws upon published and unpublished work by others, especially from the USA where a great deal has been written on bullets as evidence of 18th and 19th century military action.³ The present guidance cannot claim to be definitive, for there is a great deal still to be learnt about the ballistics and forensics of early munitions, some aspects of which are subject to ongoing fieldwork, analysis, and experimental firing.⁴ The basic principles are also applicable to the recording of lead or lead composite roundshot fired from artillery from at least the mid 15th century onwards, although progressively these were replaced with cast iron munitions during the 16th century in all but the smallest bore of ordnance.⁵

The value and potential of lead bullets

The term bullet is used here to encompass all types of small calibre ammunition, normally but not exclusively manufactured in lead, including ball, slug, case-shot and hail-shot. In contemporary documents a range of terms were in largely interchangeable use: most commonly ‘shot’ (continuing the earlier usage for arrows and other such projectiles), ‘ball’

¹ A useful description of the main weapon types in use on Civil War battlefields is given in Blackmore, (1990). Brief information on firearm related artefacts other than bullets is given in Courtney, (1988).

² Battlefields: Edgehill (Warwickshire, 1642); Siege sites: Basing House (Hampshire, 1643-45); Grafton Regis (Northamptonshire, 1643); Garrison magazines (unfired bullets): Ballymore (Ireland, 1690); Wrecks (unfired assemblages): The Vasa (Stockholm, 1628); The Swan (Scotland 1653); Unclassified sites: Easton Maudit (Northamptonshire, undated). Foard, (in preparation-c); Foard, (in preparation-a). All images reproduced here are also by the author.

³ Pers. comm.. Douglas Scott and Dan Sivilich. Some of the basic principles of bullet analysis are defined in Hamilton, (1980), Sivilich, (1996) and Sivilich, (2004).

⁴ Eg: Allsop and Foard, (2008)

⁵ More detailed discussion of later 15th century munitions will be published in Foard, (in preparation-b).

and ‘bullet’,⁶ the latter deriving from 16th century French ‘boulette’ meaning small ball.⁷ In the mid 17th century these terms were often qualified according to the type of weapon for which they were intended, such as musket or pistol.

The lead bullet was the projectile carried by half to two thirds of the infantry and all of cavalry and dragoons during the Civil War in England. It was also fired from field artillery when engaging at close quarters. Bullets were supplied in barrels by the ton to the main armies and fired in tens of thousands on the battlefield. As an archaeological find the bullet represents firepower, and by the 17th century firepower was a key determinant of victory in the field.

Because lead is such a stable metal and the bullet such a small object, the vast majority of those which were fired or lost during military action have survived, little altered, almost exactly where they fell. The bullet thus provides the most significant and tangible physical record of military action during the 17th century. Their calibre and exact character, including the damage sustained in use, particularly when analysed in terms of their distribution across the landscape, offer a wide range of information about 17th century battles. The bullet is main artefact present in sufficient numbers and which can normally be confidently related to the action to enable recovery of meaningful patterning related to the action.

The key aspects of analysis of bullets involve identification of:

- calibre, which to some degree enable identification of specific weapon types and thus of the troop that fired them
- types of bullet
- attributes indicating whether a bullet was fired, as opposed to dropped/discarded
- attributes demonstrating whether, on what type of surface and with what velocity a bullet impacted

Two very different types of assemblage will be encountered. The majority of sites, including battlefields and other fields of conflict, normally yield collections of bullets which have been used, most of them fired but a proportion dropped or discarded. A small number of special sites, representing magazines, provide assemblages which have never been fired. These may be from land sites, such as garrisons, or from wreck sites. These unfired assemblages are important in providing information on the calibres of bullet in use by particular armies and, where they survived in individual barrels, the variation in weight/diameter between bullets of the same nominal calibre, data critical for the effective interpretation of all other assemblages.

Where each bullet has been accurately located then such characterisation allows sophisticated analysis of patterning on a battlefield. However even a collection which has little associated spatial data can contribute worthwhile information in terms of the overall

⁶ E.g.: Ward, (1639), Bk 1, p.390.

⁷ Oxford English Dictionary.

signature of the assemblage, enabling comparison with other fields of conflict. It is also important that 'stray' finds of bullets are also recorded. They will show the variation in the 'background noise' of bullets that exists across the English landscape, which must be taken into account when analysing the finds from fields of conflict. The recording of such material may also yield other significant evidence: there are training sites of the militia to be located, there may be sites where target shooting was practiced, while other low density distributions might relate to hunting, for example in deer parks.

It should also be noted that of the 350 battles, sieges and skirmishes of the 17th century recorded from England on the Battlefield Trust's database of Fields of Conflict, a significant number remain unlocated while many more skirmish sites are not yet incorporated into any this or any other record. Hence metal detecting finds of more than a handful of bullets may represent the first information to identify and accurately locate such sites. It is therefore suggested that where approximately 50 or more bullets are reported from any one site, and with any collection which is accompanied by one or more powder box caps, the Battlefields Trust be asked to advise on the discovery by emailing project.officer@battlefieldstrust.com

Preparation and storage

Cleaning

Although it is normal practice to advise minimal cleaning of metal artefacts, to minimise damage to often fragile surfaces, it is essential in the case of lead bullets that all trace of soil is cleaned from the bullet surface, including from all holes and indentations. This is to ensure that all surface markings are clearly visible for the analysis. Cleaning is best done by gently brushing in water with a soft toothbrush. This will normally also remove a small amount of lead oxide or carbonate from the bullet surface, which will often be visible as a slightly milky white coloration of the water, but this does not normally represent significant damage to the artefact. Without such cleaning it is often impossible to adequately analyse the bullet.

Condition

Bullets vary significantly in condition according to the soil conditions in which they have lain since deposition, the degree of mechanical and chemical damage they have suffered depending on the history of land use on the site, and by their treatment and storage since recovery.

Recording of condition is important to the understanding of the evidence that may or may not be visible on a bullet. Thick corrosion deposits may mask fine detail of manufacture or use, while decay of the bullet surface, through chemical and/or mechanical damage in the ground or during storage, may have removed such deposits or indeed some of the detailed evidence itself. Bullets, sometimes even from the same field, may survive in very different condition, some with thick corrosion deposits intact, others where it has eroded partly or

wholly down to a clean lead surface, which might suggest, wrongly, that one bullet is early and the other more modern.

However, it should be noted that significant manufacturing detail could also be lost during original storage/transportation prior to use. Thus it is the combination of all the evidence that is essential to interpretation of the bullet.

Storage and marking

Adequate bagging of finds is an important issue, because mechanical damage to the bullet surface frequently occurs when bullets are stored together, fragmenting the corrosion deposits and potentially removing important detail of manufacture and especially of use, in addition to the resultant dust being a significant health hazard (see appendix 1). Bullets should not be coated with any material to protect the bullet surface from such decay as this can mask important evidence of manufacture and use. Instead each bullet should ideally be individually bagged, but the bullets themselves need not be marked, as once the accurate weight and linear measurements have been made then occasional errors should normally be resolvable by reference to the measurements and descriptions.

Analysis

The data should be recorded in a spreadsheet or database to enable analysis of the assemblage, including presentation of the calibre signature of the assemblage through graphing.

Levels of analysis of bullets

Full analysis will be practicable for small collections, and is essential for major survey collections with good spatial location for individual bullets. However with collections of several hundred bullets or more which are poorly located, or where it is otherwise impractical to undertake full analysis, then two less intensive levels of analysis are recommended. For all collections it is important to establish, at the very least, the overall signature of the assemblage through sample analysis.

Rapid Assessment

This is intended to assess the potential of a large assemblage to determine the potential for more detailed analysis.

A sample of several hundred bullets should be **weighed** to establish the calibre distribution, supported by a subjective assessment of the types and range of attributes of bullets in the collection.

Sample Analysis

This is intended to examine a representative sample of bullets to determine the broad signature of a large collection, where it is not practicable to undertake full analysis.

A sample of several hundred bullets is extracted and **weighed**. Each of these bullets is examined for notable attributes, and exceptional bullets are removed for full analysis. An additional sample of at least 50 bullets is selected at random from the collection for full analysis. For both of these detailed samples the bullet weight is recorded against their unique find number, each bullet being separately bagged and numbered if not already separately identified.

Full Analysis

The full range of quantitative and qualitative analysis is applied to determine the exact character of the assemblage, ensuring that particular types present in small quantity are identified and enabling analysis of spatial patterning of all attributes across a battlefield, where each bullet has an accurate spatial reference, showing the intensity and character of the action.

- **Calibre measurements**, where practicable:
 - **Maximum diameter of the width of the intended bullet**, on or immediately adjacent to the mould line, on the original bullet surface avoiding any offset, sprue or other distortion, to establish the intended original bullet calibre
 - **Maximum diameter of the depth of the bullet**, at 90 degrees to the mould line, on the original bullet surface, to establish the depth of the mould chamber as the latter is often different to the width due to manufacturing inadequacies.
- **Distortion measurements**, where relevant:
 - **Maximum diameter of the bullet**, where the bullet is not distorted, and excluding sprue, flash or impact, but including any offset, to record any manufacturing distortion.
 - **Minimum diameter of the bullet**, where the bullet is distorted, excluding sprue or flash, to record the degree of banding or of any impact damage
- **Description of main attributes:**

Each bullet is examined in strong, angled light, to cast sharp shadows which highlight surface detail. Where there is potential for finer detail, such as striation from tool use, or pitting from gunpowder combustion, then the relevant area of the bullet surface is examined using a *10 hand lens or, ideally, a binocular microscope.

Bullet photography

Although most bullets on cursory examination may look identical, the fine detail of variation is important. In any collection a sample of bullets should be photographed to provide a detailed record of all the types of features recorded in the analysis. At least until the point when adequate reference collections are available, this will provide future researchers with data that they can use to correlate analysis by different persons, particularly where the bullets are unlikely to be available for future analysis because they

are not to be retained in a museum collection. A standard metric photographic scale should be included on all images, printed on paper from a file downloaded from:

http://www.vendian.org/mncharity/dir3/paper_rulers/

Bullet Calibre

While neither weight nor diameter alone is an ideal measure of the calibre of a bullet, analysis of various collections has shown that weight is the most effective and efficient rapid measurement in most contexts, with diameter measurements providing important supplementary information for detailed analysis. In most situations lead is very stable, and the corrosion does not have significant influence on weight or diameter, but in some conditions substantial changes can occur, both to diameter and to weight. This tends only to be a problem with artefacts from some wreck sites, where very thick concretions can build up on the bullet surface.

Weight

This is the simplest way to measure the calibre of a bullet and is often the only way to establish the original calibre of impacted and other distorted bullets, including case shot, and of bullets from which hammered slugs were created. Because bullets were normally spherical, the ideal calibre (diameter) of a bullet can be calculated from the weight of the bullet, based on the specific gravity of lead.⁸ Unlike linear measurement, weight is quick to take and is an objective measurement with a definable error based on the accuracy of the scales used. There are however specific biases in weight introduced through the original manufacturing process which must be taken into account.

Modern analysis should be in grams. Measurement should be with electronic scales with a nominal accuracy of 0.01 gram, which should be re-calibrated at the start of every session. This should enable a practical working accuracy of $\pm 0.05\text{g}$, which is adequate for the analysis of lead bullets, where an interval of 0.25g is the highest normally useable for graphing purposes, given the numbers of bullets concerned. In the 17th century avoirdupois weights were used for the measurement of calibre of bullets and so for comparison with 17th century documentary sources a database conversion and parallel graph presentation should be given in bore (i.e. bullets to the pound of lead).⁹

Various factors create divergence between the weight, and hence the ideal diameter of a perfect sphere of lead, and the actual diameter of a bullet. These include poor quality casting, such as bubbles of air within the bullet or occasionally incomplete filling of the chamber because the mould was cold, all of which reduce the weight; poor registration of the mould halves, particularly as a result of wear, causing an offset and hence increased maximum diameter; and the use of poorly manufactured non spherical moulds. The weight will also be slightly distorted depending on the amount of lead that was removed in the snipping or cutting off of the sprue.

⁸ The equation is: $20 \cdot (0.021 \cdot m)^{1/3}$ where m = mass in grams.

⁹ Conversion: bore = $16 / \text{weighed grams} \cdot 0.035$

In addition it should be noted that experimental firing has demonstrated loss of lead through melting and through impacting, effects that are particularly significant with case shot. Hence the recorded weight of a fired bullet may be somewhat lower than that of the original bullet prior to firing, a reduction of as much as two bore being recorded in experimental case shot firing.

Linear measurement

Measurement is conducted in millimetres using electronic callipers with a nominal accuracy of $\pm 0.01\text{mm}$, more than adequate given that a minimum of 0.1mm has been found practicable for use in analysis of bullet diameter.

No bullet is a perfect sphere and so the recorded diameter of a bullet varies according to the exact position at which the measurements is taken. In view of the method of manufacture of bullets (see below) on the most common form of bullet, the ball, two measurements should be taken on the intact bullet surface, avoiding the sprue or snip and any impact damage: first the width on the mould line, avoiding any offset, as this should represent the intended calibre of the bullet and is likely to be the maximum diameter of the bullet; secondly the depth from the front to back of the bullet taken at 90 degrees to the mould line. However some bullets, typically heavily impacted balls or case shot, have insufficient surviving bullet surface to enable meaningful calibre diameter measurements to be taken. For *banded bullets* it is also essential to take the maximum diameter of the band, as this represents the effective calibre as fired.

For slugs the actual calibre cannot be assessed by weight and must be establish from the maximum width. For *hammered slugs* the original calibre of the ball from which some were modified can be established by the weight, while linear measurements taken are taken of the maximum length, maximum width (actual calibre) and minimum width (degree of flattening). The width should be measured with the calliper jaws running along the long sides of the bullet. For *slugs of dumbbell or capstan form*, which were cast as used, then only the maximum length of the slug and the maximum diameter of either ball is relevant.

Separate minimum diameter is taken to quantify impact damage on the bullet or, for case shot, the degree of flattening through firing.

Graphing bullet calibre from battlefield assemblages

Graphing of bullet weight and diameter are the most effective way to enable comparison between assemblages from different sites. The x axis is given in grams or millimetres, but with a parallel conversion to bore (bullets to the pound of lead) to enable comparison with the documentary record. In the basic comparative histograms between sites a weight interval of 1g is used, but for individual sites where sufficient numbers of bullets are available then either 0.5g or 0.25g intervals can be used as these may reveal finer detail.

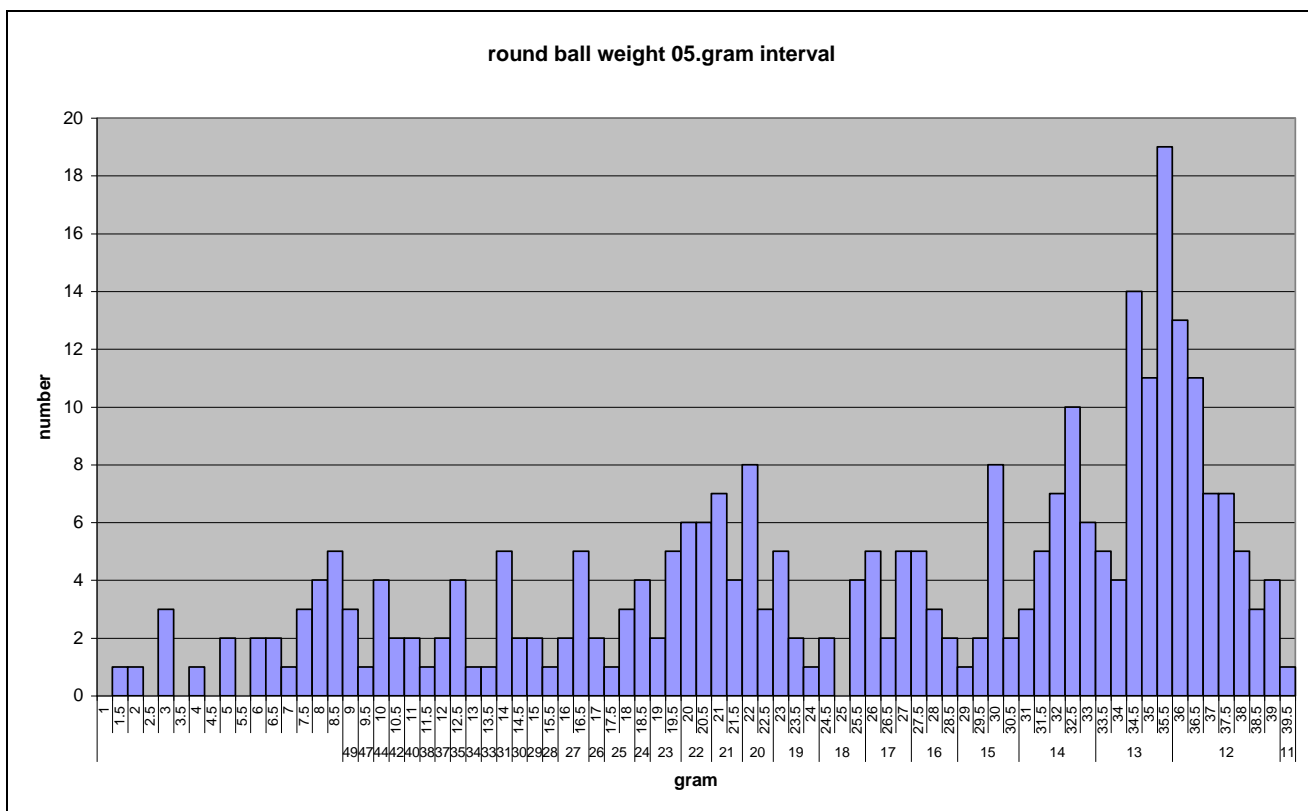


Figure 1: Edgehill battlefield survey interim data (spring 2006): bullets graphed by weight (horizontal scale: 0.5g above / bore below)

In the graphs the bullets fall into a number of groupings, in the form of normal distributions, but with overlap at the outer extremities of most distributions, meaning that a small proportion of bullets cannot be securely attributed to a specific calibre.

Interpreting calibre

The analysis of bullet assemblages of the mid 17th century and earlier is rendered more complex than for later periods due to the incompleteness of the standardisation of calibre; the high tolerances required by relatively unsophisticated manufacturing techniques, and by the progressive fouling of the barrel by gunpowder residues, which led to a progressive reduction in effective calibre of weapons during the action and hence demanded a high windage (gap between bullet and the interior barrel diameter).

The need for standardisation of firearms, to enable the mass production and supply of ammunition, had been recognised in the later 16th century and there was increasing standardisation during the 17th century, although this was around a substantial number of calibres. While some calibres went out of use by the time of the Civil War, such as the arquebus and caliver, others were introduced.

Not only was standardisation incomplete for weapons newly produced at the beginning of the Civil War, but there were also a significant number of older weapons still in use. The documentary evidence from the 17th century is not consistent but the main calibres can be broadly summarised in terms of bore (bullets to the pound of lead) as follows:

	<i>Musket</i>	<i>Dragon/ Dragoon musket</i>	<i>Bastard Musket</i>	<i>Arquebus</i>	<i>Caliver</i>	<i>Carbine</i>	<i>Pistol</i>
<i>Low – high bore</i>	<i>(11-)12</i>	<i>12 - ?</i>	<i>16- ?</i>	<i>17 - ?</i>	<i>17- 20?</i>	<i>20 – 24</i>	<i>20 – 24</i>

Bullet Types

Round ball

A range of different types of bullet are seen but the vast majority take the form of the standard round lead ball, of varying calibre.



Figure 2: Typical musket ball, viewed from above to show the snipped sprue (bar dividing two slight half circle depressions). Also showing the degree of distortion from the ideal sphere, and exhibiting a high level of corrosion deposits (Edgehill 190)

Slugs

Slugs are elongated non spherical bullets. They come in three main types: those created by hammering larger calibre round balls into smaller calibre bullets of square or round section; cut from a rod of lead; or cast as double balls linked by a sprue.

Hammered Slug

Probably the most common slug is that created from normal lead balls, which were modified by hammering to substantially reduce their calibre. The final shape, whether square, hexagonal or round in section depends on the number of times they were hammered. The length of a slug is irrelevant to the function of the bullet, being determined simply by the calibre of the original ball and the intended final calibre. The calibre of the original bullet can be determined by the weight.



Figure 3: Long box slug (Edgehill 445)



Figure 4: Irregular slug showing a number of separate facets (Edgehill 512)

Conjoined bullets

Some slugs take the form of two joined spheres or a variant thereof. Occasionally conjoined bullets may prove to be fused by impacting, where the weapon was fired loaded with two separate bullets, but most were manufactured as double bullets. In some cases the manufacturing process may simply be incomplete, the bullets not yet snipped from the sprues, though most have the sprue removed ready for use and some show clear evidence of firing, demonstrating that such double bullets were indeed used in that form.

Those double bullets joined by a distinct sprue bar can be described as a ‘dumbbell’.



Figure 5: A series of conjoined bullets, with sprue removed, showing clear evidence of firing in the form of flattened bands and, in the left bullet, clear impacting damage (Easton Maudit)



Figure 6: Dumbbell bullet with sprue intact, demonstrating manufacture in a double mould (Easton Maudit)

A rare variation is where a single bullet was cast with two broadened but non spherical ends, described as a ‘capstan’ form. These are found with the sprue removed ready for use and several show evidence of firing and impacting.



Figure 7: Capstan type bullet, with the sprue snip just visible on the top (left) and a slightly pitted lower (right) surface which might indicate firing (Easton Maudit)

Other modified bullet types

There are other distorted bullets that appear in very small numbers but their date, purpose and in some cases the method of manufacture or modification is at present uncertain. Some appear to represent bullets fired as double loads in small arms.



Figure 8: Domed bullet, with distinct banding, indicating firing, and slight concave aspect to flat base, possibly representing one ball of a double load (Easton Maudit)

In some cases distortion may be the result of ramming in the gun barrel with the ramrod, though it has not proven possible to reproduce this effect in experiments using the wooden ramrod in normal use in the 17th century. These bullets are subject to ongoing research.

Hail-shot

The terms ‘shot’ in modern usage describes very small spheres of lead used in large numbers in multiple charges, as in a shotgun. In the 17th century the term was used to cover all types of projectile fired from a gunpowder weapon. To avoid confusion therefore the 17th century term ‘hail-shot’ is used here to describe very small calibre bullets of well below pistol calibre.

The manufacture of such very small calibre projectiles was only achieved in a mass production method from 1665, when the so called ‘Rupert’ method was developed, in which the molten lead was poured through a colander like dish into water, producing a teardrop shaped rather than perfectly spherical projectile. It was not until 1769 that the use of the shot tower was developed to mass-produce perfectly spherical shot. Thus during the Civil War hail shot was produced using more cumbersome methods. The largest calibres could be produced in moulds (see figure 13), while the smaller diameters were produced by cutting sheet lead and tumbling it in a barrel.¹⁰

Post 17th century round bullet types

Unrelated bullets certainly of later date will occasionally be recovered along with battle related artefacts. There are several distinctive types of later date that can be easily identified. For the remainder without a distinctive form, calibre may be a partial indicator if large numbers of bullets are involved. For example 19th century double belted balls were for use in a four groove rifled barrel, while the single belted ball was for use in a four groove barrel.¹¹

¹⁰ Hamilton, 132.

¹¹ McKee and Mason, (1980) The metal detecting collection of Les from the siege of Boarstall Castle, Buckinghamshire, has been briefly examined by the author but not analysed.



Figure 9: Small ball for two groove rifle, with the distinctive wide raised strip all around circumference (unprovenanced: displayed at Dean Heritage Centre, Gloucestershire)

Case shot

At close quarters, against men and horses, artillery typically employed case shot. The term is used here to cover all types of multiple lead bullet anti-personnel munitions fired from ordnance. It could comprise large numbers of musket balls, square shot of iron, nails, or even pebbles, but by the mid 17th century it normally comprised lead bullets of musket calibre. Case shot is documented as having been loaded in a number of ways: loose in the bore of the gun; in a wooden case; in a metal canister; or in a strong canvas bag. The latter may have been a simple canvas bag, like that used as a cartridge for loading gunpowder into the artillery piece, or it could represent what is later called grape shot,¹² but no adequate description of the canvas bag munition has so far been identified. The only reported find of a metal case from a British battlefield is that from Culloden (Scotland, 1746).¹³ Wooden boxes for firing case shot have been recovered from the 17th century wrecks of *The Vasa* and *The Swan*.



¹² Blackmore, (1976), 193 & 196.

¹³ Tony Pollard, paper to seminar on battlefield archaeology, Royal Armouries, Leeds, February 2006.

Figure 10: Case shot: this is typically a round ball modified by firing into a polygonal form, with numerous facets resulting from impacts in the barrel during firing (Edgehill 192)



Figure 11: Case shot: though typically polygonal it can have part of the original round ball surface surviving (left) or be heavily distorted (centre). Fragments from impacting (right) might be found (Experimentally fired bullets)



Figure 12: Two case shot bullets welded together during firing and showing a high degree of melting of the bullet surfaces, due to the high temperatures in the barrel of the artillery piece (experimentally fired bullets)

Case shot is most commonly found as lead bullets of musket calibre distorted, as a result of firing, into polygonal form with a varying number of facets. Experimental firing has confirmed the interpretation of these bullets as case shot, but has shown that a wider range of deformation occurs than is most typically found on the battlefield. The numbers of facets can be far smaller (two facets is normally sufficient to identify a bullet as case shot) or the bullet may occasionally be far more intensely flattened and elongated, but always in a very distinctive, angular form. It should however be noted that there can be a degree of smoothing of the surface and especially the corners due to melting under high firing temperatures. Occasionally two case shot bullets may be found welded together, but the

faceted form and evidence of melting clearly distinguishes these from slugs of conjoined form. Experimentation has also shown that, due to melting, there is reduction in the weight of bullets fired as case shot, giving a shift down of calibre of as much as 2 bore. It has also demonstrated further loss of weight and hence calibre where the bullet has suffered a substantial, high velocity impact. Occasionally small bullet fragments may be found from fragmentation of bullets on impact with the ground close to the artillery piece.

Other munitions for ordnance

Roundshot

Roundshot, popularly known as cannon balls, are recovered in very small quantities from battlefields. They can provide valuable information as to the size of pieces used in an action, but provide limited information on the extent and character of the action. By the mid 17th century cast iron roundshot was the normal long range battlefield munition and siege munition for battering defences. Stone roundshot, though still in use, was a relative rarity by the Civil War. The smallest artillery pieces might fire lead roundshot or even occasionally iron cast-about with lead. Measurement of these munitions is by both diameter and weight of the ball, and detailed tables of reference to types of ordnance are given in the various contemporary manuals and, though there are significant variations between the sources, these tend to be in broad agreement.

Grape shot

Grape is analogous to case, but tied together on a base with a central wooden spindle. Blackmore suggests that grape was not in use in the mid 17th century, but in fact it is already present on the Vasa in 1628.¹⁴ No definitive evidence has been found for grape having been supplied for or employed in land engagement in the mid 17th century, but it is possible that descriptions of Civil War munitions which include case shot in canvas bags may be referring to what is later called grape shot (see case shot above).

Grenados

In addition to case there were cast iron explosive grenados, intended for use in mortars. These were normally used only in siege situations, not on the battlefield. Both exploded fragments and a complete unfired example of a grenado is reported from Sandal Castle excavation.¹⁵

Bullet Manufacture

Analysis of manufacturing evidence is essential to enable the bullet to be placed in its correct orientation for analysis; to isolate these features from the analysis of the marks caused by use; and, depending on presence or absence, as a guide to the degree to which the ball has been modified since manufacture, whether by use or due to post depositional factors.

¹⁴ Blackmore, (1976)

¹⁵ Credland, (1983)

Sprue

The channel by which lead was introduced into the mould, which straddles the mould line representing the junction of the two halves of the mould, results in a 'sprue' extending out from the surface of the bullet. Single bullet moulds will have typically left a single sprue, occasionally seen complete in surviving bullets with a flange around the top reflecting the single circular hole. In gang moulds a shallow channel typically ran along the top of the mould leaving a small bar joining each sprue. However the sprue was normally removed to complete the manufacturing process.



Figure 13: Very small calibre bullets of hail-shot type still attached to sprue and mould bar; also a small detached mould bar (Easton Maudit)

Sprue removal

For most use the sprue was removed, either by snipping with 'nippers', or by cutting, presumably with a knife. In later centuries there could also be a special cutter affixed to some moulds for single bullets. Nippers typically leave two opposing half moon depressions in the bullet with a narrow raised bar between, and under magnification the two face of the snip can show parallel striations at right angles to the central bar. Cutting typically produces a single, sometimes slightly oblique surface with, under magnification, traces of a single set of striations. Though ideally removed almost flush with the sphere, in mass production it could be poorly cut or snipped leaving it raised to a greater or lesser extent, or cut down into the sphere of the bullet. If left raised then the remnant sprue could become swaged over by bumping in transport, in use, or possibly in some cases to intentionally prepare the bullet for use.



Figure 14: This sprue, sitting as always astride the mould line, here clearly visible as a slight offset, was left proud when cut or nipped. The remnant sprue has subsequently been swaged over, possibly by bumping during transport (Edgehill 564)



Figure 15: Heavy corrosion deposits mask some features on this ball, but the distinct opposing half moon depressions with central dividing bar show where the nippers have cut off the sprue, close to the surface of the sphere (Edgehill 137)



Figure 16: Careless cutting of the sprue has left partial deep cuts and has also removed a substantial part of the sphere of the ball, thus significantly affecting bullet weight. The striations from the tool used can be seen on the lower face of the left bullet (Ballymore)

The removal of the sprue was important if, as most commonly, the bullet was to be loaded loose in the barrel. However the survival of an intact or substantially intact sprue is not necessarily an indicator of unfinished bullet manufacture, or that the bullet has not been fired. It has recently been suggested, in connection with mid 17th century examples from the Ukraine, that this was to enable the bullet to be tied into a cartridge.¹⁶

¹⁶ Mandzy, (2004)



Figure 17: Examples of the pistol bullets, from the seaman's chest recovered from *The Vasa*, have their sprue intact. The sprues may have been left to help tying the bullet into a cartridge. The surface of the bullets is partially distorted by the sort of concretion sometimes found on bullets from wrecks.

Moulding faults

Mould lines

Because bullet moulds were in two halves, to enable the bullet to be removed, the join between the two halves resulted in distinctive marks on the bullet. The size and nature of this seam depends upon how close and true was the fit between the two halves of the mould. This mould line, together with the sprue location, enables the bullet to be orientated as it was manufactured. The degree to which both features survive or are visible can be an important indicator as to the degree of modification or masking that the bullet has undergone.

In other cases the registration may be good, but the seating of the two halves of the mould may be poor. While typically the result is a slight ridge less than 0.5mm wide along the mould line, in exceptional cases a 'flash' can extend several millimetres out from the bullet surface, where lead has seeped along the mould join. Normally this fairly fragile flash would become swaged over by bumping in transport, but its survival on a bullet is a good indicator that the bullet has been found close to the point of its manufacture and also that the bullet has not been fired.



Figure 18: A distinct 'flash' is visible along the mould line on this unfired bullet, where the two mould halves have been poorly seated. Normally lost through bumping in transport or through use, here it is intact, suggesting the bullet was found close to its point of manufacture (Ballymore, Ireland).

Offset

Where the registration between the two halves of a bullet mould was poor, usually due to wear, then an offset is seen in the bullet along the mould line. These features vary greatly in scale according to the degree of wear on the mould. They can range from a thin line through to a large offset, where the two hemispheres of the bullet do not meet properly.

Incomplete fill

In some cases the mould has failed to fill properly and an imperfect or even incomplete sphere could result. The less dramatic fault is the 'potlid' type where lead overlaps from two stages of filling the mould chamber, with the lead starting to solidify in between. Such problems tend to occur at the beginning of a casting job, when the mould is cold. The least extreme type of fault is the slight ridging of the bullet surface with latitudinal lines that may be confused with turning lines (see below).



Figure 19: Poorly cast bullets where the mould was incompletely filled resulting in an incomplete sphere and lacking a sprue (Ballymore)

Mould brothers

If there were distinctive faults in individual mould chambers then it is sometimes possible to identify bullets produced in the same mould chamber.



Figure 20: Mould brothers: bullets showing identical distortion, resulting from manufacture in the same damaged mould (Vasa 17133.48-52)

Turning lines

On the surface of some bullets are a series of latitudinal ridges and grooves, centred on an axis running through the sprue, possibly indicating manufacture of the mould using a router. These features would tend to be destroyed by bumping during transportation and use and so they are indicative of unfired bullets from magazine assemblages. Unfortunately in

some cases such ridges can be indistinguishable from the slight ridges that can occur when casting with a cold mould.



Figure 21: Latitudinal lines centering on an axis through the sprue, possibly reflecting the original cutting of the mould with a router (Swan bullet 38)

Supply & transportation

Bumped

The bullets were typically supplied to the armies and lesser detachments in small barrels. During transportation the surface of the bullets would, to a greater or lesser degree, be modified as they bumped together in the barrels, particularly when transported by wagon or tumbrel. This not only tended to remove or at least reduce the surface features such as flash, mould ridge, turning lines and raised sprue, but also often left a distinctive pattern of tiny, shallow, rounded surface indentations. Such bullets are classified here as ‘bumped’.

Bitten & pared bullets

The calibre of oversized or distorted bullets could be modified prior to firing to allow them to correctly enter the gun barrel. This was sometimes achieved by selectively biting or even gnawing the bullet. Calibre correction could also be achieved by paring the bullet with a knife.



Figure 22: Paring represented by a series of flat surface along the mould line, where the flash has been removed by cutting (Vasa 17154.48)

On most sites bitten bullets represent a tiny percentage of the assemblage. The degree of biting varies from a few teeth marks through bullets that are chewed out of shape. While some teeth marks may be post deposition damage by animals, most notably the pig, others are definitely human teeth marks and relate to activity during or immediately after the battle.¹⁷ The holding of bullets in the mouth ready for loading was a well documented and common practice amongst musketeers. Others may have chewed the bullet for salivation to combat thirst. Finally there may be some bullets which have been used by wounded soldiers to bite upon while undergoing surgery. It was also claimed during the Civil War that some bullets were intentionally bitten prior to firing and had sand rubbed into them to promote infection in wounds, although this may have been purely propaganda.¹⁸

Burring

There are various references in manuals and supply records of burr shot and rough hewn musket balls. However there is some uncertainty as to the exact meaning of the term ‘burr shot’ and further documentary research is required before the identification of bullet suggested here as burr shot can be confirmed. These bullets are normal lead ball which have been gouged with a metal tool to grate a roughened surface. It has been suggested that such bullets were intended for use as case shot, but none of the Vasa case shot bullets are so treated. Moreover, such marks would almost certainly have been destroyed during firing as case and hence would have served little purpose. It seems more likely that they were intended for single use in small arms.

¹⁷ Sivilich, (2004)

¹⁸ Quoted by Carlton, p.322.



Figure 23: Possible burr shot, with numerous small gouges creating a rough bullet surface (Swan bullet 56)

Loading & Firing

Ramrod marks

Despite the potential to load without ramming, by simply rolling the ball into the gun barrel, musket drill typically required the ramming home of the bullet with the ‘scouring stick’ or ramrod. This would have been essential as the barrel began to foul during action, for if the bullet was not fully home then firing the gun might result in the barrel exploding and killing or injuring the musketeer. Where bullets were tight in the barrel one might expect that the ramrod will have left marks on the bullet, and this is reported from American Civil War contexts.¹⁹ However metal ramrods did not come into general use in the British army until the 18th century. Ramrods of the mid 17th century are believed to have been invariably of wood with, if anything, then occasionally only a horn or lead ferrule, in contrast to later all metal or metal tipped ramrods. This may explain why no distinctive ramrod marks have yet been identified with confidence on Civil War bullets in England.

Banding

The most distinctive firing mark is in the form of banding, where the bullet flattened to a greater or lesser degree in a band around part or the entire circumference of the bullet. Banding of this type has been occasionally reported from American Civil War contexts, but there they are stated to be ‘oddities’, interpreted as elongation of round balls when fired in rifled weapons. Several examples show cloth impression indicating that some had been fired with cloth patches, and similar examples are also reported from an early 18th century

¹⁹ Sivilich, (2004)

battlefield in Sweden.²⁰ Rifled barrels, though in use in specialist firearms of the Civil War, were not in regular military use by the common soldier. It is not therefore surprising that no evidence has yet been recognised from an English battlefield of bullets fired through a rifled barrel, though several examples have been found from the enigmatic Easton Maudit site.

Under magnification in some cases striation can be seen on the band. This is normally at right angles to the band, but occasionally it is slightly diagonal to it. On some bullets however this type of evidence may be obscured by corrosion deposits.



Figure 24: Banded carbine bullet. Several faint striation are just visible on the band, caused as bullet travelled down the barrel; also visible is the smoother upper hemisphere (Coventry, find 24)

Powder pitting

There is a close association between banded bullets and the presence of pitting on one hemisphere of the bullet, caused by the burning of the gunpowder in the gun barrel. In some bullets the degree of melting was such that a radial pattern is visible. While pitting and striation is visible on the lower hemisphere of banded bullets, which faced towards the powder charge, the upper hemisphere typically remains as an unaltered bullet surface, being the face towards the muzzle of the gun.

²⁰ McKee and Mason, (1980); Knarrstrom, (2006), 34.



Figure 25: Pitting and faintly radial striation on the lower hemisphere of the bullet (Edgehill 680)



Figure 26: An extreme example of a banded bullet. It is slightly elongated, with a wide but irregular width band, reducing the calibre of the bullet, and with the diameter tapering slightly from the top (left) to bottom of the band. There are faint traces of parallel grooves at right angles to the band, though the latter are not visible on the photograph. There is distinct pitting of the lower hemisphere, whereas the upper hemisphere shows a largely unaltered original bullet surface. (Edgehill 154)

Multiple loads

The distinctive bullet deformation caused on case shot during firing has been discussed above. However various other firearms were also sometimes fired with multiple loads.²¹ Both pistol and carbine are recorded as having often been charged with more than one bullet. These might be expected to produce facets on the bullets comparable to but less pronounced than those seen in case shot.

Removal of bullet with worm

A worm, a corkscrew form of implement that could be attached to the end of the sourcing stick, was carried by all musketeers to remove bullets when the charge failed to go off or

²¹ In the American Civil War this typically took the form of ‘buck and ball’, a combination of a large calibre bullet with several small bullets or ‘buckshot’, producing distinctive impact marks on the ball when fired. We have identified no examples of the latter in a 17th century context. McKee and Mason, (1980)

where the bullet became wedged in the barrel. The worm leaves a distinctive hole in the lead bullet.²²



Figure 27: Bullet with damage apparently caused by removal from the gun barrel using a worm (Edgehill).

Impacting

Deformation

When a bullet was fired and it impacted then the degree of deformation would vary according to the impact velocity and the nature of the surface that was hit. There are clear differences in the nature of impact surfaces which may reflect the character of the object upon which the bullet impacted.



Figure 28: Heavily impacted ball where the surface impacted appears to have been very hard, smooth and convex, such as a musket barrel or perhaps more likely a large smooth pebble. On the left the original spherical shape of the ball has been widened by the impact (Edgehill 151)

²² Sivilich, (2004)

Gouges and cuts

In addition to large scale deformation of bullets, there are also various degrees of damage to bullets in the form of gouges. Some if not most of these are like to be the result of the less substantial impacting of bullets, perhaps from impacting into the ground as these features are not present on the unfired bullets from either the Vasa or from Ballymore, thus probably providing additional evidence of fired as opposed to unfired bullets.

Post depositional effects

Significant variation has been noted between the general condition of bullets from different fields of conflict.

Corrosion deposits

In normal soil conditions, over the 350 years or so since the action, bullets typically develop a surface coating of lead oxide. This corrosion deposit, varying from pinkish-white to greyish-white, may also have various types of staining. In exceptional conditions lead oxide can also form a red or yellow-brown colour, while in some circumstances the surface may become discoloured with iron deposits. Under exceptional soil conditions surface deposits of lead carbonates may develop, creating a whitish-brown surface. Where there is waterlogging and hence reducing conditions, there can also be a blackening of the surface, where lead sulphide forms on the bullet surface. In many cases the corrosion does not necessarily destroy the fine detail of features on the bullet surface, but that it simply masks those features.

Concretion

Where bullets have been deposited in water special conditions seem to prevail. This may be a case of lead building up in solution sufficient to enable a process of crystallisation, which forms a thick concretion on the bullet surface, with sand and other material sometimes becoming incorporated into the concretion. This represents a dramatic masking of the evidence on the bullet surface, although such evidence may survive beneath the concretion as can be seen from several examples where the concretion has broken away.



Figure 29: Some bullets recovered from the Vasa show a high level of concretion which seems most distinctive of the special conditions of marine preservation (Vasa 17345.25-26)

Modern mechanical damage

Modern impact damage is seen on some artefacts, normally clearly distinguished because the corrosion deposit is damaged. In some cases this can be caused by the digging tool used in retrieval during the survey. Other damage may result from agricultural activity.

Erosion

Unlike the oxidisation of ferrous artefacts, the oxidisation of lead leads to a relatively stable condition and thus large scale loss of the bullet volume does not therefore appear normally to occur. However, mechanical and chemical effects resulting from modern arable agriculture can lead to the progressive destruction of this surface corrosion deposit and in extreme cases a fresh looking metal surface may result, sometimes with tiny fragments of corrosion deposits remaining in gouges or other small surface deformations.



Figure 30: The crazed surface of a banded bullet, apparently resulting from early stages of decay of lead oxide corrosion deposit (Edgehill)

In exceptionally aggressive soil conditions a high degree of fragmentation can occur to the body of the bullet itself leading to disintegration of a substantial part of the bullet.



Figure 31: Disintegration of bullets, presumably due to aggressive soil conditions (Ballymore, Ireland)

BIBLIOGRAPHY

- Allsop, Derek, and Glenn Foard. "Case shot: an interim report on experimental firing and analysis to interpret early modern battlefield assemblages." In *Scorched Earth: Studies in the Archaeology of Conflict (Journal of Conflict Archaeology vol.3)*, edited by Tony Pollard and Iain Banks, 111-146. Leiden: Brill, 2008.
- Blackmore, David. *Arms and Armour of the English Civil Wars*. London: Royal Armouries, 1990.
- Blackmore, H L. *The Armouries of the Tower of London: The Ordnance*. London: HMSO, 1976.
- Courtney, Paul. "Small Arms Accessories of the mid 17th century." Datasheet 11: Finds Research Group, 1988.
- Credland, A G. "Military Finds." In *Sandal Castle excavations 1964-1973: a detailed archaeological report*, edited by Philip Mayes, 259-266, 1983.
- Foard, Glenn. *The Archaeology of Battles: Pen and Sword*, in preparation-a.
- Foard, Glenn. "Bosworth battlefield survey 2005-9." The Battlefields Trust, in preparation-b.
- Foard, Glenn. "Integrating the physical and documentary evidence for battles and their context: A Case Study from 17th Century England." PhD, University of East Anglia, in preparation-c.
- Hamilton, T M. *Colonial Frontier Guns*. Chaldron: The Fur Press, 1980.
- Knarrstrom, Bo. *Slagfältete: Om bataljen vid Landskrona 1677*. Saltsjo-Duvnas: Efron & Dotter, 2006.
- Mandzy, Adrian O. "Revolutionary Armies at Zboriv." Paper presented at the 3rd International Fields of Conflict Conference, Nashville 2004.

- McKee, W Reid, and M E Mason. *Civil War Projectiles II: Small Arms and Field Artillery*. Virginia: Publisher's Press, 1980.
- Sivilich, Daniel. "Analysing Musket Balls to Interpret a Revolutionary War Site." *Historical Archaeology* 30, no. 2 (1996): 101-109.
- Sivilich, Daniel M. "Revolutionary War Musket Ball Typology - An Analysis of Lead Artifacts Excavated at Monmouth Battlefield State Park." Paper presented at the Fields of Conflict III, Nashville, Tennessee 2004.
- Ward, Robert. *Animadversions of Warre*. London: I. Dawson, 1639.