

# A Study on Development of Latent Fingerprints Deposited on Glass Surface Buried in Soil at Varying Depths

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**Abstract**—Latent fingerprints serve as one of the most reliable forms of physical evidence in forensic science, playing a crucial role in personal identification and criminal investigations. This study examines the development of latent fingerprints deposited on glass surfaces buried in soil at varying depths using physical development techniques. Glass, being a non-porous surface, allows fingerprint residues such as sweat, oils, and amino acids to remain on its surface, making it suitable for fingerprint recovery. The research focuses on how deposition pressure and environmental conditions, particularly burial depth in soil, influence the clarity and visibility of fingerprint ridge patterns. Fingerprints were deposited on clean glass surfaces using different pressure levels and subsequently buried at varying depths to simulate real-world forensic conditions. After retrieval, powder dusting techniques were employed to develop the latent prints. Observations revealed that fingerprints deposited with moderate pressure exhibited the highest clarity, while those deposited with very light pressure were faint and difficult to develop. Additionally, increased burial depth and environmental exposure affected residue preservation, thereby influencing print quality. The findings highlight the importance of deposition pressure and environmental factors in forensic fingerprint recovery and reinforce the effectiveness of physical development methods in crime scene investigations.

**Index Terms**—Latent fingerprints, Glass surface, Soil burial depth, Fingerprint powder technique.

## I. INTRODUCTION TO FINGERPRINT SCIENCE

Fingerprint science is one of the oldest and most reliable methods of personal identification used in

forensic investigations. The uniqueness and permanence of friction ridge patterns make fingerprints an indispensable tool in linking individuals to crime scenes. These ridge patterns are formed during fetal development and remain unchanged throughout an individual's lifetime, even after minor injuries. Latent fingerprints, which are invisible to the naked eye, are the most commonly encountered type at crime scenes. They are formed by natural secretions from eccrine and sebaceous glands, consisting of water, amino acids, lipids, and salts. These residues are transferred onto surfaces when a person touches them. However, since latent prints are not readily visible, specialized techniques are required to develop and visualize them. The importance of latent fingerprints in forensic science cannot be overstated. They help establish identity, reconstruct events, and provide critical evidence in criminal investigations. With advancements in forensic technology, fingerprint analysis has become more precise and reliable. Nevertheless, traditional methods like powder dusting remain widely used due to their simplicity and effectiveness.

## II. TYPES OF FINGERPRINTS AND THEIR FORENSIC RELEVANCE

Fingerprints are generally classified into three types: visible (patent), plastic, and latent fingerprints. Each type has unique characteristics and forensic applications. Visible fingerprints are formed when a finger is contaminated with substances such as blood, ink, or grease before touching a surface. These prints

are easily observable without any enhancement techniques. Plastic fingerprints, on the other hand, are three-dimensional impressions formed on soft surfaces like wax, clay, or soap.

Latent fingerprints are the most significant in forensic investigations. They are formed by natural skin secretions and are usually invisible. Their detection requires physical or chemical development techniques. Due to their frequent occurrence at crime scenes, latent fingerprints are considered highly valuable evidence. Understanding the different types of fingerprints helps forensic experts choose appropriate development techniques. While visible and plastic prints may require minimal processing, latent prints demand careful handling and specialized methods to preserve and enhance ridge details.

### III. METHODS OF LATENT FINGERPRINT DEVELOPMENT

Fingerprint development methods are broadly categorized into physical, chemical, and advanced techniques. The selection of a method depends on the nature of the surface and the condition of the fingerprint residue. Physical methods, such as powder dusting, involve applying fine particles that adhere to the moisture and oily components of the fingerprint residue. This technique is particularly effective on non-porous surfaces like glass.

Chemical methods include the use of reagents such as ninhydrin, iodine fuming, and silver nitrate. These chemicals react with specific components of the fingerprint residue to produce visible patterns. Advanced techniques, such as cyanoacrylate fuming and laser illumination, provide higher sensitivity and are used for complex cases. However, they require specialized equipment and expertise. Among these methods, powder dusting remains the most practical and widely used due to its simplicity, cost-effectiveness, and efficiency.

### IV. FINGERPRINT DEVELOPMENT ON GLASS SURFACES

Glass is a commonly encountered non-porous surface in forensic investigations. Items such as windows, bottles, and mirrors frequently contain latent

fingerprints. Since glass does not absorb residues, fingerprints remain on the surface, making it ideal for development using physical methods.

The success of fingerprint development on glass depends on several factors, including the amount of residue, environmental conditions, and the time elapsed since deposition. Powder dusting is particularly effective on glass surfaces, as the particles easily adhere to the residues. However, improper handling or excessive brushing can damage the ridge patterns. Therefore, careful application techniques are essential to obtain clear and identifiable prints.

### V. EFFECT OF DEPOSITION PRESSURE ON FINGERPRINT QUALITY

The pressure applied during fingerprint deposition plays a significant role in determining the quality of the developed print. Light pressure results in minimal residue transfer, producing faint and unclear prints. Moderate pressure yields optimal results, with well-defined ridge patterns. Excessive pressure, however, can distort ridge patterns, causing them to appear broader and less distinct. This distortion may affect the accuracy of identification. Understanding the impact of deposition pressure is crucial for forensic analysis, as it helps investigators interpret variations in fingerprint quality at crime scenes.

### VI. IMPACT OF SOIL BURIAL DEPTH ON FINGERPRINTS

The burial of glass surfaces in soil introduces environmental factors that affect fingerprint preservation. Soil composition, moisture, temperature, and microbial activity can degrade fingerprint residues over time. Shallow burial may expose fingerprints to environmental fluctuations, while deeper burial may reduce exposure but increase pressure and contamination. As depth increases, the clarity of fingerprints tends to decrease due to degradation of organic components. This study highlights the importance of considering environmental conditions when recovering fingerprint evidence from buried objects.

## VII. CHEMICAL COMPOSITION OF FINGERPRINT RESIDUES

Fingerprint residues consist of a complex mixture of organic and inorganic substances, including water, amino acids, lipids, and salts. These components originate from eccrine and sebaceous gland secretions. The composition of fingerprint residues influences the effectiveness of development techniques. For instance, powders adhere to oily components, while chemical reagents react with amino acids. Environmental factors can alter the chemical composition over time, affecting the visibility and clarity of fingerprints. Understanding these changes is essential for selecting appropriate development methods.

## VIII. FACTORS AFFECTING LATENT FINGERPRINT DEVELOPMENT

Several factors influence the development of latent fingerprints, including surface type, environmental conditions, residue composition, and deposition pressure. Non-porous surfaces like glass provide favorable conditions for fingerprint development. Environmental factors such as heat, humidity, and light exposure can degrade residues. Additionally, improper handling during development can damage prints. Advancements in forensic science have introduced new techniques to overcome these challenges. However, understanding fundamental factors remains essential for effective fingerprint recovery.

## IX. CONCLUSION

The study of latent fingerprint development on glass surfaces buried in soil at varying depths provides valuable insights into the complexities of forensic evidence recovery. Fingerprints continue to be one of the most reliable and widely used forms of identification in forensic science due to their uniqueness and permanence. However, their successful recovery depends on several variables, including deposition pressure, environmental exposure, and the techniques used for development. One of the key findings of this study is the significant influence of deposition pressure on fingerprint quality. Moderate pressure consistently produced the clearest and most identifiable ridge patterns, while very light

pressure resulted in faint prints and excessive pressure caused distortion. This observation emphasizes the importance of understanding how fingerprints are deposited in real-world scenarios, as it directly impacts their forensic value.

Another important aspect explored in this study is the effect of soil burial depth on fingerprint preservation. Environmental factors such as moisture, temperature, and microbial activity play a crucial role in degrading fingerprint residues. As burial depth increases, the clarity of fingerprints generally decreases due to these factors. This finding is particularly relevant in forensic investigations involving buried evidence, where the recovery of usable fingerprints can be challenging.

The study also reaffirms the effectiveness of physical development techniques, particularly powder dusting, in visualizing latent fingerprints on non-porous surfaces like glass. Despite the availability of advanced techniques, powder dusting remains a preferred method due to its simplicity, cost-effectiveness, and reliability. However, proper application techniques are essential to avoid damaging delicate ridge patterns.

Furthermore, the research highlights the importance of understanding the chemical composition of fingerprint residues. The interaction between residue components and development techniques determines the success of fingerprint visualization. Environmental changes can alter this composition, further complicating the recovery process.

In conclusion, this study contributes to the field of forensic science by providing a deeper understanding of the factors affecting latent fingerprint development. It underscores the need for careful handling of evidence, appropriate selection of development techniques, and consideration of environmental conditions. The findings can help improve forensic practices and enhance the accuracy and reliability of fingerprint analysis in criminal investigations.

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