A Compositional Analysis of Aged Latent Fingerprints Post-Rehydration

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Introduction

Evidence found at a crime scene can be instrumental in identifying the perpetrator of the incident. As a result, it is imperative that forensic scientists are able to analyze all latent fingerprint evidence found at a crime scene. Latent fingerprints are invisible to the naked eye and require additional development to visualize. However, the effectiveness of these development methods changes as more time passes since deposition. Fingerprints begin to evaporate and dry out almost immediately after deposition [1], which alters the composition of the print. Unfortunately, as the composition of the print changes, so does the effectiveness of the techniques used to develop the print. Additionally, as more time passes, fingerprints become more degraded and the development methods are even less effective [2].

Though there are effective development methods for developing aged latent fingerprints, these development methods only work on porous surfaces [3]. This poses a significant challenge to forensic scientists because not all latent prints at a crime scene are deposited on porous surfaces. In fact, the majority are on non-porous surfaces. However, my previous research investigated a possible solution: the utilization of a humidifier to rehydrate aged latent fingerprints. This study was able to develop an effective method was developed for the rehydration of aged latent fingerprints [4].

Unfortunately, the process by which this occurs is still not understood. Previous research has shown that aged fingerprints are composed predominantly of lipids and amino acids [5][6]. However, lipids are hydrophobic and the most abundant amino acids in a fingerprint are non-hygroscopic [7]. Therein lies the conundrum: the rehydration methodology was proven successful and yet the predominant components of an aged print do not absorb water.

This gap in knowledge prevents latent fingerprint examiners from utilizing this methodology in a forensic laboratory as they are unable to articulate how the method works for expert testimony in a court of law. The purpose of this project was to explore the microscopic processes that occur at the rehydration interface of a fingerprint in an effort to determine what occurs when a fingerprint is rehydrated. Continued research into this process will ensure the methodology is admissible in a court of law and can be used in forensic laboratories where it has important implications in the analysis of fingerprints from cold cases.

Methodology

Rehydration Workflow*

*Based on established rehydration methodology from previous research [4]. Sole methodology for long-term evaporation fingerprints

- Fingerprint deposited onto glass substrate
  - 30 total fingerprints for each development method
  - 10 replicate fingerprints for each stage of the methodology
- Fingerprint ages/evaporates for 1 hour at 45-50% relative humidity
  - Long-term evaporation fingerprints were aged for 7 months at variable humidity
- Substrate with aged fingerprint placed in humidity chamber for 30 minutes at 80-85% relative humidity

Dye Staining/Fingerprint Development

- Assists with the visualization of fingerprint components
- Protein
  - Gentian Violet (**Fig. 1, left**)
- Lipid Stains
  - Small Particle Reagent (**Fig. 1, center**)
  - Oil Red O (**Fig. 1, right**)
- Fingerprints were stained after each stage of the methodology: deposition, evaporation, and rehydration
- Dye stains were also used to determine approximate ratio of lipids to amino acids in an aged fingerprint

Fingerprint Imaging and Microscopic Analysis

- Developed and undeveloped fingerprints imaged under an Olympus microscope at 40x and 100x magnification at each stage (**Fig. 2**)
- Photograph sets were overlaid in Adobe Photoshop to compare fingerprint components being stained (**Fig. 3, left**)
  - Sets included photographs taken after deposition, evaporation, and rehydration
  - Investigate effect of rehydration on 3rd level detail (**Fig. 3, right**)

Results

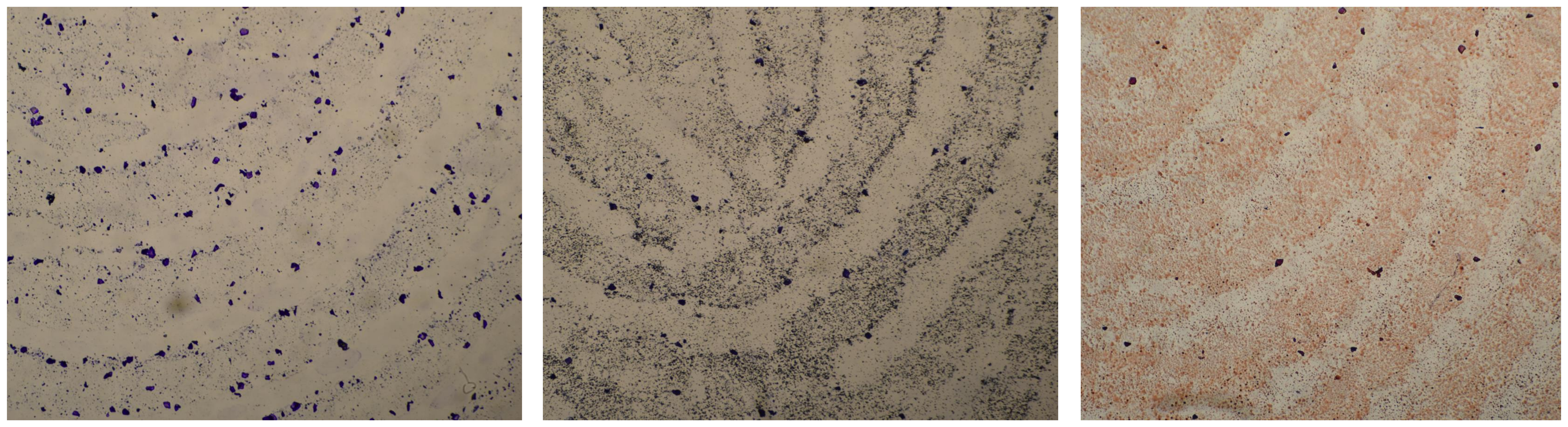

Figure 1. Images of gentian violet (left), small particle reagent (center), and oil red o (right) dye staining. All images were taken at 4x magnification under the microscope.

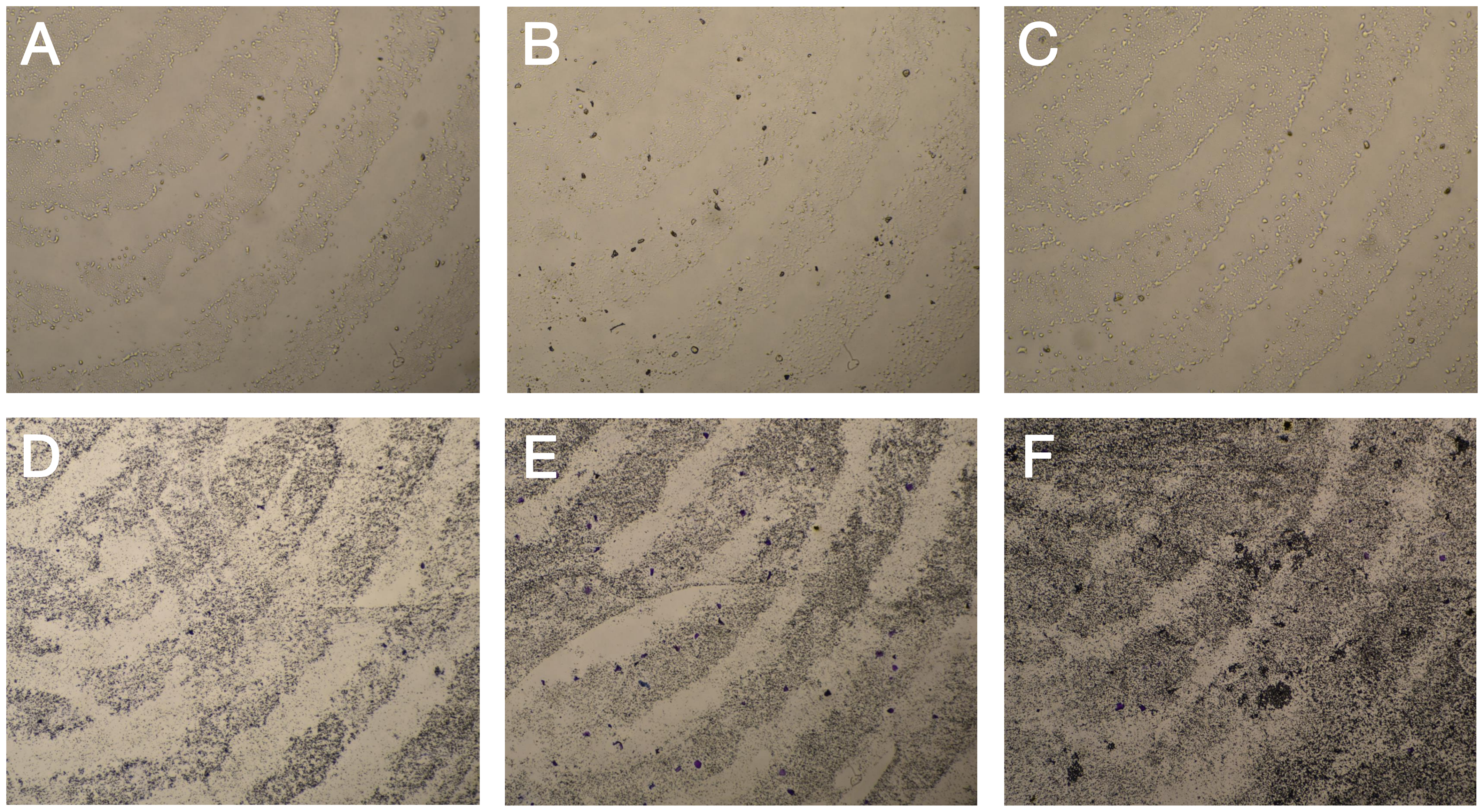

Figure 2. Undeveloped (A-C) and developed (D-F) fingerprints at 4x magnification. Fingerprints were developed with small particle reagent. Images were taken at each stage of the methodology for comparison: deposition (A,D), evaporation (B,E), and rehydration (C,F).

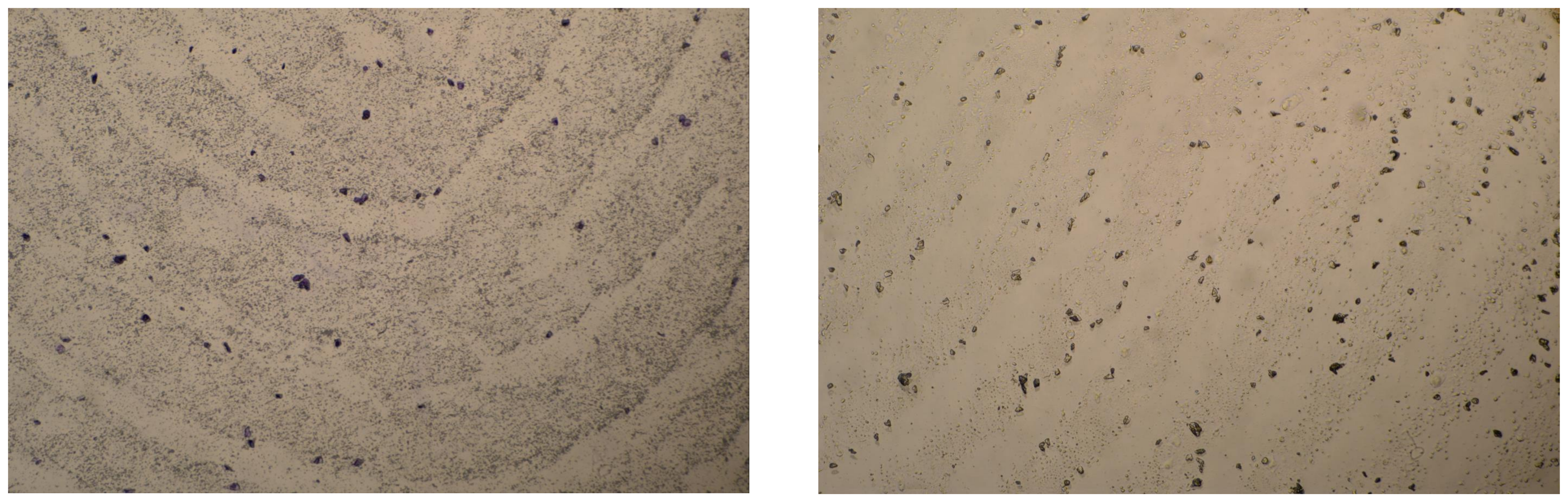

Figure 3. Overlay of undeveloped fingerprint, gentian violet developed fingerprint, and small particle reagent developed fingerprint (left). Overlay of the deposition and rehydration images of the same fingerprint (right). Overlays created using Adobe Photoshop.

Long Term Evaporation

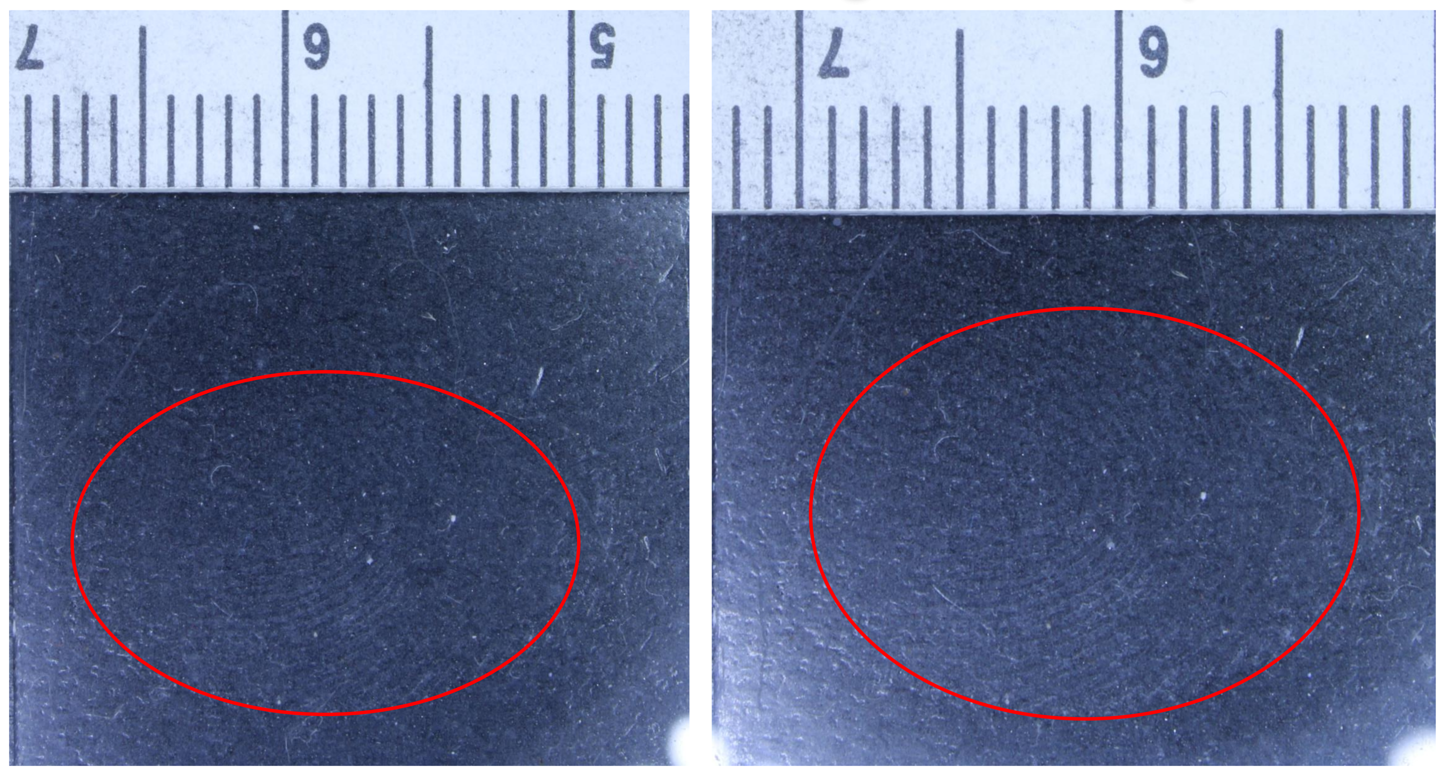

Figure 4. Comparison between a fingerprint that has been aged for 7 months (left) and the same fingerprint after it has been rehydrated (right). Red circles indicate the fingerprint.

Comparison of Long Term vs. 1 Hour Evaporation on Glass		
Evaporation Time	n	Average Difference from 100% Recovery (%)
1 Hour	6	0.510
7 Months	6	3.733

Table 1. Average difference between experimental percent recovery of fingerprints aged for 1 hour and 7 months, respectively, and 100% recovery on a glass substrate.

Conclusions

- Trace elements that exist within the rehydration interface of a fingerprint absorb water from the air during rehydration causing the aged ridge widths to return to their depositional widths
  - Comparison of stained images taken after deposition, evaporation, and rehydration, respectively, revealed no change in the size of the epithelial cells (**Fig. 2, D-F**)
  - Comparison of the same stained images revealed that the lipids (stained black by small particle reagent) appeared to shrink when the print was aged and grow when the print was rehydrated (**Fig. 2, A-C**)
    - Lipids do not absorb water so there must be trace elements present with the lipids at the rehydration interface that act as the rehydration component
- Third level detail is not impacted by the rehydration process
  - Overlaid images of an aged and rehydrated fingerprint reveal that the shape of the ridges do not change during the process of rehydration (**Fig. 3, right**)
- The rehydration methodology can still be successfully applied to fingerprints that have aged for longer than 1 hour in uncontrolled conditions
  - Fingerprints aged for 7 months in an uncontrolled indoor environment displayed an increase in quality after being rehydrated (**Fig. 4**)
  - Though the experimental percent recovery in 7 month old prints was further from the ideal 100% recovery than that of the prints that had aged for 1 hour, this difference is still minimal and the quality of the rehydrated fingerprint has undeniably improved
    - Revelation that third level detail does not change during rehydration also makes the need for 100% recovery less important

Deliverables

- Explanation of the events occurring at the rehydration interface of a latent fingerprint
- Recommendations for the implementation of the developed rehydration methodology within forensic crime labs
- Determination of most effective chemical development methods for rehydrated fingerprints on glass substrates

Future Directions

- Utilization of forensic chemistry to determine the identity of the trace elements within the rehydration interface of a latent fingerprint
  - GC/MS
  - IR spectroscopy
  - Raman spectroscopy
- Continued longitudinal study to obtain more replicates of latent fingerprints that have been aged for longer periods of time and/or in different environmental circumstances, and to assess the success of alternative rehydration intervals
  - 35 minutes
- Further chemical and physical development of rehydrated latent fingerprints
  - Assessed gentian violet, small particle reagent, oil red o, and iodine fuming
  - Investigation of more chemical and physical development methods is necessary to generate a comprehensive list of effective development methods for rehydrated fingerprints

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