Revealing Writing that has been Covered Using Correction Tools

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One particular challenge encountered by the forensic document examiner is that of obliterations through use of correction utensils and opaquing solutions (eg. Wite-Out®). Underlying writing can be difficult to distinguish due to this type of obliteration. In the past, various methods have been implemented to deal with these types of evidence, such as physically removing the solution. However, this method has the potential to destroy the original evidence in the process (1,2). An alternate non-destructive method for the visualization of the underlying writing is preferred. ESDA® and the VSC® are both non-destructive techniques widely used in the analysis of questioned documents. The ESDA® was proposed and examined as a novel method for visualizing this type of obliterated writing. This non-destructive method was then compared to that of using the VSC® for this same type of examination. The evaluation was carried out through the use of a variety of writing instruments, inks and printing methods. A series of samples consisting of handwritten, typewritten, and non-impact printed material was prepared and sections of each were covered with a different correction tool. Both the ESDA® and VSC® were used to view the underlying writing. The ESDA® was able to distinguish the underlying writing from the front in three of the eight samples where the correction tape was used and from the back in three of the eight samples where correction fluid was used. Surprisingly, for all other samples, the ESDA® did not succeed in revealing the obliterated writing. In all cases, however, the VSC® was able to generate a legible image of the original writing. In short, the VSC® was exceptionally effective at visualizing writing obliterated by opaquing solutions. There might, however, be some situations where the ESDA® may be more advantageous.

Introduction

Writing on documents is sometimes covered by correction utensils (Wite-Out®, correction tape, etc.), which can obscure the writing underneath. The challenge for the Questioned Document Examiner is to decipher the original text; a process that has often proven difficult (1,2). In this paper, two different instruments were utilized for accomplishing this challenge: the Electrostatic Detection Apparatus (ESDA®) and the Video Spectral Comparator (VSC®).

The ESDA® is a technique used to detect and visualize latent impressions on paper. These impressions are created as a result of writing on a stack of papers. The pressure applied by the writer to the top sheet causes indentations on the underlying sheets. When the top layer is not available, the underlying sheets are used for analysis. The ESDA® reveals these indentations which might otherwise go undetected.

To examine a document with the ESDA®, a thin, transparent polyester film is placed over the paper and the two are held together by vacuum suction. An electrical current is applied over the surface of the film. The areas of indentation have electrostatic properties different from areas without indentations. Black toner is applied over the surface of the film and is preferentially attracted to the charged areas of indentations. The toner results in a gray background with black traces along the areas of indentation.

The VSC® is comprised of a camera, filters, and light sources that produce different wavelengths and angles of light to assist in Questioned Document examinations. The data relating to optical properties of a document acquired with the VSC® can be used to confirm the authenticity or forgery of a document. The key to assessing a document using the VSC® is through the use of various optical properties of a document. The various inks and features of a document will react differently to the different illumination and viewing settings. As a result, they will have similar or dissimilar properties, such as reflectance and can be distinguished (3).

To examine a document with the VSC®, all the settings are chosen and the preferred illumination and viewing conditions are selected. Once the settings are established, the analyst or the VSC® software systematically applies each condition and collects an image of the document. Once the analysis is complete, the analyst assesses the collected images and selects one or more that demonstrate the results of the examination.

The purpose of this study is to determine if the ESDA® can be used for analysis of documents obliterated by correction utensils and if so, how well it compares to the VSC®. Using the ESDA® has several incentives: it is commonly the first step in many questioned document examinations. The VSC® is an expensive piece of equipment to which all forensic laboratories may not have access. As a result, it would be beneficial to use the ESDA® for a multitude of analyses. Additionally, it increases efficiency to analyze evidence for indentations as well as obliterations simultaneously. This reduces time spent on a single piece of evidence and reduces the cost of carrying out additional, unnecessary analyses.

Materials & Methods

Nine writing samples were prepared. The samples were full pages of printed material created on standard computer paper. The text produced on each page was the same to keep the samples uniform. Each sample was created using a different method of printing.

- I. Five writing instruments used:
  - A. Two gel-ink pens
    1. Uni-ball® signa RT GEL 0.38pt
    2. BiC® Velocity® Gel 0.7pt
  - B. Two BiC® Ultra Round Stic Grip ball point pens
    1. one black ink
    2. one blue ink
  - C. One No. 2 pencil
- II. Four electronic printers and copiers used:
  - A. Inkjet printer (EPSON® STYLUS PHOTO R1900)
  - B. Typewriter (SWINTEC® 2600) (Note: the correction ribbon that is part of the typewriter was not used in this study.)
  - C. Toner copy machine (KONICA MINOLTA® bizhub501)
  - D. Phaser printer (XEROX® Phaser 4500)
- III. Three types of correction utensils used:
  - A. Correction fluid applied with a brush (BiC Wite-Out® Cover-It)
  - B. Correction pen applied by squeezing the utensil and marking over the paper (BiC Wite-Out® Shake n' Squeeze)
  - C. Correction tape applied by rolling a film over the paper (BiC Wite-Out® EZcorrect)

Every page of text created contained the three different methods of correction.

The corrections covered between a few words to a complete sentence. Their placements were separated from one another to prevent any influence of one correction upon another (Figure 1).

The Foster + Freeman Ltd ESDA2® and the VSC 6000® were used for these experiments. Prior to analyzing with the ESDA®, the writing samples were humidified for approximately three minutes. With the VSC®, initial examinations were carried out using all of the various options (UV, IR, fluorescence, visible light and absorption). Further examinations were carried out using excitation, visible light and contrast as these appeared to produce the best results.

All samples were first examined using the ESDA® followed by the VSC®. The writing samples were analyzed with both the writing side up and the writing side down. This resulted in two images per sample. For the images generated from the back of the samples with the VSC®, the images were flipped using the Microsoft Paint program to display a readable image, rather than the reversed side of the writing. The best visualized image of the obliterated writing captured by the VSC® was selected, printed and represented the VSC®'s distinguishing capabilities for that particular sample and correction type.

Results were assessed by considering the underlying text in the category as: visible, not visible or partially visible. Since the original document was available for examination, this method of reporting was chosen.

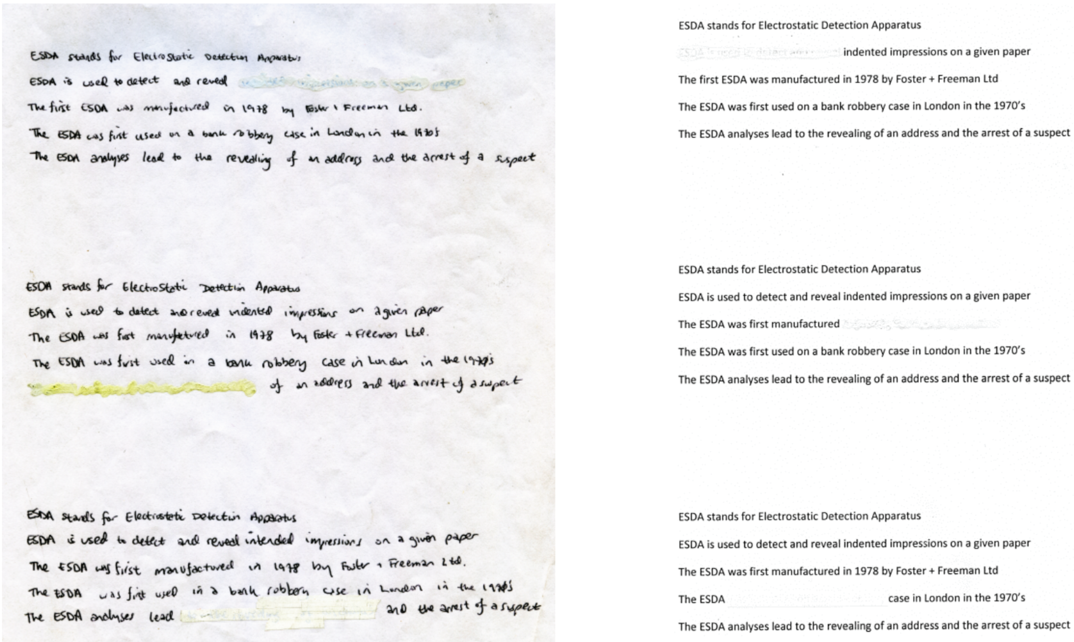


Figure 1. Two examples of the writing samples used, showing the three different types of correction obliterations: black ball point pen (left) and Xerox® Phaser printer (right). In the first paragraph, the correction fluid was used, followed by the correction pen and lastly, the correction tape.

Results

Correction Fluid

ESDA®:

For every sample, there was no successful visualization of any of the writing obliterated by the correction fluid. Instead, most of the samples developed dark gray or black sections over the areas with correction fluid (Figure 2). However, when the samples were analyzed from the back, writing with the Velocity® gel-ink pen, pencil, and ball point pen could be seen (Figure 3).

VSC®:

Most of the writing samples were successfully visualized through the front of the document, but to various degrees of clarity. For example, the BiC® Velocity® gel-ink pen writing was visible, but only partially (Figure 4). The text from the Xerox® sample was clearly visible (Figure 5).

When the back of the documents were analyzed, all samples were clearly visible except that from the black ball point pen (Figure 6).

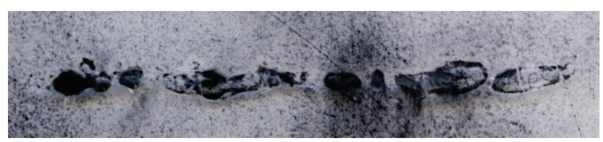


Figure 2. Ball point pen writing sample with correction fluid developed with the ESDA® from the front.

Figure 3. Velocity® gel-ink pen writing sample with correction fluid, developed with the ESDA® from the back side.

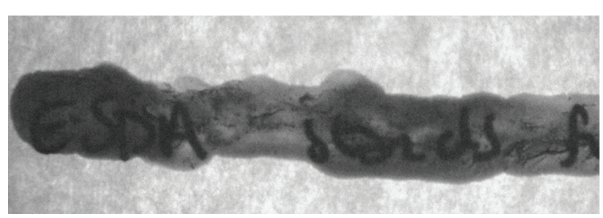


Figure 4. Velocity® gel-ink pen writing sample with correction fluid, viewed with the VSC® from the front. (Transmitted light, Longpass filter – 1000nm)

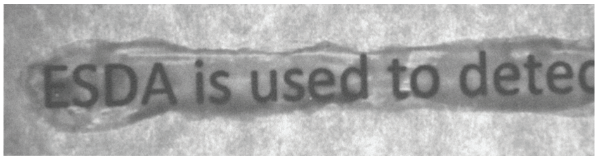


Figure 5. Xerox® writing sample with correction fluid, viewed with the VSC® from the front. (Transmitted light, Longpass filter – 1000nm)

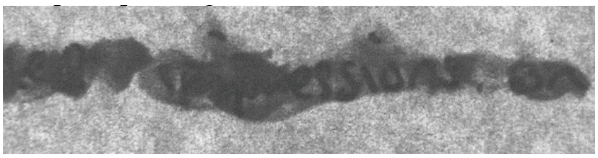


Figure 6. Black ball point pen writing sample with correction fluid, viewed with the VSC® from the back and inverted. (Transmitted light, Longpass filter – VIS)

Correction Pen

ESDA®:

No successful visualization was made for any sample regardless of which side was analyzed. Black or gray sections developed in place of writing obliterated by the correction pen when developed from the front (Figure 7) and nothing developed when analyzed from the back (Figure 8).

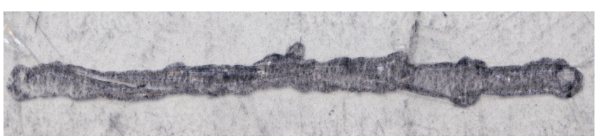


Figure 7. Velocity® gel-ink pen writing sample with correction pen developed with the ESDA® from the front.

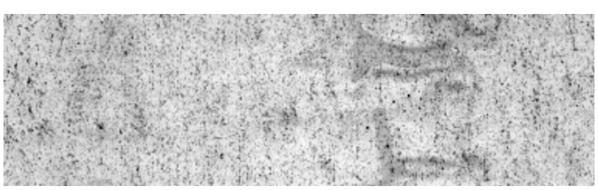


Figure 8. EPSON® inkjet printer sample with correction pen developed with the ESDA® from the back.

VSC®:

None of the writing samples, when viewed from the front, were successfully visualized (Figure 9) except for the two ball point pens. The black ball point writing was visible, but only partially, and the blue ball point writing was clearly visible (Figure 10). When the back of the samples were analyzed, all writing was successfully visualized to various degrees of clarity (Figure 11).

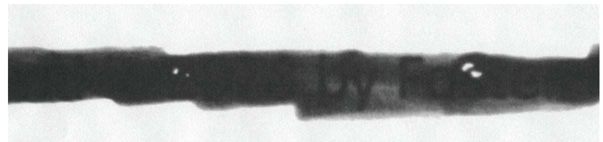


Figure 9. Toner copier writing sample with correction pen, viewed with the VSC® from the front. (Transmitted light, Longpass filter – 1000nm)

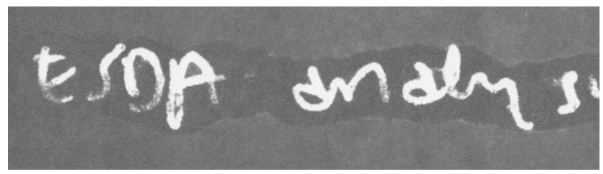


Figure 10. Blue ball point pen writing sample with correction pen, viewed with the VSC® from the front. (Spot light – 515nm-640nm, Longpass filter – 695nm)

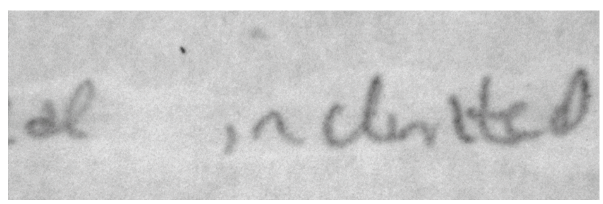


Figure 11. Velocity® gel-ink pen writing sample with correction pen, viewed with the VSC® from the back and inverted. (Flood light, Longpass filter – 780nm)

Correction Tape

ESDA®:

On the pages of text generated by the handwritten instruments and the EPSON® inkjet printer, the results of unsuccessful visualization were similar to those of the correction pen when developed from the front of the documents. However, on the pages generated by the typewriter, toner copy machine and the Xerox® Phaser printer, the obliterated writing was successfully visualized. For the samples created with the typewriter and the toner copy machine, the visible writing was dark on a gray background without much contrast (Figure 12). However, for the sample created with the Xerox® Phaser printer, the writing was black on a very light gray background with increased contrast allowing for clearly legible text (Figure 13). On the back of all writing samples, there was no visualization of any text or obliteration (Figure 14).

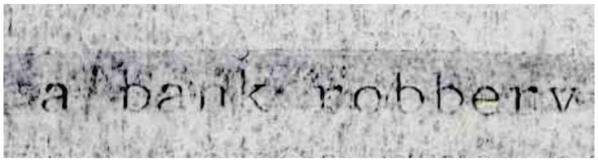


Figure 12. Typewritten text with the correction tape developed with the ESDA® from the front.

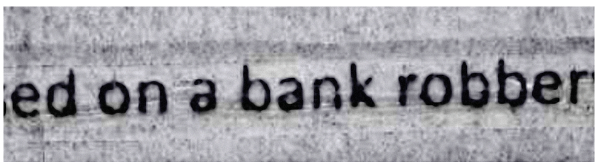


Figure 13. Xerox® Phaser printer text with the correction tape developed with the ESDA® from the front.

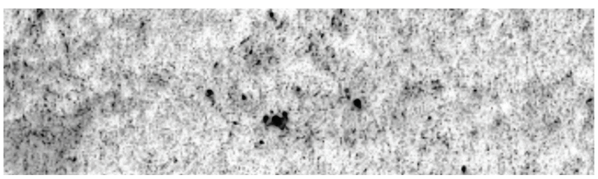


Figure 14. Typewritten text with the correction tape developed with the ESDA® from the back.

VSC®:

For the correction tape, all of the samples, when viewed from the front and the back, were successfully visualized (Figure 15). However, when viewed from the back, there was more variation in the clarity of visualization.

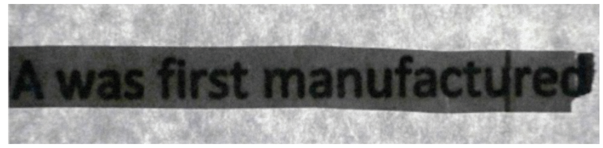


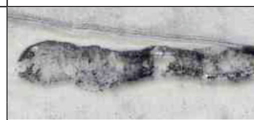
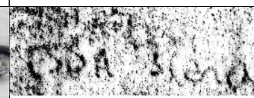
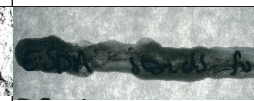
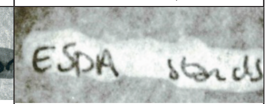
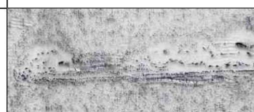
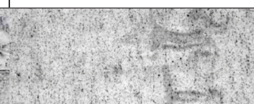
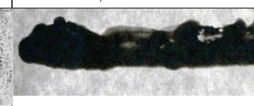
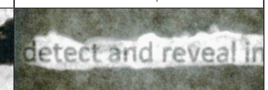
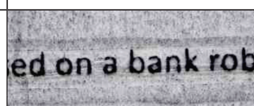
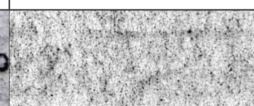
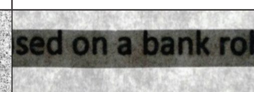
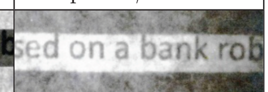
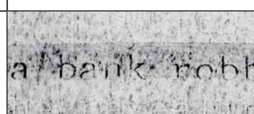
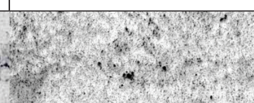
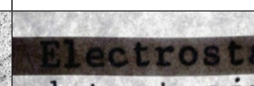
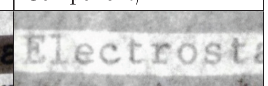
Figure 15. EPSON® printer writing sample with correction tape, viewed with the VSC® from the front. (Transmitted light, Longpass filter – 1000nm)

Table 1 summarizes the findings of the VSC® with the different inks and correction types as well as notations of when the ESDA® was able to develop text for the various corrections. Table 2 displays a visual comparison of selected results for both the ESDA® and the VSC® illustrating the differences in quality between the two methods for various corrections.

Table 1. Summary of VSC® results for each writing sample, respective correction method, and which side of document examined. (Text developed by ESDA® is indicated in bold and italics.)

Handwritten		**Uni-Ball® Gel-ink pen**	**BiC® Velocity® Gel-ink pen**	**BiC® Ball Point Pen**		**Pencil**
				Black ink	**Blue ink**	
Correction Fluid	Front	Visible	Partially visible	Partially visible	Not Visible	Visible
	Back	Visible, clearly	Visible, clearly ***ESDA® Developed Text***	Partially visible ***ESDA® Developed Text***	Visible, clearly	Visible ***ESDA® Developed Text***
Correction Pen	Front	Not Visible	Not Visible	Partially visible	Visible, clearly	Not Visible
	Back	Visible, clearly	Visible	Visible, clearly	Visible, clearly	Partially visible
Correction Tape	Front	Visible	Visible	Visible, clearly	Visible, clearly	Partially visible
	Back	Visible, clearly	Visible, clearly	Visible, clearly	Partially visible	Partially visible
Electronic		**EPSON® Inkjet Printer**	**Xerox® Phaser printer**	**SWINTEC® Typewriter**		**KONICA MINOLTA® Toner Copier**
Correction Fluid	Front	Visible, clearly	Visible, clearly	Visible		Partially visible
	Back	Visible, clearly	Visible, clearly	Visible, clearly		Visible, clearly
Correction Pen	Front	Not Visible	Not Visible	Not Visible		Not Visible
	Back	Visible, clearly	Partially visible	Visible, clearly		Visible, clearly
Correction Tape	Front	Visible	Visible ***ESDA® Developed Text***	Partially visible ***ESDA® Developed Text***		Visible, clearly ***ESDA® Developed Text***
	Back	Visible	Visible, clearly	Visible		Visible, clearly

Table 2. A side by side comparison of selected results of the ESDA® and the VSC®.

Sample	ESDA® (front)	ESDA® (back)	VSC® (front)	VSC® (back and inverted)
Velocity® gel-pen: *Correction fluid*			 (Transmitted light, Longpass filter—1000nm)	 (Spot light—485nm-610nm, Longpass filter—665nm)
EPSON® Inkjet printer: *Correction pen*			 (Transmitted light, Longpass filter—1000nm)	 (Spot light—545nm-675nm, Longpass filter—780nm, Red Component)
Xerox® Phaser printer: Correction tape			 (Transmitted light, Longpass filter—1000nm)	 (Spot light—445nm-570nm, Longpass filter—645nm, Red Component)
Typewriter: *Correction tape*			 (Transmitted light, Longpass filter—780nm)	 (Spot light—485nm-610nm, Longpass filter—665nm)

Discussion

Correction Fluid

ESDA®:

The areas covered with correction fluid appeared as solid gray sections rather than producing an image of text when samples were developed from the front. This may have been due to the fact that the correction fluid uses a thick, uneven layer of liquid to obliterate the writing. This uneven layer of liquid may also have created some indented or raised areas on top of the text. The properties of the dried correction fluid may have prevented the black toner from preferentially attracting to the image of the text, resulting in the gray sections.

Interestingly, when the samples were developed from the back of the documents, three of the handwritten samples developed text: the Velocity® gel-ink pen, the black ball point pen and the pencil. It is possible that this may be attributed how the ink is applied to the paper, since handwriting instruments require the use of force onto the page which may have caused indentations on the back of the documents.

VSC®:

The writing beneath the correction fluid was visualized to varying degrees of clarity. This may have been due to the fact that the fluid is brushed on and an uneven amount of fluid may have been deposited on any given sample or section of sample. It is interesting to note that the fluid is also very near in color to the white of the paper, which may have somehow lessened the inhibiting attributes in comparison to the correction pen.

The only sample that was unsuccessfully visualized with the correction fluid was the blue ball point pen when viewed from the front. The visualization settings that produced the best image were set at the same settings at which the fluid itself fluoresces. This resulted in the visualization of the fluid to mask that of the ink.

Correction Pen

ESDA®:

The correction pen obliterations were developed as gray areas rather than text on the front and nothing on the back. Similarly to the correction fluid, this may have been due to the unevenness and thickness of the correction application and its composition. Additionally, the correction pen would have resulted in indentations or raised areas which would again not attract black toner in a manner that would differentiate the text image from the background.

VSC®:

Most of the writing obliterated by the correction pen was not discernible through the front of the documents. This was possibly due to the physical thickness of the correction solution. Additionally, the correction pen was found to reflect most wavelengths and did not fluoresce or transmit light. This would also explain why the results improved when the back of the document was analyzed: the reflectance of the correction pen had a backlighting effect on the absorbing ink.

Correction Tape

ESDA®:

Most of the handwritten samples with correction tape did not develop text, however, most of the electronic samples did. The electronically deposited text obliterated by the correction tape had the best results with ESDA® analysis. The application process of and consistency of the correction tape was, as with all the others, the most likely cause. The correction tape was a thin and even layer of dry tape. This even layer assists in observing the shape and alignment of the ink of the underlying writing. The correction fluid and pen would not have been able to do this and instead would have caused a disruption of the indentations around the ink. The properties of the materials used in the electronic samples, e.g. the toner used for printing, may have also played a role in the preferential deposition of black toner from the ESDA® to the image areas.

VSC®:

The correction tape was the easiest obliteration method through which to visualize the underlying writing. This was most likely because of the consistency of the tape. The correction tape is very thin which would aid in the penetration of light. The tape also allows for the transmittance of light, unlike the correction pen, which also contributed to the successful visualization of the underlying ink.

ESDA®: Handwritten vs. Electronic

Since the handwritten samples were the only ones to develop text for the correction fluid from the back and the electronic writing samples were the only ones to develop text for the correction tape from the front, it was considered that the different methods of application of ink may have played an effect on the results.

Ink is deposited onto paper in a variety of different methods depending on the writing instrument or machine. Gel-ink pens use a viscous, water-based ink. The ink consists of many more pigment particles in the medium. The movement of the barrel of the gel-ink pen allows the ball housing in contact with the stored gel to shear the gel and allow for ink flow as it moves across the paper. The gel flows from the pen and onto the paper where the fibers absorb the water-based ink.

Ballpoint pens store the ink as an alcohol-based liquid which is much thinner than the gel inks. As the ball moves across the paper, the ink flows through the ball and onto the paper where it quickly dries. The result is much less pigment absorbed into the paper fibers (4,6).

The pens created little indentation on the front of the pages of text. When the ESDA® analysis was performed on the front of these pages, no writing developed. The black toner did not tend to deposit in greater concentration on any deep indentation and therefore remained uniform over the page. However, on the back of the pages, indentations did occur which allowed for the development of some text. Since the extent to which pressure was applied when creating the writing samples varied, it is possible that only some of the handwritten pages developed text on the back, but not others.

Pencils, unlike pens, use a mixture of graphite and clay rather than ink (5). When pencil is used, the materials are only partially absorbed into the paper and do not evaporate. This results in the graphite and clay remaining raised on top of the page, allowing the charges from the ESDA® to cluster on these areas and develop text when not obliterated. The pressure applied while writing with the pencil may have also caused the developed text with the ESDA® on the back of the sample.

The inkjet printer sprays tiny droplets of liquid ink onto the page which then dry on the surface of the page. No impact or pressure is used to apply the ink. Therefore, there were no areas of indentation left by the inkjet printer.

The typewriter uses impact to apply carbon pigment to the surface of the page. The carbon pigment is dry and therefore is not absorbed into the fibers of the paper. This impact process is the most likely cause of the successful visualization of the writing when analyzed with the ESDA® (7).

The toner copy machine and the phaser printer differ from the other processes of the printing. These two print by placing electrically charged toner directly onto the paper (8). Like the typewriter, the toner is dry and does not absorb into the fibers, but it is melted onto the surface of the paper as part of the printing process. The result is similar to that of the graphite pencil where it is raised above the paper's surface.

The phaser printer probably had the best result. This could be due to a thicker deposit of pigment onto the page than any of the other electronic methods, which would leave text that is more raised from the surface of the page.

VSC®: Front vs. Back

Both the front and back of the documents were analyzed. One theory is that the light's interaction with the corrective utensils may inhibit the camera's ability to detect any reaction of the light with the underlying ink. It was suggested that the paper would be less inhibitive than the correction methods. Overall, analyzing the samples from the back of the documents either improved the clarity of the writing (Figures 16 and 17) or had no effect on the clarity.

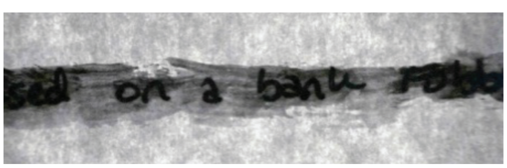


Figure 16. Uniball® gel-ink pen writing sample with correction fluid, viewed with the VSC® from the front. (Transmitted light, Longpass filter – 1000nm)

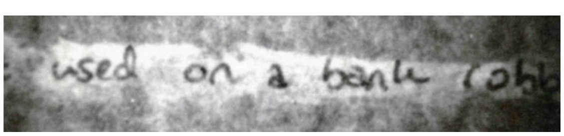


Figure 17. Uniball® gel-ink pen writing sample with correction fluid, viewed with the VSC® from the back and inverted. (Spot light – 445nm-570nm, Longpass filter – 645nm, Red Component)

Conclusion

The study showed that the only samples where the ESDA® developed text on the front were from the Xerox®, typewriter, and toner copier and only those obliterated by the correction tape as well as the Velocity® gel-ink pen, the black ball point pen and the pencil obliterated by the correction fluid and developed on the back. However, the results with the VSC® differed greatly from those with the ESDA®. Table 1 displays the results of the VSC® and the ESDA®. It is clear from the examples tested that the ESDA® was not nearly as effective in developing an image of the obliterated writing as the VSC®.

Ultimately, the VSC® was able to provide an image of the obliterated writing for every sample with each type of correction. In some cases, the writing could not be distinguished by viewing the front of the document. However, in all of those cases, the writing could be seen from the back of the documents. Overall, the VSC® was successful in generating a legible image of writing defaced by a variety of correction techniques. The type of ink used and whether it was deposited by hand or electronically did not appear to have an effect on the VSC®'s ability to obtain a discernible image or on the quality of the images, whereas it did play a role in the ESDA® examinations.

The superior ability of the VSC® to visualize the obliterated text is likely due to the fact that the VSC® is designed to be able to analyze these types of samples. The VSC® is made to use the properties of light and color to distinguish between different sources of text, among other applications, including obliterations. The ESDA® is not designed to discern obliterated text. It is designed to visualize indented text. Analyzing obliterated documents is a new application for this technique and as such, it was expected that it would not be as effective as the VSC®.

The VSC® was certainly more successful than the ESDA® in visualizing the obliterated writing; however there are some advantages to using the ESDA® for this type of examination. The first step in many questioned document examinations is the use of the ESDA®, so awareness that this can be useful for correction utensils is beneficial. Additionally, the VSC® is an expensive piece of equipment and all forensic laboratories may not have access to one. Although similar results may be obtained from the manual placement of filters in front of a suitable camera and illuminations sources, this would be time consuming. In such situations, it would be advantageous to use the ESDA® for as many types of analyses as possible so that the evidence would not need to be submitted to another agency. And finally, it increases efficiency to be able to analyze evidence for indentations as well as obliterations simultaneously. This reduces time spent on a given piece of evidence and reduces the cost of carrying out additional, unnecessary analysis.

References:

Beal, B. L. (2004). Removal of Opaquing Solutions from Documents. AAFS Presentation.

Hilton, O. (1982). Scientific Examination of Questioned Documents. Elsevier Science Publishing, Inc.

Foster + Freeman. (2008). VSC® 6000 Software Help Manual 04.

Schwartz, D. A. (2001). The Last Word: Just for the gel of it. Chemical Innovation. 31(9): IBC.

Ritter, S. "C&EN: PENCILS & PENCIL LEAD." Science & Technology. American Chemical Society, 15 Oct. 2001. Retrieved 11 Dec. 2014. <http://pubs.acs.org/cen/whatstuff/print/7942sci4.html>.

Brunelle, R. L., and Reed, R. W. Forensic Examination of Ink and Paper. Springfield, IL: C.C. Thomas, 1984.

Ordway, H., Scientific Examination of Questioned Documents. Rev. ed. Boca Raton, FL: CRC, LLC, 1993.

Hays, D. A. "How Does a Photocopier Work?" Scientific American Global RSS. 31 Mar. 2003. Retrieved 22 Dec. 2014. <http://www.scientificamerican.com/article/how-does-a-photocopier-wo/>.

Brown, T. L., Lemay, Jr, H. E, and Bursten, B. E. Chemistry: The Central Science. 7th ed. Upper Saddle River, NJ: Prentice Hall, 1997.

Skoog, D. A., Holler, F. J., and Crouch, S. R. Principles of Instrumental Analysis. 6th ed. Belmont, CA: Thomson: Brooks/Cole, 2007.

Yue, C. (2012). ESDA® Project. NYPD Police Laboratory.