Spring 5-2018

# Exploring Various Techniques to Process and Identify Latent Friction Ridge Details from Fingers on Semi-Porous Surfaces

Emily Campo
*University of Southern Mississippi*

The University of Southern Mississippi

# Exploring Various Techniques to Process and Identify Latent Friction Ridge Details from Fingers on Semi-Porous Surfaces

by

Emily Campo

A Thesis
Submitted to the Honors College of
The University of Southern Mississippi
in Partial Fulfillment
of the Requirement for the Degree of
Bachelor of Science in Forensics
in the School of Criminal Justice

May 2018

Approved by

Dean Bertram, Ph.D., Thesis Adviser
Assistant Teaching Professor of Forensic Science
School of Criminal Justice

Lisa Nored, Ph.D., Director
School of Criminal Justice

Ellen Weinauer, Ph.D., Dean
Honors College

**Abstract**

Numerous terrorist groups in the Middle East have been recently making detonators for IEDs (Improvised Explosive Devices) using items as basic as flip flops. Because of the semi-porous nature of flip flops, military forensic response teams have been unable to find an effective method through which they can identify, process, and lift latent fingerprints from the surface of a flip flop. The present study aims to use three fingerprint principles to formulate a reliable method that can be used for such purposes. This study specifically investigated the potential use of powders and cyanoacrylate fuming as processing techniques. The case study method was used in this project to evaluate how a change in one variable might alter a subsequent next test, and thus hopefully achieve a better outcome than before. After testing each case, the most reliable method was found to be black magnetic powder. For future testing, further studies should use fluorescent powders, ninhydrin, and the Rough Lift gel.

Key Words: latent prints, forensics, semi-porous, IED detonators, powder, cyanoacrylate

**Dedication**

This is for my parents, my brother, Ethan, and my nanny.

Thank you for all the support.

From lending a shoulder to cry on, to listening to random fits of rambling, and most importantly the countless cups of coffee.

To the rest of the family –

thank you for keeping life light-hearted and full of laughter.

I love y'all.

## Acknowledgements

First, I would like to thank Dr. Dean Bertram for all his help and support throughout this stressful and complicated research. I would also like to thank Mr. Kelley Counts for giving me the idea for this research topic and helping me whenever he could throughout my research.

## Table of Contents

**List of Visuals and Tables**

## List of Abbreviations

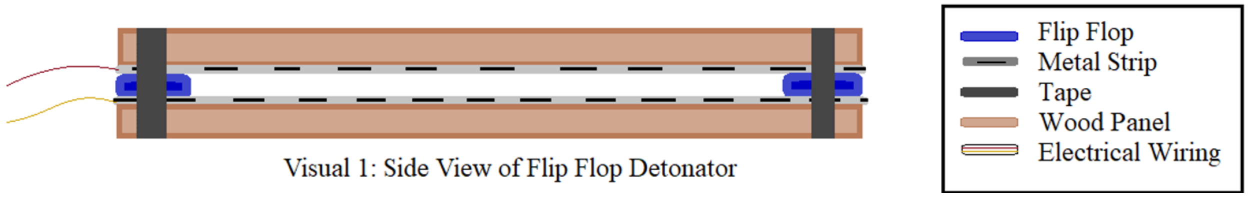
| | |
|---|---|
| IED | Improvised Explosive Device |
| AFIS | Automated Fingerprint Identification System |
| VMD | Vacuum Metal Deposition |
| ALS | Alternate Light Source |

# Chapter 1: Introduction

Fingerprints are "impressions of a fingertip on any surface; also: an ink impression of the lines upon the fingertip taken for the purpose of identification" (Merriam-Webster, 2018). Beginning in the early 20th century, fingerprints became a highly-used means of identification (Holder, Jr., Robinson, & Laub, 2012). As time passed, three major principles developed: (1) no two fingerprints are the same, as minute differences (known as minutiae) make every fingerprint individualistic; (2) fingerprints are permanent, unless surgically removed, dermal layers of the skin that continue to reproduce the same intricate design on the palm side of hands until death; (3) fingerprints are classified into three major categories which are essential to the identification process: loops, arches, and whorls (Saferstein, 1995). This thesis aims to apply these principles, along with latent processing techniques, to process and, with any luck, lift fingerprints off semi-porous surfaces (specifically flip flops).

Middle Eastern terrorist groups are currently manufacturing bombs (often using homemade pressure-plate detonators) for placement on roads frequented by U.S. troops travelling between barracks and villages. The following prototype (see Visual 1) illustrates the electrical circuit which allows an IED to detonate. Essentially, application of pressure to the top piece of wood causes the metal strip to bow, which in turn allows the top and bottom metal strips to come together. Forensic analysts have concluded that the only piece of the bomb that withstands the explosion is the flip flop, but they presently are unable to process that remnant for prints due to the absence of effective processing techniques.

Visual 1: Side View of Flip Flop Detonator




This research is primarily concerned with whether a modification to a current technique can create a new method to process fingerprints from bomb remnants. The research questions for this thesis are as follows:

- Is latent friction ridge detail detectable on semi-porous surfaces? If YES,
- What process(es) can be used to yield the best results for identification purposes?

The hypotheses for these research questions are as follows:

- It is possible to detect friction ridge detail on a semi-porous surface.
- The best results will be a proportional variation of magnetic black powder and fluorescent powder after being treated by cyanoacrylate fuming.

The hypotheses for these research questions were influenced by the knowledge of Mr. Kelley Counts, an expert fingerprint examiner, who provided the information about the research topic, and contributed insight into some of the techniques used during research.

## Chapter 2: Literature Review

There are three major categories of fingerprint impressions: latent, patent, and plastic (Saferstein, 1995). Latent print impressions are comprised of sweat and oils leaving them undetectable to the naked eye. Patent print impressions are visible to the naked eye, and common forms include prints made in ink, paint, and blood. The third major category of fingerprint impressions is plastic prints. Plastic prints, like patent prints, are visible to the naked eye. Plastic prints impressions are created when the print is pressed into a pliable substrate. This produces a three-dimensional mold of the print. Common surfaces that generate quality plastic prints include clay, soft wax, and heavy grease (Holder, Jr., Robinson, & Laub, 2012). For purposes of this research, the only category observed will be latent print impressions. For this reason, some reagent (such as a powder, ninhydrin, or cyanoacrylate) will be required to detect and perchance lift these impressions.

When processing latent fingerprint impressions, numerous variables must be considered to achieve the best results. If the wrong technique is chosen, the print could be destroyed – resulting in the loss of key evidence. One variable of importance is whether a technique is permanent (e.g., cyanoacrylate fuming; dye staining) or semi-permanent (e.g., ninhydrin; powder techniques) (Saferstein, 1995). Permanence is desired so that the lifespan of the evidence will undoubtedly outlast that of the trial process – evidence that is degraded is not easily accepted in trial by both judges and juries. Although photography is used as an alternative to permanence, defense attorneys question its authenticity on the basis that photographs can be easily altered and enhanced. A second important variable revolves around which of three types of surfaces a latent print is impressed upon; (1) porous (such as sponges or paper), (2) semi-porous (such as stones), and (3) nonporous (such as countertops or glass). The type of surface the latent print is found on determines the processing technique used on that print. For instance, trying to use ninhydrin on a piece of glass (a nonporous surface) will yield no results because the chemicals produced by the process cannot permeate the surface. Only semi-porous items will be examined in this study.

**Ninhydrin**

If an evidentiary item reaches a fingerprint laboratory in an acceptable package, then virtually every processing technique is available for use. Not all pieces of evidence, however, can be removed from a crime scene. Certain techniques (such as cyanoacrylate fuming and ninhydrin) are not readily available to forensic specialists and certified fingerprint examiners while in the field, and therefore it is crucial for the examiner or specialist to immediately decide which technique will yield the best results.

In 1910, Ruhemann first referenced the ninhydrin solution – a chemical and physical process that, along with heat, makes latent prints visible on a porous surface. The ninhydrin solution is first applied to the surface containing latent prints (Crown, 1969). Once the solution has dried, it is then exposed to a heat source in order to accelerate the transition of the prints to a visible, pink-purple coloration. Unfortunately, there are problems associated with using this method. "Prints developed with ninhydrin are not permanent. Fading will start to occur as soon as one month after optimum development" (p. 264). As such, the temporary nature of ninhydrin lends itself for best use in combination with other techniques (such as iodine fuming) to create a more permanent result.

Using these guidelines, Davis and Fisher (2015) used ninhydrin to reveal latent fingerprints from porous surfaces – specifically brick, limestone, and sandstone. Each stone was covered in a ninhydrin solution consisting of "25 g of ninhydrin dissolved in absolute ethanol, ethyl acetate, and acetic acid and then further diluted with HFE7100 [a solution that replaces ozone-depleting substances, and is used to create crisp ridge detail]" (p. 98). The authors used a pipette to distribute the solution across the entire surface of each stone, and then placed the stones in an oven – set to 80° C – to dry completely. After 15 minutes, the stones were examined under both white and fluorescent light. Their ninhydrin findings produced scaling across four grades (0 = lowest to 4 = highest). The authors concluded that ninhydrin was an insufficient technique for use on porous stones. From 33 individual samples of each stone (99 samples total), 92 samples were graded zero after testing (31 bricks, 29 limestone, and 32 sandstone).

Hefetz, Pertsev, and Bar-sheshet (2015) also tested ninhydrin as a technique to uncover latent fingerprints from stones, and claimed that "ninhydrin for porous stones yield[ed] fingerprints of good evidentiary value" (p. 214). Unlike Davis and Fisher (2015), Hefetz and colleagues found that stones processed by ninhydrin did yield reliable results. While the print was not complete, a certified fingerprint examiner was able to identify 12 individual minutiae points from the partial print, which was sufficient to conclude a match using the Automatic Fingerprint Identification System (AFIS).

**Powders**

Powders (with numerous subcategories and varying methods) represent one of the broadest techniques used to process latent fingerprints. Fluorescent powder is one subcategory that comes in both magnetic and nonmagnetic forms, as well as different particle sizes. There also are assorted colors (or pigments) of powders for use on countless surfaces. Black powder (both magnetic and nonmagnetic) is the most used powder in crime scene kits (Gurbuz, Monkul, Ipeksac, Seden, & Erol, 2015). As with any technique, however, problems still occur. One problem is that while a finer particle powder shows more minute ridge detail (the smaller particles adhere to the sweat and oils present in the latent print easier because they are lighter in weight than normal powder particles), it also can create more noise (powder around the print that makes it difficult to see friction ridges and minutiae).

When researching the particle size of magnetic powder, Gurbuz and colleagues (2015) came across the problem of excess noise around the latent print. To address this problem, they began by milling different powders (using a ball mill and multiple sieves) to sift out larger particles. Once the powders were refined, one donor left fingerprints on multiple surfaces which included four porous (raw wood, bare filter paper, Whatman black filter paper, $A_4$ copier paper) and two non-porous (smooth porcelain dish and glass microscopic slide). The researchers discovered that finer particles did not reveal more detail than coarser particles after processing the porous surfaces. They concluded that the small nature of the particles and porous nature of the surface caused the powder to clump, thus disfiguring the print beyond the point of identification.

Weston-Ford et al. (2016) conducted a study which used black powder on porous objects (specifically elephant ivory) to test whether degraded fingerprints on the ivory could be retrieved. Along with powders "these authors [also] evaluated a number of widely used development techniques, including…cyanoacrylate fuming (using along with it a range of dyes), and vacuum metal deposition (VMD)" (p. 1). The purpose of their research was to determine if latent prints could be lifted from poached ivory. Using different techniques, they sought to determine whether placement and distribution of prints affected development, and how long latent prints were distinguishable. Black powder was found to work best. The longest amount of time that the latent fingerprints remained before processing was 7 days. Processed prints lasted up to 28 days, but by then there was no remaining evidence of ridge detail.

Researchers (Bihor & Anghel, 2013) have experimented with a refined phosphorescent powder that requires no fluorescent wavelengths produced by an alternate light source (ALS). This phosphorescent powder is premised on the idea of photoluminescence, which is “the quality of a substance to produce an emission of light by illuminating in advance the emitting substance or by irradiating it with ultraviolet or X-ray” (p. 1428). Essentially, phosphorescent powder is comparable to solar panels in that emitted light is harnessed and subsequently “charged” by the excitement of electrons through the absorbance of light energy. When the light source is turned off, the particles then continue to glow. The authors used five different nonporous surfaces to see how the two powders performed on an aluminum can, compact disc, candy bar wrapper, plastic credit card, and a magazine. Each item had multiple prints on it, and each was dusted with different powders. The processed prints were then examined under both white and ultraviolet light to assess the detailing of each print. While some surfaces worked well with fluorescent powder, others had more visible detail with phosphorescent powder. After testing and processing all the latent fingerprints, the researchers concluded that “in some situations, using certain powders can be more indicated and the results more satisfactory” (p. 1431).

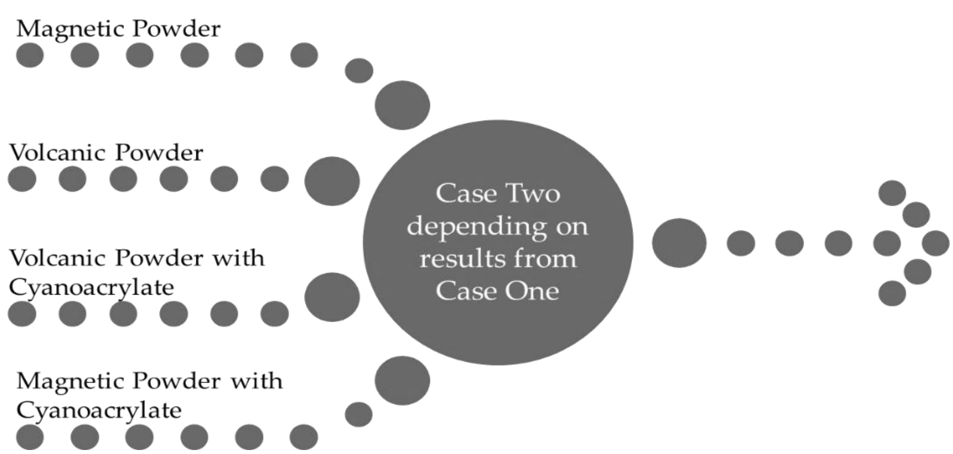
### Summary of Literature Review

Given that ninhydrin was only partly successful in the aforementioned studies, it will not be used as a technique in this project. Ultra-fine powders also will be excluded because the surfaces to be tested are semi-porous (foam flip flops). Black powders (both magnetic and volcanic), fluorescent powders, and cyanoacrylate fuming will be used when necessary.

## Chapter 3: Methodology

The first step in this study was to acquire the needed research materials, including various types of powder [black and fluorescent; in both volcanic (refined synthetic volcanic ash) and magnetic form (larger magnetized particles)], a semi-porous surface (flip flops), cyanoacrylate, aluminum dishes, powder brushes, alternate light source (ALS), cyanoacrylate fuming chamber, heating plate, and digital camera for documentation. This case study – defined as an intensive analysis of an individual unit stressing developmental factors in relation to an environment – aims to ensure proper documentation of the results (Merriam-Webster, 2018). Each case tested experimental materials in different proportions until the best visibility ratio – ratio between powders and other techniques used that yield the best results to the naked eye – could be determined for the friction ridge markings. The first case studies merely established a standard for the cases to be subsequently tested. An example of the case study structure can be seen in Visual 2 below.

Visual 2: Flow Chart of Case Study Structure



The standard tests included one case using only volcanic powder, one case using only magnetic powder, one case using cyanoacrylate and volcanic powder, and a final case using cyanoacrylate and magnetic powder. The direction for the remaining cases was determined based on the results from these four preliminary cases. In a general sense, the current case study was compared to the previous case study where the goal was to identify the technique that yielded better results from the two.

**Powdering Methodology**

Even though there are countless variations of powders created to process latent prints, they all operate under the same general basis. Latent prints deposit oils and sweat in the intricate design of the friction ridges from the fingerprint that created them. The powder brushed across the latent print adheres to the sweat and oils, thus making the intricate design visible to the naked eye. The following was the methodology for processing latent prints when using various powders. The first step was to gather all of the necessary materials which included the flip flop fragment (roughly 2 square inches in size), powders, brushes/wands, paper towels, a digital camera, and safety gloves and goggles. After all the supplies were in the work area, pre-cut flip flop fragment was taken, and a single fingerprint was placed on each square side of the flip flop. Next, a paper towel was placed on the work bench to act as a protective barrier between the powder and the work bench surface. Then, while wearing protective gloves, the powder jar was carefully opened and placed on the paper towel along with the powder jar cap. The flip flop fragment was then placed on the same paper towel. The powder brush (for volcanic powders) or the powder wand (for magnetic powder) was placed inside the jar to collect some of the powders particles onto the application side of the brush; excess powder was removed from the brush or wand by gently tapping the brush or wand over the powder jar. With the flip flop fragment on the paper towel, the brush or wand was rotated in a back and forth motion between the fingers of the researcher while also rotating the entire brush or wand in a clockwise movement over the flip flop fragment – this left a lightly dusted surface while keeping the ridge detail of the fingerprint. If there were any fluorescent powders used, the same methodology was used with the fluorescent powder as well as an ALS to enhance the visualization of the processed print. Once all processing was complete, the digital camera was used to document the case study results.

**Cyanoacrylate Methodology**

Cyanoacrylate, also known as super glue, is used as a permanent form of latent print processing. As previously stated, latent prints are composed of sweat and oils left behind by the friction ridges of fingertips. Cyanoacrylate, when it is heated and transformed into is gaseous state, adheres to the sweat and oils in the intricate pattern of the friction ridges on any particular nonporous surface. The following steps were taken when cyanoacrylate was used during this research. First all materials were acquired including flip flop fragments, a cyanoacrylate fuming chamber, hanging clips, cyanoacrylate, aluminum dishes, a heating plate, a digital camera for documentation, and safety gloves and goggles. Once all of the supplies were gathered, a small, pre-cut flip flop fragment (roughly 2 square inches in size) was taken, and a single fingerprint was placed on both square sides of the flip flop. By using a hanging clip, the flip flop fragment was then placed inside of the fuming chamber and hung from the fuming rack. Next, the heating plate was placed inside of the fuming chamber, and the temperature dial was turned on and to the “HIGH” setting. Once the heating plate had reached the desired temperature, the aluminum dish was prepared by placing a quarter sized amount of cyanoacrylate into the dish. The dish was then placed on the heating plate inside of the fuming chamber. Before the door was closed, a control print was placed in the top right corner of the viewing window of the fuming chamber. The door was then closed completely to hinder the fumes from escaping. After a span of 15 minutes (or until the control print was completely developed), the heating plate was unplugged, and the chamber vent was turned on for 5-10 minutes to expel the fumes from the chamber before opening the chamber door. Once the chamber was cleared of any fumes, the flip flop fragments were removed from the chamber, and dusted with powder (which type of powder depended on the particular case study that was being conducted). The powdering technique used was the same technique used in the previous methodology section. Once the processing techniques were completed, the digital camera was used to document the results of the case study.

**Rough Lift Methodology**

Rough Lift is a fairly new technology in the fingerprint examining community. Essentially, it is a rubberized substrate. When applied, it fills all cracks, crevices, and corners which makes the lifting portion of processing latent prints much easier. When Rough Lift was used, the materials gathered included, the flip flop fragment (roughly 2 square inches), powders, brushes/wands, paper towels, digital cameras, safety gloves and goggles, and the Rough Lift gel. Because the Rough Lift was only used in addition to powdered prints, the same steps listed in the powdering methodology section are also used here. Once the flip flop fragment was powdered, the Rough Lift gel was, and applied to the top square of the fragment – because the Rough Lift was applied in liquid form, only one side of the fragment could be processed at a time. The Rough Lift was spread to cover the entire square so that all of the print was covered. Once the entire surface was covered, the fragment was left to dry at the work station – there was no specific amount of time needed because it depended on the thickness of the Rough Lift layer applied to the flip flop fragment.

### Documentation Methodology

The case studies were processed, documented, and evaluated by comparing results of the current case with those of previous case studies. Each case consisted of two flip flop fragments containing two prints – one on each side of the flip flop. Prints were scaled (using a system created for this study as seen in Table 1) to grade for probable identification. Each case was photographed and maintained until research concluded.

## Chapter 4: Results

Through exploration of several methods, it was determined that black magnetic powder provided the greatest detail on the semi-porous surface. Conversely, cyanoacrylate fuming had no effect on the semi-porous surface because there was an insufficient amount of cyanoacrylate particles to cover the surface and an excessive amount of porous surface area within the material. It is possible positive results could have been reached if more cyanoacrylate was used, however, it would have been unrealistic because the materials used for cyanoacrylate fuming are too costly for the average fingerprint lab to use an entire bottle of cyanoacrylate on one fingerprint. The print could also have been damaged from the extreme amount of heat exposure during the fuming process. The Rough Lift gel – in addition to the previously powdered surface – was difficult to apply, and therefore difficult to lift from the 1 square inch experimental surface. If given more time to conduct research, the right window of opportunity for the gel to dry completely without adhering to the semi-porous surface could be found.

Table 1 defines the scale used to rate the amount of visual detail after processing latent prints on each semi-porous surface. Table 2 outlines the case number and process for each study, as well as their respective result, description, and rating. In total, 32 latent prints were processed – two flip flop fragments for each case study with 2 prints on each fragment. The Rough Lift case studies was conducted twice (16 prints in total) to make a second attempt at lifting the print from the flip flop's surface. When comparing the original case studies (1-4), black magnetic powder without cyanoacrylate yielded the best results. The back of the flip flop (ridged side) was assigned a rating of three because minutiae were (1) visible to the naked eye and (2) visibly magnified using a camera. The front of the flip flop, however, was assigned a rating of two because there was more noise visible (i.e., the surface was smoother, and thus held more powder than the ridged side). The volcanic powder used in Case 2 still showed some ridge detail, but both sides were smudged due to the powder's particle size. Cases 3 and 4 were both unsuccessful because the cyanoacrylate filled the flip flop like a sponge, and thus would not remain on the surface of the flip flop. In Cases 5 and 6, the Rough Lift gel was used. Because the Rough Lift gel was clear, the powder could still be seen through the Rough Lift after it dried. Even though the Rough Lift material could not be removed from the flip flop surface, powdered ridges were still visible. The Rough Lift acted as a protective barrier, preserving the print from any sort of damage throughout the research process.

Table 1: Visibility Rating Scale

| Visibility Rating Scale | |
|---|---|
| No Detail (Nothing) | 0 |
| Slight Detail (Faint/Smudged) | 1 |
| Good Detail (Ridges) | 2 |
| Great Detail (Minutiae) | 3 |
| Best Detail (Pores) | 4 |

Table 2: Case Number, Process, and Description (Rating)

| Case Number | Process | Rating |
|---|---|---|
| 1 | Black Magnetic Powder | Front → some detail visible (2) |
| | | Back → good detail visible (3) |
| 2 | Black Volcanic Powder | Front → some detail visible (2) |
| | | Back → no details detected (0) |
| 3 | Black Magnetic with Superglue | Front → not details detected (0) |
| | | Back → not details detected (0) |
| 4 | Black Volcanic with Superglue | Front → not details detected (0) |
| | | Back → not details detected (0) |
| 5 | Black Magnetic with Rough Lift | Front → Before: some detail visible (2) After: could not lift (0) |
| | | Back → Before: some detail visible (2) After: could not lift (0) |
| 6 | Black Volcanic with Rough Lift | Front → Before: slight detail visible (1) After: could not lift (0) |
| | | Back → Before: some detail visible (2) After: could not lift (0) |

## Chapter 5: Conclusion

Hypotheses for this study were both supported and refuted. First, it was shown that latent friction ridges indeed were detectable on semi-porous surfaces when using both magnetic and volcanic powders – though magnetic powder did produce more ridge detail. The second hypothesis which stated that the best results would be a proportional variation of magnetic black powder and fluorescent powder after being treated by cyanoacrylate fuming was not supported, as cyanoacrylate proved to be an ineffective means to process latent prints because it required too much fuming when applied to a semi-porous surface. Although the Rough Lift product was not known at the outset of this study and thus not originally included in the experiments until its usefulness was shared by a peer, it proved to be a valuable alternative. While prints on the semi-porous surface were unable to be lifted, the powdered prints were not damaged by the Rough Lift – and were still visible through it. The appropriate window of time to allow the Rough Lift to dry, but not adhere to the semi-porous surface can be found given an extension for research. Over time, it is believed that the preliminary groundwork established by this research will assist in identifying a more reliable method by offering a starting point to future researchers and giving them examples of processes that did not work as well as others.

## Works Cited


Bihor, J., & Anghel, G. M. (2013, October). Fluorescent powder vs. phosphorescent powder. *Romanian Journal of Forensic Science, 14*(89), 1428-1431.

Crown, D. A. (1969). The Development of Latent Fingerprints with Ninhydrin. *Journal of Criminal Law and Criminology, 60*(2), 258-264.

Davis, L., & Fisher, R. (2015). Fingermark Recovery from Riot Debris: Bricks and Stones. *Science and Justice*(55), 97-102.

Gurbuz, S., Monkul, B. O., Ipeksac, T., Seden, M. G., & Erol, M. (2015). A systematic study to understand the effects of particle size distribution of magnetic fingerprint powders on surfaces with various porosities. *Journal of Forensic Sciences, 60*(3), 727-736.

Hefetz, I., Pertsev, R., & Bar-sheshet, E. (2015). Development of latent fingerprints from stones: field work provides identifications. *Journal of Forensic Identification, 3*(65), 214-218.

Holder, Jr., E. H., Robinson, L. O., & Laub, J. H. (2012). *The Fingerprint Sourcebook.* Washington: U.S. Department od Justice Office of Justice Programs.

Merriam-Webster. (2018, April 8). Retrieved from Dictionary by Merriam-Webster: America's most-trusted Online Dictionary: https://www.merriam-webster.com/dictionary/fingerprint

Saferstein, R. (1995). *Criminalistics: An Introduction to Forensics Science.* Englewood Cliffs: Prentice-Hall, Inc.

Weston-Ford, K. A., Moseley, M. L., Hall, L. J., Marsh, N. P., Morgan, R. M., & Barron, L. P. (2016). The retrieval of fingerprint friction ridge detail from elephant ivory using reduced-scale magnetic and non-magnetic powdering materials. *Science and Justice*(56), 1-8.