A Trial Study of the Use of Luminol in Conflict Archaeology: The Revolutionary War Battle of Bennington

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ABSTRACT

In the fall of 2015, Commonwealth Cultural Resource Group, Inc. (Commonwealth) conducted an intensive metal detector survey on several areas of the Bennington Battlefield in Hoosick Falls, New York, as part of a New York State Office of Parks, Recreation, and Historic Preservation (NYOPRHP) study. The NYOPRHP was awarded a grant from the American Battlefield Protection Program of the National Park Service to conduct archival research, landscape analysis, and archaeological research to better guide the interpretation and preservation of the Bennington Battlefield. Metal detection recovered more than 100 projectiles from the battlefield. In addition to determining the size, type, and condition (dropped or fired) of the projectiles, as well as any discernible spatial patterning evident from this initial analysis, Commonwealth added a pilot study in the use of Luminol testing to screen these artifacts for blood residue. Determining the presence or absence of blood would potentially add another layer of useful data in interpreting the events of the battle and allow the NYOPRHP to more accurately interpret and preserve the battlefield. The pilot study resulted in the expected pattern of a few positive results among the fired projectiles, and no positive results among the dropped projectiles. The potentially blooded artifacts spatially occurred in only two known areas of heavy casualties.

Introduction

In 2014 the New York State Office of Parks, Recreation, and Historic Preservation (NYOPRHP) was awarded Grant GA-2287-14-013 from the American Battlefield Protection Program of the National Park Service. The purpose of the grant was to conduct archival research, landscape analysis, and archaeological research to better guide the interpretation and preservation of the Bennington Battlefield in Hoosick Falls, New York. NYOPRHP issued a request for proposals, and the project was awarded to Commonwealth Cultural Resources Group, Inc., now Commonwealth Heritage Group, Inc. (Commonwealth). As part of the study, Commonwealth conducted an intensive metal detector survey on several areas of the battlefield in the fall of 2015. Over 10 days, a crew of three professional archaeologists conducted the survey. On four weekend days, avocational detectorists worked under the supervision of the archaeologists (Figure 1). Following a standard methodology nicknamed the "Doug Scott Approach" (Balicki and Espenshade 2010), the locations of recovered battle-related artifacts were plotted with a GPS unit with submeter accuracy.

In conflict archaeology, spatial patterning is of paramount importance in understanding the landscape of the battle. Typically, artifacts are sorted into dropped or fired rounds and dropped equipage. If there are weapon/munition types or equipage that were distinctive to the army or another unit their patterning is also considered. Patterns of these artifact classes are then used to help reconstruct military actions.

Figure 1. Volunteer detectorists assisting in Bennington study. (Photo by Chris Espenshade, 2015.)

For the Bennington research, Commonwealth chose to add a pilot study in the use of Luminol, in hopes of adding another layer of data to our interpretations. The Bennington sample was well-suited for the trial because we had fairly good archival information and mapping of where battle actions occurred, and we recovered 38 dropped munitions and 98 fired munitions (Selig et al. 2016).

Recent studies have applied a protein residue analysis referred to as crossover immunoelectrophoresis to screen for the presence of blood on fired munitions (Puseman 2007). This method is relatively costly and time-consuming. Such an approach is appropriate for examining a small sample of balls, but would be time and cost-prohibitive if applied to a large sample. Because two of the authors (Espenshade and Yeshion) had previously worked together in screening stone tools for blood residue using Luminol, Commonwealth knew that Luminol was a relatively rapid and inexpensive screening technique that could be applied to large samples of munitions. Commonwealth recognized that the detection threshold of Luminol is very high (approximately one-part blood per million particles), though there is a risk of false positives depending on soil conditions. Because the dropped balls would provide a control sample (i.e., it would be unusual for a dropped ball to have been exposed to blood), Commonwealth chose to proceed with the pilot study, and Dr. Yeshion and his students at Edinboro University agreed to conduct the study.

The sample provided for screening included 98 fired and 38 dropped lead balls, buckshot, and slugs or cylinder shot. A buck-and-ball load combines one large lead ball (of the size that would be fired from the musket) and multiple pieces of buckshot. The buck-and-ball load increased the odds of striking an enemy in close combat, without significantly decreasing accuracy. The use of buck-and-ball cartridges by Continental Army soldiers was common beginning in the early years of the war, and in June of 1776 General Washington recommended that for initial volleys muskets be loaded with one musket ball and 4–8 buckshot, depending on the type of musket (Washington 1776). While the use of a buck-and-ball load was recognized as common practice in the Continental Army, on October 6, 1777, Washington made the practice standard for his troops by ordering that "buckshot shall be put into all cartridges which shall hereafter be made" (Washington 1777). Buckshot is commonly found on Revolutionary conflict sites, and given Washington's orders is generally attributed to American fire. All artifacts were bagged separately upon recovery, with a provenance card that recorded the metal detector find number, the date, the detectorist, and the artifact type.

Overview of the Battle of Bennington

The Battle of Bennington (also known as the Battle of Walloomscoick) was fought on 14–16 August 1777. Approximately 2,000 American militia from Vermont, New Hampshire, and Massachusetts were engaged with a multi-national Crown Forces column of approximately 1,400 soldiers including German, British, American Loyalists, Canadians, and Mohawk Indians. When the two forces first came together, the Crown Forces recognized that they were significantly out-numbered and prepared defensive positions (several redoubts and breastworks) centered on a high knoll. The first phase of the battle began in the middle afternoon of 16 August when, despite the breastworks, the Americans were able to surround and overwhelm the Crown Forces. A second phase of the battle took place after the collapse of Crown defenses when a relief column numbering approximately 700 men approached the battlefield. This 700-person force encountered elements of the American militia, now much disorganized. Hard fighting eventually forced the relief column back along its route of approach, losing two cannons in the process before nightfall ended the engagement. Losses for the Crown Forces were staggering—nearly 1,000 men killed, wounded, and captured. American losses were reported at less than 200. American forces also captured four cannons, muskets, and supplies (Selig et al. 2016).

Brief Overview of Luminol Screening

Luminol is a presumptive blood test that is primarily used by forensic investigators for the purpose of analyzing crime scenes to aid in the reconstruction of events. It is sometimes used in the crime laboratory on evidence recovered from crime scenes to determine if there are chemical indications for the presence of trace blood. Luminol and other presumptive blood tests have also served as useful tools in civil cases and for archaeologists and historians in the reconstruction of battlefields, other types of historical scenes, and artifacts of interest (see

Vish and Yeshion 2004 for an analysis of Luminol testing on prehistoric artifacts).

Luminol was first synthesized by Schmitz (1902), and its first forensic use as a presumptive test for blood was reported by Specht (1937). Luminol is a solution consisting of water, sodium carbonate, sodium perborate, and Luminol (3-aminophthalyhydrazide). When this solution comes into contact with the hemoglobin found in red blood cells, a chemiluminescent reaction occurs. Unlike other presumptive blood tests that provide a color change, this reaction appears as a blue-white luminescence that can be seen by the unaided human eye in a darkened environment.

One significant advantage of using Luminol is that the test has a sensitivity of one part per million as compared to other presumptive blood tests such as the Reduced Phenolphthalein test or the Tetramethylbenzidine test that provide a maximum sensitivity of approximately one part per thousand. The Luminol test does not possess a high degree of specificity, however, as it is reactive to chemical oxidants (e.g., bleach), plant/vegetable peroxidase (e.g., horseradish), and chemical catalysts (e.g., copper). Due to this range of substances that will react to Luminol, it is important to note that this is only a presumptive blood test and, as such, the Luminol test cannot prove to any degree of scientific certainty whether blood is present or, if present, is of human origin. And while repeated testing is possible, each additional application of the solution will further dilute already trace levels of suspected blood.

Despite its limitations, the Luminol test presents a number of benefits. Luminol is a relatively inexpensive test (generally costing less than $100 to process many items of interest) and positive reactions will be triggered by trace amounts of blood due to its high degree of sensitivity. In addition, Luminol is easily and quickly applied to large areas or onto many items at once in the form of a light spray.

Analysis Methods

Prior to the ammunition's shipment to Edinboro University, Juliette Gerhardt of the Commonwealth artifact laboratory recorded the items as dropped or fired. Fired balls are generally misshapen due to contact with bodies (people or horses), rocks, vegetation, or the ground. In cases where balls were only mildly distorted, we looked for marks from the ramrod. A ball with a ramrod mark must be fired, unless it also has marks from having been extracted from the barrel. Spherical balls with no obvious distortion and no ramrod marks were considered dropped balls. Soldiers often dropped balls, especially when reloading under fire. After classifying balls and buckshot as either dropped or fired, each sample was repackaged individually and grouped according to classification and ammunition type. The groupings were then sent to Dr. Yeshion at Edinboro University of Pennsylvania to undergo forensic testing for the presence of blood.

To begin the experiment, positive and negative control samples were first tested. The use of controls is critical to indicate whether the chemicals are working properly and also to reveal the presence of contaminants such as copper in the ammunition or contaminants in the soil, either of which could yield false positive reactions. To conduct a positive control, Luminol was applied to a sample that is known to cause a reaction. In this case a copper penny was used rather than a known bloodstain so as not to introduce any possible trace contaminant of blood to the laboratory testing area. The penny provided a positive reaction, as expected. To conduct a negative control, Luminol was applied to the dropped ammunition, which likely would not have come into contact with blood, and so the samples would not yield a positive reaction. As expected, no reactions occurred and so it was determined that 1) there were no interfering chemical catalysts in the makeup of the ammunition, and 2) there were no contaminants in the soil from which the ammunition was recovered.

To begin testing the remaining samples, two rows of dropped buckshot were set out on butcher paper in numerical order, based on the assigned sample numbers. The lights were then turned off and the investigators' eyes were allowed to adjust to the dark. Luminol was then sprayed lightly and evenly over the samples. Once sprayed, the surface was examined for any sign of luminescence. Luminescence will typically last for approximately 20 seconds to 2 minutes. The larger the stained surface area, the longer the luminescence. Given a very small surface area and the consistency of the surface, luminescence will be relatively short. In this particular study, luminescence generally lasted less than 20 seconds. As long as the surface is sprayed lightly and then allowed to dry completely, the test object can be resprayed to visualize the reaction (or lack

thereof) again, though oversaturation from repeated testing will result in diminished reactions. If a reaction occurred, the artifact number was recorded as a positive reaction. The samples were then returned to the corresponding bags and set aside. This process was repeated for the dropped musket balls, followed by dropped slugs, fired buckshot, fired musket balls, and fired slugs.

Results

A total of 99 samples of ammunition were tested (Table 1). No positive indications for the presence of blood were detected on the 5 dropped buckshot, 3 dropped musket balls, or 69 fired musket balls. Of the 22 fired buckshot tested, 6 (27%) gave positive chemical indications for the presence of blood (Figure 2). These results are not confirmatory for the presence of blood nor do they necessarily represent the findings of blood of human origin. In other words, this test alone could not eliminate the possibility that such reactions could have resulted from injured or killed soldiers or battlefield horses. However, certain contaminants known to cause false positive reactions to Luminol could be excluded.

Spatial Distribution of the Positives

The consistently negative results among the dropped balls provide confidence that environmental factors did not cause the positive reactions among the fired buckshot. The next step in this pilot study was to examine the spatial distribution of the artifacts that tested positive for the presumptive presence of blood. Upon review, the positives were found clustered in two areas, both of which saw intensive small arms exchanges during the battle.

The first area contained three positives within 60–70 m of each other, behind the south end of a defensive breastwork termed the Tory Redoubt (Figure 3). This location saw multiple Loyalist (i.e., Tory) casualties when the American Rebels exited a ravine just downslope and caught them unaware. At least 13 Loyalists died in this segment of the battle, and others were injured. Although the exchange was brief the Loyalists were fully exposed to enfilading small arms fire, and were quickly routed.

The second area was represented by three positives, all 50–60 m in front of the so-called "Hessian" Redoubt (Figure 4). This location corresponds to where the Rebels first broke from the woods and received a salvo of small

Table 1. Summary of Results.

	Tested	Negative	Positive
Dropped buckshot	5	5 (100%)	0 (0%)
Dropped balls	3	3 (100%)	0 (0%)
Fired buckshot	22	16 (73%)	6 (27%)
Fired balls	69	69 (100%)	0 (0%)

Figure 2. Buckshot that tested positive. (Photo by Kevin Bradley, 2016.)

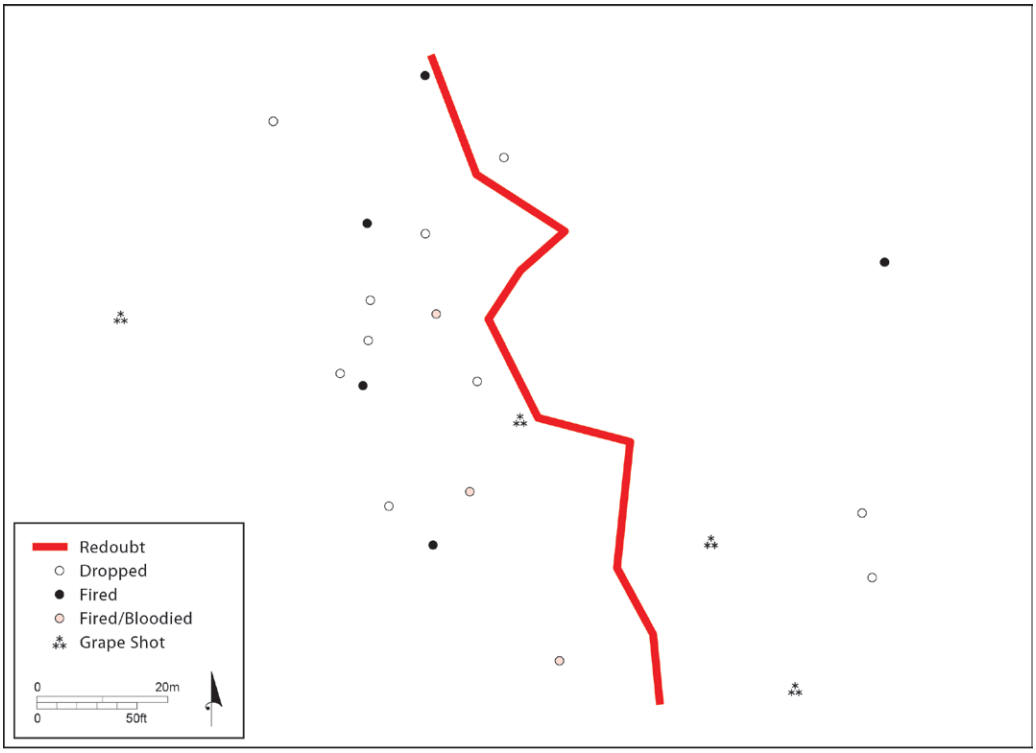

Figure 3. Positive projectiles at the Tory Redoubt. (Graphic by James Montney, 2016.)

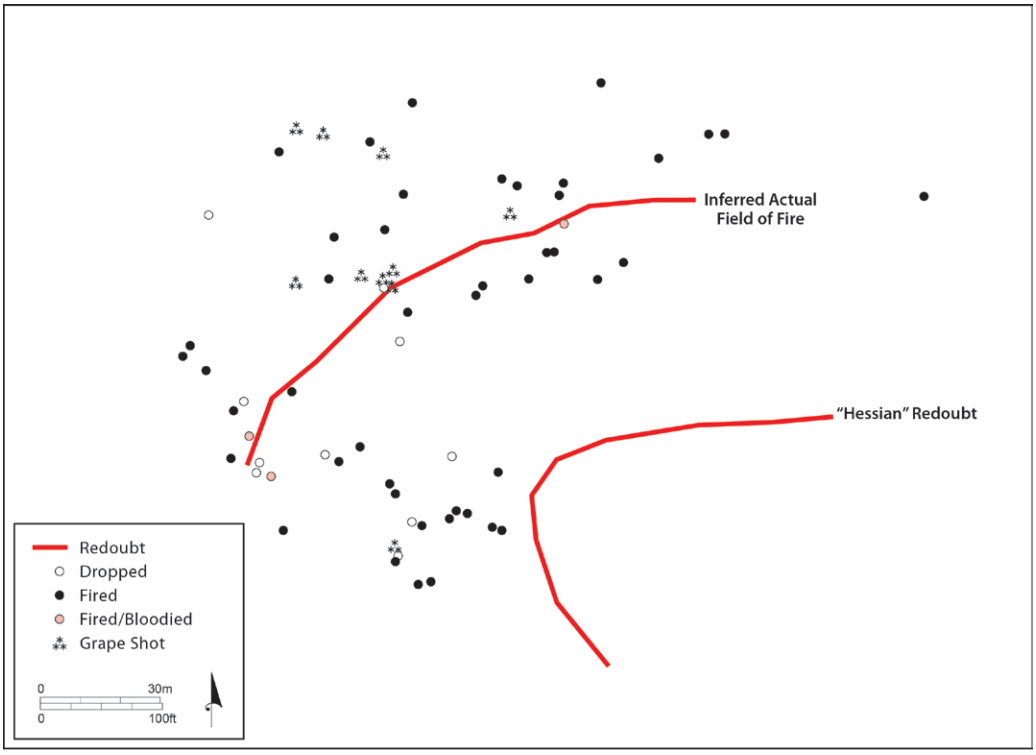

Figure 4. Positive projectiles at the "Hessian" Redoubt. (Graphic by James Montney, 2016.)

arms fire from the German troops. That salvo accounted for a large segment of the Rebel casualties at Bennington.

The spatial distributions of balls that screened positive support our reconstruction of battle events. In other words, it was presumed that evidence of the most intense conflict based on historical accounts would be present in the vicinity of the defensive breastworks. The recovery of the only projectiles that had positive reactions to Luminol testing near these two battlefield features potentially validates that presumption.

Future Research

Luminol is ideal for screening large areas or multiple samples. Despite the stated limitations, its high sensitivity to detect trace amounts of blood that have been significantly diluted due to rain and melting snow over long periods of time does indeed make this test well suited for future studies of this nature. Appropriate considerations must be taken, however, to ensure the highest possible confidence in test results.

Dropped munitions make for excellent negative controls to ensure there are no contaminants present in either the makeup of the ammunition itself or within the soil from which they were recovered that could result in erroneous interpretations. Testing of positive and negative controls must always be conducted to check for such possibilities and to ensure that the Luminol solution has been properly prepared.

Consulting the spatial data can also prove critical in determining the value that positive reactions hold in understanding a battlefield. A concentration of munitions that test positive for blood residue may inform researchers on a site of conflict, but stray balls and buckshot may also represent other activities, such as hunting. Test results should always be validated with available spatial data, such as historic maps and accounts.

Should stronger reactions be observed in future investigations, tests to determine whether the blood is of human or animal origin would be most desirable. If forensic DNA analysis could be performed and compared against a genealogical database (e.g., Daughters of the American Revolution) or against other known profiles, an important layer of further information could be obtained. Luminol testing does not preclude or disrupt future tests of this nature.

At this juncture, it is unclear how productive Luminol testing might be on items that were collected long ago, washed, and stored in museum collections. Another possible step to build on our pilot study would be to examine shot from older collections in museums. As one reviewer commented, if Luminol screening is effective on museum artifacts, it would represent a means of extracting new data from existing collections.

Luminol testing of recovered battle-related munitions could certainly add a useful layer of information to existing spatial analytical data to future research. The responsible addition of this method to a researcher's "toolbox" may allow archaeologists to address more complex battlefield questions, such as efficacy of weapons and loads.

References

Balicki, Joseph, and Christopher T. Espenshade
2010 Doug Scott Military Archaeology, Eastern Style: Status 2010. *Journal of Middle Atlantic Archaeology* 26:1–6.

Puseman, Kathryn
2007 Protein Residue Analysis of Musket Balls from the Sackets Harbor Battlefield, New York. *Paleo Research Institute Technical Report 07-16*. Golden, CO.

Schmitz. A.
1902 Uber das Hydrazid der Trimensinsaure und der Hemimellitsaure (About the Hydrazides of Trimensinic Acid and Hemimellitic Acid). Inaug. dissertation, Heidelberg [cited in Curtius, T. and Semper, A. (1913) *Ber. Btsch. Chern. Ges.* 46:1162].

Selig, Robert, Christopher T. Espenshade, Wade Catts, Elizabeth LaVigne, and James Montney
2016 *Historical and Archaeological Study of the Bennington Battlefield of the Revolutionary War*. Commonwealth Heritage Group, Inc., Jackson, MI.

Specht, Walter
1937 Die Chemiluminescenz des Hamins ein Hilfsmittel zur auffindung und erkennung Forensisch wichtiger Blutspuren (The Chemiluminscence of Proteins as an Aid in Finding and Understanding Forensically Important Traces of Blood), Angew. *Chemie* 50:155–157.

Vish, Al, and Theodore Yeshion
2004 The Use of Luminol as a Presumptive Blood Test for Prehistoric Archaeological Artifacts. *North American Archaeologist 25:2*.

Washington, George
1776 General Orders June 29. In *The George Washington Papers at the Library of Congress, 1741–1799*. Letterbook 1, image 297. The Series 3g, The Varick Transcripts. http://memory.loc.gov/ammem/gwhtml/gwhome.html.

1777 General Orders October 6. *The George Washington Papers at the Library of Congress, 1741–1799*. Letterbook 1, image 263. The Series 3g, The Varick Transcripts. http://memory.loc.gov/ammem/gwhtml/gwhome.html.

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