Technical Note

Comparative Effectiveness of Black and Magnetic Powders in Single and Sequential Latent Fingerprint Development

Christine Loewenhagen

Crime Scene Unit, Mesa Police Department

Abstract: This study enumerates the variables affecting latent fingerprint development with black and magnetic powders. Through systematic testing with fingerprints from 50 participants on a glass surface, the research examined four processing sequences: black powder only, magnetic powder only, and two sequential (aka: "Double Processing") combinations. Magnetic powder consistently demonstrated improved detail and contrast when compared to traditional black powder processing. Sequential processing proved most effective when applying black powder followed by magnetic powder, showing significant improvement in print visibility. However, the reverse sequence (magnetic followed by black powder) resulted in considerable print degradation and potential loss of evidence. The findings suggest that while magnetic powder is the better single-method choice, strategic sequential processing can enhance fingerprint development success rates. These results highlight the complex interplay of variables in fingerprint development and underscore the importance of continued research in optimizing processing techniques. This research addresses an important gap in determining optimal processing for latent fingerprints at crime scenes.

Introduction

The field of crime scene investigation has undergone significant transformation over the past two decades, driven by technological advancements, deeper insights into forensic processes, and the dynamic nature of criminal behavior. Techniques once considered reliable have been reevaluated, with new research challenging long-standing methodologies. Latent fingerprint development has evolved from a seemingly straightforward physical process to one influenced by numerous subtle variables.

Among the traditional tools used in latent print development are black powder and magnetic (magna) powder. Standard operating procedures have typically dictated the choice of powder based on surface characteristics: black powder for non-porous surfaces such as glass, mirrors, and vehicle exteriors; and magnetic powder for textured or porous surfaces such as painted materials, plastics, and cardboard. While this approach has often produced successful results, personal field observations have revealed inconsistencies and limitations in practice.

One notable example involved the processing of a glass window at a residential burglary scene located high upon the building. A clearly visible palm print was on the glass window but due to the location, photography of the print was impossible, though it would have been the most desirable and ideal method of documentation. Additionally, the print failed to develop using black powder but yielded a high-contrast, well-defined print when magnetic powder was applied. This raised important questions about the underlying factors influencing powder adherence, especially given that the process is primarily physical—relying on the interaction between powder particles and fingerprint residue—rather than chemical, as in cyanoacrylate fuming [1–5].

Subsequent personal field applications explored the concept of sequential powdering, referred to here as “Double Processing.” This technique involves the initial application of one powder followed by a second, prior to lifting the print. In many instances, this approach enhanced the visibility and contrast of latent fingerprints. However, it also introduced potential risks, such as the unintentional removal of previously developed prints. As a result, cautious testing on non-critical or smudged areas was employed to assess whether the secondary powder would improve or obscure the development. In real world application, however, it is strongly recommended that any developed latent prints be photographed prior to the next sequential step to ensure all detail is captured in the event the next step ends up removing information.

Further examination of surfaces with multiple contributors—such as commercial door handles or frequently accessed vehicle panels—revealed another significant finding. When surfaces were first processed with black powder and subsequently with magnetic powder or vice versa, new latent fingerprints often appeared with the secondary powder that were not initially developed. This phenomenon suggested that certain residues or donors may respond exclusively to one type of powder, and that reliance on a single technique may result in missed evidence.

These observations prompted a deeper investigation into the latent fingerprint development process, with a focus on the interactions between fingerprint residue, developing agents, and surfaces. Despite the method's historical roots in 19th-century forensic science, it remains clear that the physical principles governing powder-based development are influenced by a complex set of variables. Understanding these variables is essential for optimizing development techniques and ensuring the highest possible fidelity in latent fingerprint recovery.

This next section will cover a comprehensive illustration of variables that can affect the latent fingerprint developmental process with regards to simple latent fingerprint powders.

1. Composition of Fingerprint Residue

Latent fingerprints are composed of natural secretions from eccrine and sebaceous glands, as well as contaminants from the environment. These residues include:

- Eccrine Secretions: Comprising of water, salts (e.g., sodium chloride), and small organic molecules such as amino acids and urea. These are "sweaty" impressions derived from hands, fingers, and feet [1-5].
- Sebaceous Secretions: Primarily lipids, including fatty acids, squalene, and wax esters. These are "greasy" impressions not found on friction ridge surfaces of the hands and feet. However, sebum can transfer to the hands through contact with other body areas, such as the face, arms or scalp [1-5].
- Apocrine Secretions: Containing proteins, carbohydrates, lipids and various organic compounds, apocrine secretions are produced in areas such as the underarms and groin region. While not secreted directly from the friction ridge skin of the hands and feet, they can still contribute to latent fingerprint composition through transfer. [2, 5]
- Skin Cells: Latent prints can also contain shed skin cells from the outer layer of the epidermis. These cells may contain trace amounts of eccrine, sebaceous, or apocrine materials.
- Environmental Contaminants: Dust, cosmetics (e.g. hair, skin and facial products), food/beverage residues, tobacco residues, and other external substances that may alter the chemical profile of a fingerprint [1-5].

The variability in residue composition is influenced by factors such as diet, age, activity levels, and the donor's recent physical activities (e.g., touching oily or dry surfaces). Even health affected by diseases or medications can have a dramatic influence on residue variability [5]. These variations can affect how residues interact with fingerprint powders and other developing agents.

2. Nature of the Surface

The surface on which a fingerprint is deposited plays a critical role in development outcomes. Key considerations include:

- Porosity: Non-porous surfaces (e.g., glass, metal) retain fingerprints on the surface, while porous surfaces (e.g., paper, wood) absorb residues, making development more challenging [4].
- Texture: Smooth surfaces allow for clearer ridge detail, whereas textured or grooved surfaces may fragment prints [4].
- Cleanliness of Surface: If a layer of contaminants such as blood or dust is present, contaminant material may transfer from the surface to the ridged skin [4].
- Chemical Reaction to Surface: In some instances, inorganic salts present in eccrine sweat, especially sodium chloride, can undergo redox corrosion with certain metals, leading to the formation of lasting etched impressions of the fingerprint pattern on the surface [4]. Beyond these metal interactions, fingerprint residue may also react with environmental substances such as cleaning agents, acidic or basic compounds, or oily contaminants.

3. Environmental Conditions

Latent fingerprints degrade over time due to environmental exposure. Key factors include:

- Humidity: Moisture levels can enhance or degrade the visibility of prints, depending on the substrate and residue composition [4, 5].
- Temperature: High temperatures accelerate the degradation of unsaturated lipids (e.g., squalene) and amino acids, reducing development success [2, 4-5].
- Light Exposure: UV light and oxidation processes degrade fingerprint residues, particularly lipids [2, 4-5].

4. Effect of Time on Latent Fingerprint Development

The amount of time that has passed since a fingerprint was deposited can significantly impact how well it develops.

- Degradation of Eccrine Residues: Water-soluble components, such as amino acids and salts from eccrine sweat, break down quickly, especially in warm or dry conditions, reducing powder adhesion [2, 4-5].
- Persistence of Sebaceous Residues: Lipids and fatty acids remain longer than eccrine residues, but oxidation and environmental contamination can alter their composition over time [2, 4-5].

5. Properties of Fingerprint Powders

Fingerprint powders are formulated to adhere selectively to fingerprint residues without overpainting the substrate. Important variables include:

- Particle Size and Morphology: Fingerprint powders are manufactured to either be spherical or flake shaped. The size of these particles can vary greatly depending on the manufacturer. The shape and size can affect the efficiency with which the particles adhere to the fingerprint residues [6-8].
- Composition: Fingerprint powder manufacturers use proprietary formulations, each with a unique blend of ingredients designed to optimize adhesion and contrast on various surfaces. Resultant of this, carbon-based powders, magnetic powders, and fluorescent powders have varying affinities for residue types (e.g., lipids or moisture) which can affect performance [6, 8].
- Binders and Enhancers: Fingerprint powder manufacturers incorporate different binders and enhancers, such as lycopodium, iron powder and starch, in their formulations. These ingredients can influence the powder’s adhesion, sensitivity, and overall performance on various surfaces [8].

- Contaminants: Though unintended, some fingerprint powders can become contaminated during the manufacturing process and contain ingredients not listed on the Safety Data Sheets, potentially impacting the powder's performance and effectiveness [8].

An in-depth analysis according to Moreno, Brown, Klein, Wang, Markiewicz, Alemán, Rushton and Quiñones regarding all of these properties (for black powder only) indicated that "powders with high carbon content, spherical morphology, and uniform particles sizes in the 50nm range lead to a superior quality of latent prints." When compared to six major forensic manufacturers, Lightning and Lynn Peavey had superior performance, followed by Sirchie coming in third [8].

6.Properties of Fingerprint Brushes

The powder selected can determine which type of fingerprint powder brush is used. Things to consider:

- Magnetic Powder Brushes: Magnetic powders must rely on a good magnetic brush that can create a sufficiently sized "powder ball" for processing. The operator must be proficient in its use to ensure that only the "powder ball" touches the delicate latent and not the hard magnet to prevent damaging the ridges through physical contact [7].
- Synthetic Powder Brush: These brushes typically consist of fine, straight fibers and are made from fiberglass, polyester or nylon [9]. Fiberglass brushes can be less ridged than nylon brushes.
- Feather Powder Brushes: These brushes have jagged barbs towards the tips but can create a softer, more delicate application [9].
- Natural Hair Powder Brushes: Depending on the type of hair used (squirrel being the most popular), these brushes may have varying degrees of porosity, affecting their ability to retain and release powder [9].

7. Operator Skill and Technique

The expertise of the forensic examiner plays a vital role in determining developmental outcomes. Factors include:

- Consistency in powder application: Black powder brushes have fibers that can get entangled over time depending on the vigorousness of processing and the method (twirling versus brushing/painting) of processing. If a brush is used too vigorously, or used in a twirling method, fibers can be more prone to tangling, thus potentially affecting its ability to process as effectively [9].
- Avoidance of over-powdering prints: When applying powders to a latent fingerprint, it is important to apply light, controlled motions to avoid obscuring ridge detail. Application must be regularly assessed as development progresses, stopping once the print is sufficiently visible. Regarding magnetic powder, it can be possible to over saturate fingerprint ridges immediately upon first application. However, a forensic examiner can carefully remove excess powder by using a black powder brush with light, controlled strokes to strip away excess material while preserving ridge detail.

Apart from challenges in latent fingerprint processing, difficulties also arise during the lifting and preservation process. The forensic examiner must carefully apply lifting tape to avoid bubbles and creases that could distort or damage the print. In the same manner, the tape must then be smoothly transferred onto a latent lift card to maintain clarity. Alternatively, developed fingerprints can be photographed as a preservation method, ensuring the integrity of ridge detail, of which can present its own set of challenges.

Materials and Methods

To explore the variables influencing latent fingerprint development, a study was conducted with fifty participants. The age range of the participants were between twenty-one and fifty-six years old, with twenty-eight being female and twenty-two being male. Participants gave their informed consent, and all samples and participant information were anonymized and identified using an alphanumeric code.

A clean glass pane was segmented into four quadrants, and each participant pressed simultaneously their uncharged index, middle, ring and pinky fingers in each of the quadrants: left hand on the upper left quadrant, right hand on the upper right quadrant, left hand on the lower left quadrant and right hand on the lower right quadrant. Residues were visually confirmed to be present in each quadrant after collection, and the glass pane was stored at room temperature in a secure office workspace.

Within six to eight hours after deposition, the samples were processed. For this study I used the following brushes and powders:

- Lightning Powder Zephyr Fiberglass Fingerprint Brush
- Arrowhead Forensics Zenith Magnetic Applicator
- Arrowhead Black Latent Print Powder
- Sirchie M114L Magnetic Latent Print Powder, Regular Black

Regarding the application technique, I utilized a twirling motion for the fiberglass brush. For the magnetic applicator however, I utilized a painting motion instead.

The quadrants were processed as follows:

1. Black Powder Only: One quadrant was processed using traditional black fingerprint powder.
2. Magnetic Powder Only: A second quadrant was processed using magnetic fingerprint powder.
3. Magnetic Powder Followed by Black Powder: A third quadrant was first processed with magnetic powder and then re-processed with black powder.
4. Black Powder Followed by Magnetic Powder: The final quadrant was initially processed with black powder and subsequently re-processed with magnetic powder.

Each quadrant was photographed using a Canon 90D camera mounted on a copy stand. Latent prints were initially evaluated in-situ and subsequently re-evaluated using the digital images. The digital format permitted closer examination of the latent detail to confirm that the in-situ observations corresponded with the photographic record. The outcomes were categorized based on the development quality average of all four fingerprints:

- Black Powder Only: high contrast (Figure 1), low contrast (Figure 2), or no development
- Magnetic Powder Only: high contrast (Figure 3), low contrast (Figure 4), or no development
- Black Powder Followed by Magnetic Powder: Initial processing indicating high contrast, low contrast or no development with secondary processing indicating high contrast, low contrast, no development or erasure of previously developed latent (Figures 5-8)
- Magnetic Powder Followed by Black Powder: Initial processing indicating high contrast, low contrast or no development with secondary processing indicating high contrast, low contrast, no development or erasure of previously developed latent (Figures 9-11)

Note: The grader used subjective judgement of high contrast, low contrast, no development or erasure. This is a limiting factor in this research.

Figure 1

Example of latent fingerprints processed only with black powder with high contrast

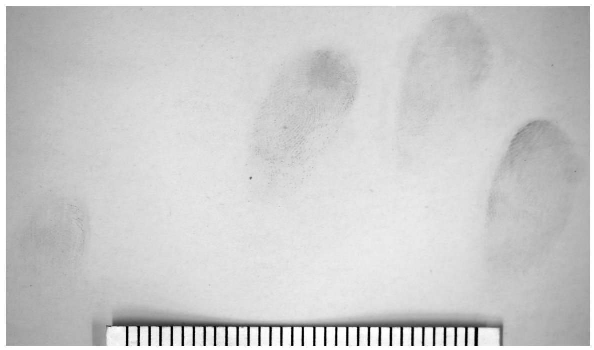

Figure 2

Example of latent fingerprints processed only with black powder with low contrast

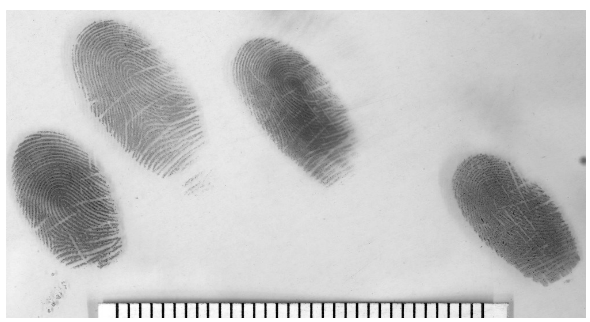

Figure 3

Example of latent fingerprints processed only with magnetic powder with high contrast

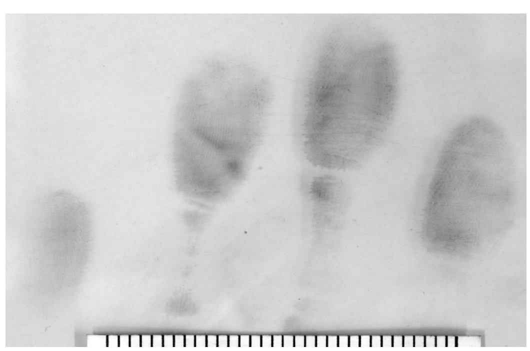

Figure 4

Example of latent fingerprints processed only with magnetic powder with low contrast

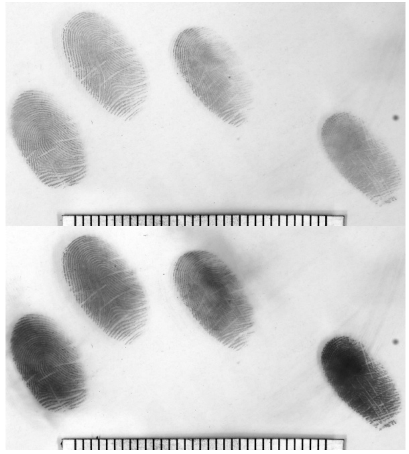

Figure 5

Example of latent fingerprints processed first with black powder with high contrast then with magnetic powder with high contrast

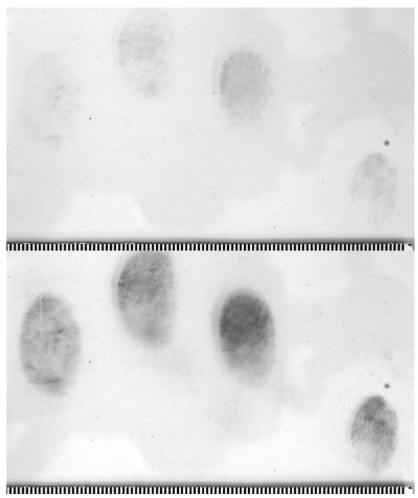

Figure 6

Example of latent fingerprints processed first with black powder with low contrast then with magnetic powder with high contrast

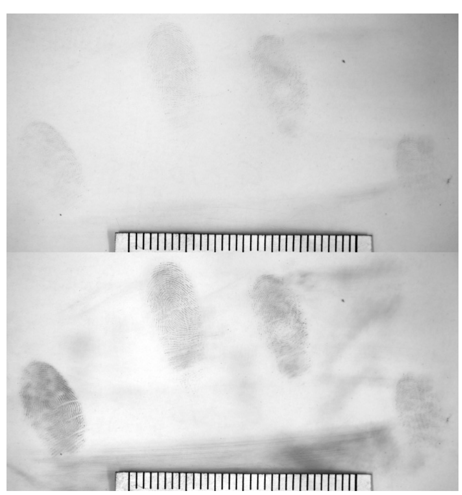

Figure 7

Example of latent fingerprints processed first with black powder with low contrast then with magnetic powder with low contrast

Figure 8

Example of latent fingerprints processed first with black powder with high contrast then with magnetic powder with first pass indicating erasure of fingerprints. Full secondary processing was not done to prevent full erasure of fingerprints.

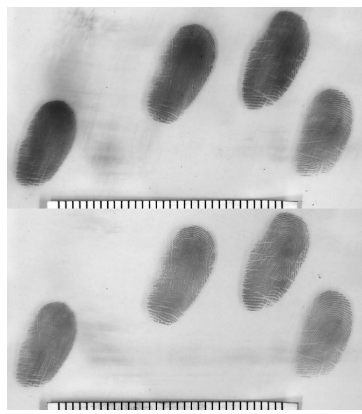

Figure 9

Example of latent fingerprints processed first with magnetic powder with high contrast then with black powder with high contrast

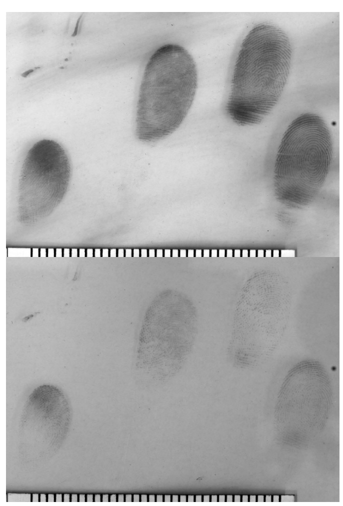

Figure 10

Example of latent fingerprints processed first with magnetic powder with high contrast then with black powder with low contrast

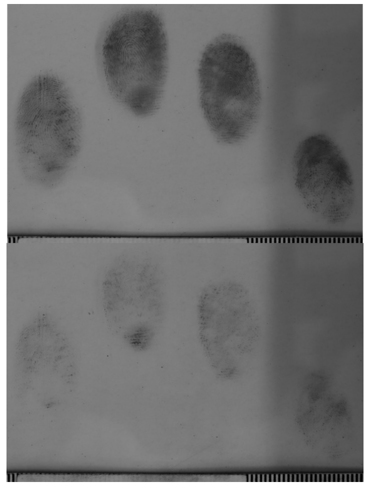

Figure 11

Example of latent fingerprints processed first with magnetic powder with high contrast then with black powder with erasure of fingerprints

Statistical data was collected to analyze the performance of each method, and findings were compared to understand the interaction of powders with fingerprint residues.

The glass pane was then cleaned with an alcohol-based solution to remove any residues or powders left behind and the process was repeated for the next participant.

Results

The complete results of the powder processing analysis are summarized in Table 1, which presents the development outcomes for all four methods tested.

Powder Sequence	Sample Count	Percentage
Black Powder Only		
Low contrast	24	48%
High contrast	23	46%
No development	3	6%
	total 50	total 100%
Magna Powder Only		
Low contrast	10	20%
High contrast	39	78%
No development	1	2%
	total 50	total 100%
Magna Powder then Black Powder (Double Processing)		
high contrast to high contrast (no change)	17	34%
low contrast to low contrast (no change)	9	18%
high contrast to low contrast (degraded)	7	14%
low contrast to high contrast (improved)	0	0%
high contrast to erased latent (degraded)	13	26%
low contrast to erased latent (improved)	3	6%
no development to no development (no change)	1	2%
no development to low contrast (improved)	0	0%
no development to high contrast (improved)	0	0%
	total 50	total 100%
Black Powder then Magna Powder (Double Processing)		
high contrast to high contrast (no change)	19	38%
low contrast to low contrast (no change)	9	18%
high contrast to low contrast (degraded)	0	0%
low contrast to high contrast (improved)	14	28%
high contrast to erased latent (degraded)	1	2%
low contrast to erased latent (degraded)	3	6%
no development to no development (no change)	1	2%
no development to low contrast (improved)	3	6%
no development to high contrast (improved)	0	0%
	total 50	total 100%

Table 1

Comparison of powder processing sequences.

Analysis of these results revealed several key patterns for each processing method:

1. Black Powder Only Method:

- High contrast was observed in 46% of the samples (23 out of 50)
- Low contrast occurred in 48% of the samples (24 out of 50)
- Nearly balanced distribution between low (48%) and high (46%) contrast suggests moderate consistency
- No development was noted in 6% of the samples (3 out of 50); low failure rate

- Demonstrates reliability as a baseline processing technique

2. Magnetic Powder Only Method:

- High contrast was observed in 78% of samples (39/50)
- Significantly lower low contrast occurred in 20% of samples (10/50)
- No development was noted in 2% of samples (1/50); extremely low failure rate compared to black powder
- Suggests superior visualization capabilities compared to black powder

3. Magnetic Powder then by Black Powder Sequence (Double Processing): Outcome Categories:

- 35% of samples (17/50) maintained high contrast
- 18% of samples (9/50) maintained low contrast

Degradation Scenarios:

- 14% of samples (7/50) worsened from high to low contrast
- 26% of samples (13/50) worsened from high contrast to being erased
- 6% of samples (3/50) worsened from low contrast to being erased
- High potential for image degradation (46% negative changes)
  - Total Negative Changes: 7 + 13 + 3 = 23 samples
  - Percentage Calculation: (23/50) * 100 = 46%

Improvement Scenarios: None detected

No Development Maintained: 2% of samples (1/50)

4. Black Powder then by Magnetic Powder Sequence (Double Processing): Outcome Categories:

- 38% of samples (19/50) maintained high contrast
- 18% of samples (9/50) maintained low contrast
- High contrast was observed in 65% of the samples.

Degradation Scenarios:

- 2% of samples (1/50) worsened from high to low contrast
- 6% of samples (3/50) worsened from low contrast to being erased

Improvement Scenarios:

- 28% of samples (14/50) improved from low to high contrast
- 6% of samples (3/50) improved from no development to low contrast
  - Total Positive Changes: 14 + 3 = 17 samples
  - Percentage Calculation: (17/50) * 100 = 34%

No Development Maintained: 2% of samples (1/50)

Discussion

The technique of ”Double Processing” proved most effective when black powder was applied first, followed by magnetic powder. This sequence yielded a significant improvement rate, with

28% of samples transitioning from low to high contrast development and only 8% experiencing negative changes (2% high contrast to erased latent, 6% low contrast to erased latent). Magnetic powder applied second effectively enhances the initial black powder development, creating a more detailed visualization of the latent print. Conversely, applying magnetic powder first and then black powder increased the risk of print degradation, with 46% of samples experiencing negative changes, including 26% of high contrast samples being completely erased.

It is important to note that 8% of samples remained completely unresponsive across all processing methods. These unresponsive prints represent a challenging subset that defies standard visualization techniques and suggests that advanced double processing methods have limitations in fingerprint recovery.

Additionally, even though each hand deposited two impressions in immediate succession, the appearance of the print (low versus high contrast) did not correlate with whether the impression was the first or second touch. This observation indicates a consistent and significant role of residue depletion, rather than contact order, in determining the visibility of latent prints.

Conclusion

The interplay of these variables underscores the complexity of latent fingerprint development. Each factor, from the composition of the residue to the substrate characteristics and environmental conditions, interacts in unique ways to affect the visibility and quality of fingerprints. These findings, while insightful, are circumstantial and can vary significantly depending on several factors, including the type of powders used, the surface conditions, and the biological characteristics of the individuals providing the fingerprints. The data from this study showed clear differences in how black and magnetic powders developed prints, as well as how sequential techniques influenced outcomes. Such results highlight the importance of understanding both the strengths and limitations of each development method. The list of variables that can modify the development of latent fingerprints cited earlier in this paper lay out a framework for future systematic testing for optimization of field processing at crime scenes. Future studies could further explore these variables to refine fingerprint development techniques and ensure adaptability to diverse crime scene conditions.

For further information, please contact:

Christine Loewenhagen
City of Mesa
Christine.Loewenhagen@MesaAZ.gov

References

1. Ruth S. Croxton, Mark G. Baron, David Butler, Terry Kent, Vaughn G. Sears; Variation in amino acid and lipid composition of latent fingerprints. *Forensic Science International*. 199 (2010) 93-102. https://www.sciencedirect.com/science/article/abs/pii/S0379073810001325?via%3Dihub.
2. Joseph De Alcaraz-Fossoul, Cristina Mestres Patris, Antoni Balaciart Muntaner, Carme Barrot Feixat, Manel Gené Badia; Determination of latent fingerprint degradation patterns – a real fieldwork study. *International Journal of Legal Medicine*. 127 (2013) 857-870. https://doi.org/10.1007/s00414-012-0797-0.
3. Gurvinder Singh Bumbrah, Rakesh Mohan Sharma, Om Prakash Jasuja; Emerging latent fingerprint technologies: a review. *Research and Reports in Forensic Medical Science*. 6 (2016) 39-50.
4. Amanda A. Frick, Xanthe Spindler, Stephen M. Bleay; Chemistry of Fingerprint Residue. *Encyclopedia of Forensic Sciences, Third Edition, Volume 1*. (2023) 521-529. https://doi.org/10.1016/B978-0-12-823677-2.00065-9.
5. Aline Girod, Robert Ramotowski, Céline Weyermann; Composition of fingermark residue: A qualitative and quantitative review. *Forensic Science International*. 223 (2012) 10-24. https://doi.org/10.1016/j.forsciint.2012.05.018.
6. G. S. Sodhi, J. Kaur; Powder method for detecting latent fingerprints: a review. *Forensic Science International*. 120 (2001) 172-176. https://doi.org/10.1016/S0379-0738(00)00465-5.

7. Brian Yamashita, Mike French; *Fingerprint Sourcebook – Chapter 7: Latent Print Development.* National Institute of Justice: Washington, D. C.; 2010.
8. Sara Moreno, Glenna Brown, Mieke Klein, Qiang Wang, John T. Markiewicz, Elvin A. Alemán, Catherine G. Rushton, Rosalynn Quiñones; Chemical Composition Effect on Latent Print Development Using Black Fingerprint Powders. *Forensic Chemistry, Volume 26*. 100366 (2021) 1-40. https://doi.org/10.1016/j.forc.2021.100366.
9. Helen L. Bandey; The Powders Process, Study 1: Evaluation of Fingerprint Brushes for Use with Aluminum Powder. *Home Office Police Scientific Development Branch: Crime Investigation and Officer Safety Sector*. (2004) 54/04.