# Exhibit 1

**BIOGRAPHY**

Larry F. Stewart was born in Asheville, North Carolina. He has earned an Associate of Arts degree from Florida Technological University in Orlando, a Bachelor of Science in Forensic Science degree from the University of Central Florida, also in Orlando and a Master of Forensic Sciences degree from Antioch University in Yellow Springs, Ohio. Mr. Stewart has worked for the U.S. Government as a forensic scientist for over 25 years. During that time he has worked on many notable cases to include; the Unabomber, the John Wilkes Booth diary, numerous accused Nazi war criminals, e.g. John Demjanjuk, a.k.a. Ivan the Terrible, the reinvestigation of the Dr. Martin Luther King murder, the reinvestigation of the Kennedy assassination/CIA conspiracy theory, the Quedlinburg Treasure, the 1933 Saint-Gaudens Double Eagle gold coin, the Jon Benet Ramsey murder investigation, the 9/11 terrorist attacks, the DC Sniper investigation and the 2010 Brazilian presidential election scandal . He has testified as an expert witness in state, federal and military courts of law, as well as testified or been deposed in foreign court systems to include; Austria, Australia, Canada, Germany, Sri Lanka, and Thailand. He has also testified at The Hague in the Netherlands and three times before the U.S. Congress. Mr. Stewart most recently held the position of Laboratory Director and Chief Forensic Scientist for the United States Secret Service. In that role, he managed up to 120 scientists, technicians, and support staff in the areas of document analysis, handwriting, fingerprints, trace evidence, audio and video analysis, photography, toolmarks, computer evidence and counterfeit analysis. In 2005, Mr. Stewart began the independent forensic consulting and investigative firm known as Stewart Forensic Consultants, LLC and its subsidiary, Global Investigative & Intelligence Services.

**RESUME**

Larry F. Stewart

**Occupation:**

Chief Forensic Scientist and President – Stewart Forensic Consultants, LLC
San Luis Obispo, California

**Education:**

Associate of Arts Degree - Received June 1976
Florida Technological University
Orlando, Florida

Bachelor of Science in Forensic Science Degree - Received August 1979
University of Central Florida
Orlando, Florida

Master of Forensic Sciences Degree - Received June 1983
Antioch University
Yellow Springs, Ohio

**Pertinent Specialized Courses:**
Forensic Microscopy Course - March 1978
McCrone Research Institute
Chicago, Illinois

Atomic Absorption Spectrophotometry - April 1979
Perkin-Elmer Corporation
Gaithersburg, Maryland

Gas Chromatography Course - December 1979
Virginia Polytechnic Institute and State University
Gaithersburg, Maryland

Advanced Gas Chromatography - March 1980
Perkin-Elmer Corporation

Advanced High Pressure Liquid Chromatography Course - January 1981
Virginia Polytechnic Institute and State University
Washington, DC (course location)

Ink and Paper Analysis Seminar - January 1981
U.S. Air Force
Office of Special Investigations
Washington, DC

High Pressure Liquid Chromatography/Mass Spectrometry - July 1981
U.S. Justice Department, F.B.I.
Quantico, Virginia

High Pressure Liquid Chromatography/Computer Operation - March 1984
Perkin-Elmer Corporation
Rockville, Maryland

Questioned Document Course - February 1985
U.S. Secret Service
Washington, DC

Fourier Transform Infrared Spectroscopy Course - June 1986
Nicolet Analytical Instruments
Lanham, Maryland

Scanning Electron Microscopy - September 1994
Philips Electronic Instruments
Mahwah, New Jersey

ASCLD/LAB Inspector Training Course – January 2000
Portland, Oregon

**Work Experience:**
December 1975 through March 1979
Laboratory Technician
University of Central Florida

March 1979 through September 1979
Internship
Bureau of Alcohol, Tobacco and Firearms

September 1979 through July 1982
Forensic Chemist
Bureau of Alcohol, Tobacco and Firearms

July, 1982 through June, 2005 (retired)
Counterfeit Specialist
Questioned Document Examiner
Lead, Instrumental Analysis Section
Lead, Instrumental and Computer Analysis Section
Senior Document Examiner/National Expert for the United States Secret Service
Chief, Questioned Document Branch
Assistant Laboratory Director

Laboratory Director/Chief Forensic Scientist
United States Secret Service

June 2005 to present
Chief Forensic Scientist and President
Stewart Forensic Consultants, LLC

**Instructor:**
Bureau of Alcohol, Tobacco and Firearms
Rockville, Maryland

United States Air Force, Office of Special Investigations
Special Investigator's Course
Washington, DC

United States Secret Service
Washington, DC

Federal Law Enforcement Training Center
Glynco, Georgia

Drug Enforcement Agency
Washington, DC

International Law Enforcement Academy
Budapest, Hungary

Naval Criminal Investigative Service
Washington, DC

Rochester Institute of Technology
Rochester, New York

Cuesta College
San Luis Obispo, California

California Polytechnic University

San Luis Obispo, California

**Guest Speaker:**
Montgomery College
October 1980
Rockville, Maryland

Antioch School of Law
November 1980 and February 1981
Washington, DC

Montgomery College
Ink and Paper Analysis/Instrumental Techniques - February 1982
Rockville, Maryland

DocSec'85
Document Security - May 1985
Washington, DC

George Washington University
Ink and Paper Analysis - February 1986
Washington, DC

Inspector Generals Office - Health and Human Services
Tri-regional Conference - January 1991
Mt. Pocono, Pennsylvania

Bolling Air Force Base
Joint Basic Computer Forensic Workshop - September 1993
Washington, DC

Virginia Military Institute
The Uses of Chemistry and Biology in the Forensic Sciences - April 1994
Lexington, Virginia

UCLA
Forensic Examination of Financial and Identity Documents – August 1998

American Society of Questioned Document Examiners meeting
Los Angeles, California

Catholic University
Science Under Oath – February 2000
Washington, DC

GATF Conference
Security Printing, Computers and the Forensic Scientist – August 2000
Pittsburgh, PA

Fraud Prevention Workshop
Security Printing – October 27, 2000
U.S. Department of State
Ft. Lauderdale, Florida

International Association for Identification
Forensic Science and Fraudulent Documents – May 2004
Sacramento, California

San Luis Obispo Criminal Bar Association
Getting the Most from Forensic Technology in Criminal Investigations – December 13, 2006
San Luis Obispo, California

California Association of Licensed Investigators
Counterfeits Are All Around Us! – February 2, 2007
Palm Springs, California

California Association of Licensed Investigators
Leveling The Playing Field - December 4, 2008
Pismo Beach, California

**Specialized Tours/Training:**
Crane-Weston Paper Mill
Dalton, Massachusetts - July 28, 1982

Philadelphia Mint

Philadelphia, Pennsylvania - July 29, 1982

Bureau of Engraving and Printing
Washington, DC - July 30, 1982

Visa International
San Francisco, California - January 3-6, 1984

Malco Plastics
Garrison Park, Maryland - January 1985

BIS CAP International, Ink Jet Printing Conference
Boston, Massachusetts - September 17-19, 1990

**Achievements:**
Participated as a "referee" in the 1980 Crime Laboratory Proficiency Training Program Forensic Sciences Foundation, Colorado Springs, Colorado

Testified in May of 1989 and 1990 before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, U. S. House of Representatives. These matters concerned the investigation of fraud in science.

Certified by the US Secret Service as an accredited Examiner of Questioned Documents, February 1, 1991.

Recipient of the Health and Human Services Inspector General's Integrity Award, 1991.

Appointed Chairman of A.S.T.M. task groups (1991) concerned with developing standards for performing "Writing Ink Comparisons" and "Writing Ink Identifications."

United States Delegate at the 14th European Meeting on Currency Counterfeiting, The Hague, The Netherlands, October 9-11, 1991 and the First International Conference on Fraudulent Documents, Ottawa, Canada, April 27- May 1, 1992.

United States Delegate at the 6th European Conference for Police and Government Experts, London, United Kingdom, October 2-4, 1996. Presented a paper on Ink Dating, Relative and Absolute: New Approaches to Old Problems.

Testified on July 22, 1999 before the House Judiciary Committee, Subcommittee on Immigration and Claims, U.S. House of Representatives. This matter concerned detection and prevention of counterfeit documents.

Classified as an “Inspector” for the American Society of Crime Laboratory Directors.

Elected to the Board of Directors for the American Society of Crime Laboratory Directors, September 14, 2000.

Elected to the Board of Directors for the Document Security Alliance, December, 2003.

Appointed as the forensic consultant for the United Nations, tasked with developing and implementing a successful forensic laboratory in Nigeria, Africa, 2007.

Elected to the Board of Directors for The Academy, June, 2007.

Certified Forensic Consultant, American College of Forensic Examiners Institute, October, 2007.

Appointed as a forensic consultant for the US Department of State, Bureau of International Narcotics and Law Enforcement Affairs in Yerevan, Armenia, January, 2008 (ongoing assignment).

Appointed as a forensic consultant for the US Department of State, Bureau of International Narcotics and Law Enforcement Affairs in Tbilisi, Georgia, May, 2008.

Elected to the Board of Directors for the American Board of Forensic Examiners, February, 2009.

**Original Research Publications/Presentations:**

"Detection of Volatile Accelerants in Fire Debris. 1. A Comparative Evaluation... " Richard A. Strobel, Richard A. Tontarski, Larry F. Stewart, Philip Wineman presented at the American Academy of Forensic Sciences, New Orleans, Louisiana, February 1980, and the Mid-Atlantic Association of Forensic Scientists, combined meeting, Louisville, Kentucky, May 1980.

"Artificial Aging of Documents," L.F. Stewart. Published in the Journal of Forensic Sciences, Vol. 27, No. 2, April 1982.

"Ballpoint Ink Age Determination by Volatile Component Comparison," L.F. Stewart, Presented at the American Academy of Forensic Sciences meeting, Orlando, Florida, February 1982, and Mid-Atlantic Association of Forensic Scientists/Northeastem Association of Forensic Scientists joint meeting, Harrisburg, Pennsylvania, April 1982.
Published in the Journal of Forensic Sciences, April 1985.

"The Role of the Secret Service in Counterfeit Deterrence," L.F. Stewart. Presented at the Mid-Atlantic Association of Forensic Scientists meeting, Baltimore, Maryland, April 1983.

"The Forensic Analysis of Printing Inks," Larry F. Stewart. Presented at the American Society of Questioned Document Examiners, Lake Tahoe, Nevada, September 1983.

"Counterfeit Credit Card Deterrence," Larry F. Stewart. Presented at the American Society of Questioned Document Examiners/Canadian Society of Forensic Scientists annual meeting, Montreal, Quebec, Canada, September 1985.

"Detection of Counterfeit Currency," Larry F. Stewart. Presented at the International Association of Identification conference, Arlington, Virginia, August 1987.

"Identification of United States Currency Security Fibers by Fourier Transform Infrared Spectroscopy," J.E. Brown and L.F. Stewart. Presented at the Canadian Society of Forensic Scientists annual meeting, Toronto, Ontario, Canada, October, 1988.

"U.S. Secret Service Ink Identification System," J.W. Hargett, J.E. Brown and L.F. Stewart. Presented at the Canadian Society of Forensic Scientists annual meeting, Toronto, Ontario, Canada, October 1988.

"Use of Enlargement Ratios of Negatives and/or Printing Plates to Characterize Counterfeit Currency," L.F. Stewart, R.L. Outland and J.E. Brown. Presented at the Canadian Society of Forensic Scientists annual meeting, Toronto, Ontario, Canada, October 1988.

"Current Status of Ink Age Determination," L.F. Stewart and S.L Guertin. Presented at the Ninth INTERPOL Forensic Science Symposium, INTERPOL Headquarters, Lyon, France, December 12, 1989. Published in INTERPOL International Criminal Police Review, March-April, 1991.

"A.S.T.M. Standard for Writing Ink Comparisons," L.F. Stewart and J.L. Becker

Presented at the Mid-Atlantic Association of Forensic Scientists 1991 meeting, Bethesda, Maryland, May 31, 1991.

"Standard Guide For Test Methods For Forensic Writing Ink Comparisons," L.F. Stewart (Task Group Chairman). Published in the American Society For Testing and Materials (ASTM), Standard Designation number E-1422-91, November 1991.

"Counterfeit Documents Produced by Color Copier Systems," L.F. Stewart, Presented at INTERPOL Headquarters, Lyon, France, December 11-19, 1991.

"Sentence Insertions Detected Through Ink, ESDA and Line Width Analysis," S.L. Fortunato and L.F. Stewart. Published in the Journal of Forensic Sciences, November 1992.

"Status of U.S.S.S. Ink Dating Program," J.W. Hargett and L.F. Stewart. Presented at the Humboldt University, Berlin, Germany, April 2, 1993. Published in Kriminalistik und Forensische Wissenschaften, No. 82, 1994.

"U.S.S.S. International Ink Library and Bulletin Board System," L.F. Stewart. Presented at the Mid-Atlantic Association of Forensic Scientists meeting, Baltimore, Maryland, May 20, 1993.

"Standard Guide For Test Methods For Forensic Writing Ink Identifications," L.F. Stewart (Task Group Chairman). Published in the American Society For Testing and Materials (ASTM), Standard Designation number E-1422, 1995.

"The Government Response to Ink Age Determination," L.F. Stewart, J.L. Becker. Presented at the American Academy of Forensic Sciences meeting, Seattle, Washington, February 17, 1995. Published in the International Criminal Police Review - INTERPOL, Spring, 1996.

“Distinguishing Between Relative Ink Age Determination and the Accelerated Aging Technique,” L.F. Stewart and S.L. Fortunato. Published in the International Journal of Forensic Document Examiners, January/March, 1996.

“Forensic Examination of Financial Crimes Documents,” L.F. Stewart and J.W. Hargett. Presented at the 6th European Conference for Police and Government Document Experts, London, United Kingdom, October 2-4, 1996 and the GFS Conference, Luzerne, Switzerland, September 9-12, 1997.

“Unusual Document Examination Approaches and Their Relationship to the Daubert Challenge,” L.F. Stewart. Presented at the American Board of Forensic Document Examiners meeting, Las Vegas, NV, June 23, 2002 and the American Society of Questioned Document Examiners meeting, San Diego, CA, August 14, 2002.

“Forensic Science – Fake Fingerprints?,” L.F. Stewart, Published in the Forensic Expert Witness Association, Fall, 2007.

"Leveling The Playing Field," L.F. Stewart. Presented at the California Association of Licensed Investigators, Central Coast meeting, Pismo Beach, California, December 4, 2008.

“Crime Scene Investigation,” L.F. Stewart, on-line course developed for and published by the American College of Forensic Examiners Institute, January 2009.

“Identity Theft,” L.F. Stewart, A-Z Literary Book Publisher, 2009.

“Document Examination,” L.F. Stewart, A-Z Literary Book Publisher, 2009.

“Forensic Science – Fake Fingerprints?,” L.F. Stewart, Published in the HG Experts Legal Experts Directory on-line publication, Spring, 2010.

“Forensic Science - The Good and the Bad,” L.F. Stewart, Published in the HG Experts Legal Experts Directory on-line publication, Spring, 2010.

“Forensic Science - Erroneous Handwriting Opinions,” L.F. Stewart, Published in the HG Experts Legal Experts Directory on-line publication, Spring, 2010.

“Forensic Handwriting Examination - Selecting Your Expert,” L.F. Stewart, Published in the HG Experts Legal Experts Directory on-line publication, Winter, 2011.

**Professional Affiliations:**
American Academy of Forensic Sciences - Fellow
Canadian Society of Forensic Scientists (past member)
American Society of Crime Laboratory Directors
Document Security Alliance (past member)
Mid-Atlantic Association of Forensic Scientists (past member)
California Association of Licensed Investigators

Forensic Expert Witness Association
American College of Forensic Examiners Institute
American Chemical Society
Association For Intelligence Officers
Business Espionage Controls & Countermeasures Association

**Offices Held:**
Mid Atlantic Association of Forensic Scientists
Secretary/Treasurer
November 1981 to October 1984.

American Society of Crime Laboratory Directors
Board of Directors
September 14, 2000 to September, 2003

Document Security Alliance
Board of Directors
December 2003 to November 2004

The Academy
Board of Directors
June, 2007 to present

American Board of Forensic Examiners
Board of Directors
February, 2009 to December, 2009

**Contact Information:**
Physical Address:
Stewart Forensic Consultants, LLC
570 Peach Street, #30
San Luis Obispo, California 93401

Additional Office:
Stewart Forensic Consultants, LLC
1629 K Street, NW
Suite 300

Washington, DC 20006

Mailing Address:
Stewart Forensic Consultants, LLC
793A East Foothill Boulevard, Suite 200
San Luis Obispo, California 93405

Tel/Fax: (805) 595-1333/3333, Cell: (202) 550-6233
Email: contact@stewartforensicconsultants.com
Website: http://www.stewartforensicconsultants.com

**Larry Stewart Partial Case Citations:**

| Case Number | Date | Citation | Location |
|---|---|---|---|
| 4704-0280-0001 V | 11/13/80 | US v. Grady Ingram | Richmond, VA |
| OK-469 | 12/11/80 | MD v. Wrublesk | Upper Marlboro, MD |
| 9BKF-1245 | 3/9/81 | Follies Lounge | Memphis, TN |
| II-376 | 3/27/81 | Joseph Berry/ Dr. C. Woolpert | Lansing, MI |
| II-360 | 5/27/81 | Jerry Simmons | Alamagordo, NM |
| OK-93 | 6/4/81 | Vermont v. Warner | Newport, VT |
| 11-400 | 7/28/81 | FL v. Osbome Pryor | Crestview, FL |
| 1DI-454 | 12/8/81 | US v. Barry Fakier | Tampa, FL |
| 2I-241 | 4/30/82 | 213-CO-8SO3-6 | St. Louis, MO |
| 2I-583 | 10/19/82 | US v. P. Norman | Miami, FL |
| 2I-583 | 10/19/82 | US v. S. Norman | Miami, FL |
| 83-143 | 5/18/83 | US v. Leard E. Lisk | Winston Salem, NC |
| 83-118 | 7/21/83 | US v. Senator Broadwater | Baltimore, MD |
| 83-066 | 7/28/83 | US v. Zaldivar | Miami, FL |
| 82-344 | 9/19/83 | US v. Charles A. Bamman | Richmond, VA |
| 83-298 | 10/6/83 | Allen Weideman | Salt Lake City, UT |
| 83-116 | 11/28/83 | US v. Azanan | Miami, FL |
| 108-18501-5 | 1/26/84 | US v. Dominic Marino | New York City, NY |
| 83-256 | 2/28/84 | US v. Sonia L. Goranson | Kalamazoo, MI |
| J-223-2059-S | 5/7/84 | Tire Town | Springfield, MO |
| J208-CO-9046-1 OC | 6/5/84 | US v. W. Sandridge | Kansas City, MO |
| J105-COI-33756-7 | 7/26/84 | US v. Debardeleben | Charlotte, NC |

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|---|---|---|---|
| J318-711-8416-1 | 10/22/84 | US v. J. Gunter | Tampa, FL |
| OK-917 | 3/21/85 | Ponder v. State Farm Ins. | Dover, DE |
| 135-711-10164-1 | 6/18/85 | US v. Sherman | Wimington, DE |
| 318-711-8500608-INC | 7/18/85 | US v. Walker | Tampa, FL |
| 205-711-8389-1 | 8/7/85 | US v. Griffin | Detroit, MI |
| 331-711-8500522 | 10/22/85 | US v. Frank Shinn | Dothan, AL |
| 307-CO-8466-2 | 1/22/86 | US v. Billy Joe Crabb | Jacksonville, FL |
| 327-711-8600957 | 5/21/86 | US v. Banbury | Orlando, FL |
| J108-768-189950-S | 5/27/86 | US v. Rice | New York City, NY |
| 419-711-10902-1 | 2/4/87 | Aryan Nations - David Ross Dorr | Tucson, AZ/Spokane, WA |
| J205-712-57394-S | 2/9/87 | US v. Lynch | Detroit, MI |
| 311-769-31956 | 5/4/87 | Robert Spoillo | Ft. Lauderdale, FL |
| 327-711-8600957 | 9/14/87 | US v. Rentfrow | Orlando, FL |
| 417-711-12464-1 | 5/11/88 | US v. XXXXXX | Las Vegas, NV |
| 404-711-12464 | 7/26/88 | US v. XXXXYX | Phoenix, AZ |
| 108-711-12366 | 9/14/88 | US v. Mills | New York City, NY |
| 145-712-1446 | 10/5/88 | US v. Cumber | New Bern, NC |
| 175-865-6215 | 11/17/88 | US v. Streissel | Baltimore, MD |
| 302-711-12050-1 | 1/4/89 | US v. Barnette | Birmingham, AL |
| 327-848-5728-S | 2/6/89 | FL v. Scrima | Orlando, FL |
| 175-865-5768 | 5/4/89 | US House of Representatives- Subcommittee on Oversight and Investigations | Washington, DC |
| 327-848-5728-S | 5/10/89 | FL v. Tripensee and Evans | Orlando, FL |
| 175-865-6351 | 6/5/89 | Crown v. Peabody | Toronto, CANADA |

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| 175-865-6351 | 7/7/89 | Crown v. Peabody | Toronto, CANADA |
| 108-711-12080-20 | 10/11/89 | US v. Upfalow | New York City, NY |
| 175-865-8585 | 10/18/89 | DE v. Huang, M.D. | Dover, DE |
| 115-711-9863 | 11/1/89 | US v. Chbeir | Alexandria, VA |
| 175-865-10156 | 3/23/90 | Crown v. Finta | Toronto, CANADA |
| 175-865-5768 | 5/14/90 | US House of Representatives-Subcommittee on Oversight and Investigations | Washington, DC |
| 175-865-08430 | 8/7/90 | US v. Bryan, MD | Harrisburg, PA |
| 327-712-6025-S | 8/6/90 | US v. Hill | Orlando, FL |
| J134-711-11872-1 | 10/5/90 | US v. Green | Roanoke, VA |
| 175-865-6351 | 10/9/90 | Crown v. Peabody | Toronto, CANADA |
| 303-712-32541-S | 11/6/90 | US v. Paul Smith | Lubbock, TX |
| 175-865-12178 | 1/30/91 | US v. Eric Miller | Washington, DC |
| 175-865-11665 | 3/29/91 | US v. Flake | New York City, NY |
| 318-711-13649 | 4/30/91 | US v. Weidick | Tampa, FL |
| 327-722-6171 | 5/14/91 | US v. Pascal | Orlando, FL |
| 209-712-24892 | 6/13/91 | US v. Adkins | New Albany, IN |
| 175-865-58596 | 6/27/91 | CA v. Jarvis Masters | Marin Co., CA |
| 175-865-14220 | 11/25/91 | US v. 90-CR-494 | New York City, NY |
| 105-712-42757 | 2/20/92 | US v. XXXXYX | Winston Salem, NC |
| 213-711-13198 | 3/9/92 | US v. Shinkle | St. Louis, MO |
| 429-711-14342 | 3/26/92 | Sri Lanka v. Fadi Hassan Sinno | Colombo, SRI LANKA |
| 332-711-15490 | 6/16/92 | Dacasta Brown | W. Palm Bch., FL |
| 175-865-16113 | 7/16/92 | US v. Kwong | New York City, NY |

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| 175-865-16328 | 8/18/92 | US v. Purvis & Varick | Washington, DC |
| 175-711-7917 | 8/19/92 | MD v. Mercado | Rockville, MD |
| 175-865-15788 | 11/6/92 | IN v. Leon | Lafayette, IN |
| 311-725-38258-S | 11/19/92 | US v. Thimot | Miami, FL |
| 227-712-01610-S | 3/9/93 | KY v. Salisbury & Hicks | Lexington, KY |
| 175-865-18729 | 6/9/93 | US v. Varricchio | White Plains, NY |
| 175-865-18768 | 6/22/93 | Crown v. Aguilera | Toronto, CANADA |
| 175-865-19474 | 9/9/93 | US v. Breyer | Philadelphia, PA |
| 175-865-18768 | 1/26/94 | Crown v. Aguilera | Toronto, CANADA |
| 175-865-19450 | 3/23/94 | International Atomic Energy Agency Tribunal | Vienna, AUSTRIA |
| 175-865-21167 | 6/15/94 | Foster v. Bray | Scottsville, KY |
| 175-865-18768 | 7/12/94 | Crown v. Aguilera | Toronto, CANADA |
| 175-865-16113 | 8/4/94 | US v. Kwong | New York City, NY |
| 305-727-37950 | 10/4/94 | TX v. Hinkle | Houston, TX |
| 175-865-13876 | 10/18/94 | PR v. Antonsanti | San Juan, PR |
| 175-865-22060 | 10/24/94 | Northrup v. H.H.S. | Washington, DC |
| 331-711-8320S | 11/30/94 | US v. Trotter | Montgomery, AL |
| 175-865-23504 | 6/21/95 | US v. Ciurinskas | Hammond, IN |
| 175-865-5768 | 8/29 thru 9/1/95 | HHS v. Theresa Imanishi Kari, PhD. | Washington, DC |
| 101-848-36875 | 7/24/96 | MD v. Massie | Hagerstown, MD |
| 175-865-32534 | 6/20/97 | US v. Gaines | Boston, MA |
| 175-865-28839 | 4/25/97 | FL v. Arnold | Milton, FL |
| 175-865-28839 | 8/14/97 | FL v. Arnold | Milton, FL |
| 175-865.000 | 7/22/99 | US House of Representatives- | Washington, DC |

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| | | Subcommittee on<br>Immigration and Claims | |
| 175-848-36882 | 1/31/00 | US v. Hasson | Miami, FL |
| 175-865-43557 | 5/30/01 | US v. Demjanjuk | Cleveland, OH |
| 175-865-00000 | 2/04 | US v. Martha Stewart/<br>Peter Bacanovic | New York, NY |
| 07-01-400 | 1/31/07 | Lemus v. St. Francis<br>Medical Center | Los Angeles, CA |
| 07-03-100 | 3/14/07 | CA v. Brock Collette<br>report used in lieu of testimony | Sutter Co., CA |
| 07-02-400 | 3/22/07 | Joohak Kim v. Saehan Bank | Los Angeles, CA |
| 07-02-400 | 3/29/07 | Joohak Kim v. Saehan Bank | Los Angeles, CA |
| 07-05-100 | 5/1/07 | Frances Emeribe v.<br>Kinsley Emeribe | West Covina, CA |
| 07-08-400 | 8/29/07 | CA v. Jack Quigley | Fresno, CA |
| 07-09-200 | 9/9/07<br>report used | US v. Jordan Leonard<br>in lieu of testimony | Hammond, IN |
| 06-04-100 | 9/20/07<br>(ongoing) | Sandhoff v. Fjaeran | San Diego, CA |
| 06-08-200 | 10/11/07 | Sharon Mogavero v. CCSF, LLC<br>X-Ref. A522115 | Las Vegas, NV |
| 07-06-100 | 10/19/07 | Plant Insulation Co. v.<br>Fireman's Fund Ins., et al<br>X-Ref. CGC-06-448618 | San Francisco, CA |
| 07-08-100 | 11/29/07 | CA Dept. of Health Svs.<br>v. Alberto Salcedo, M.D.<br>Appeal SR5-1104-267-DN | Los Angeles, CA |
| 07-06-200 | 02/08 | CA v. Scott Ernst | Yuba City, CA |
| 08-03-100 | 03/21/08 | CA v. A.D. Webb<br>Case No. BF119087A | Bakersfield, CA |
| 07-06-100 | 05/29/08 | Plant Insulation Co. v.<br>Fireman's Fund Insurance<br>Case No. CGC 06 448618 | San Francisco, CA |

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| 08-09-200 | 11/7/08 | CA v. Jason Langdon<br>Case No. VCF204177A | Visalia, CA |
| 08-11-300 | 12/31/08 | CA v. Mark Ortega<br>Case No. F08902271 | Fresno, CA |
| 09-04-200 | 06/15/09 | Pradia v. Gulart<br>Case No. PR 080076 | San Luis Obispo, CA |
| 09-02-200 | 08/11-12/09 | AL v. Gissendanner<br>Case No. CC-01-350.60-Q | Ozark, AL |
| 09-09-100 | 11/06/09 | Estate of David Almquist<br>INP 021189 | Palm Springs, CA |
| 09-08-400 | 12/8/09 | Lafayette Life v.<br>Gabriellian, et al<br>Case No. BC398076 | Los Angeles,CA |
| 09-08-500 | 12/17/09 | Third Eye Blind v.<br>Eric Godtland, et al | San Francisco, CA |
| 09-09-600 | 01/19-20/10 | BC Supreme Court Action<br>Number: S045170<br>Elsen v. Elsen | Vancouver, BC<br>CANADA |
| 10-02-200 | 03/25/10 | Lake Forest MCA v. NTS, et al<br>07-CA-1867-16 | Sanford, FL |
| 09-09-100 | 03/26/10 | Estate of David P.<br>Almquist<br>INP 021189 | Palm Springs, CA |
| 10-05-100 | 05/18-20/10 | Germany v. John Demjanjuk<br>Ladgericht Munchen II<br>Regional Court Munich II<br>1st Criminal Division | Munich, Germany |
| 10-06-100 | 06/04/10 | BC Supreme Court Action<br>No. H070296<br>Hoffman, et al v. Percheson<br>and Micra Capital, Inc. | Vancouver, BC<br>CANADA |
| 10-05-100 | 06/8-10/10 | Germany v. John Demjanjuk<br>Ladgericht Munchen II<br>Regional Court Munich II<br>1st Criminal Division | Munich, Germany |
| 09-12-100 | 08/27/10 | Ralph Gianella v.<br>Big Rock, LLC | San Diego, CA |

| | | | |
|---|---|---|---|
| | | Case No. 37-2007-00081541 | |
| 10-06-400 | 08/31/10 | Vanderbilt Mortgage v. Clayton Homes<br>Case No. 09-08-48240-CV | Santa Barbara, CA |
| 09-08-400 | 09/09/10 | Lafayette Life Ins.<br>Leo Gabrielian<br>Case No. BC398076 | WestLake Village, CA |
| 10-06-400 | 11/15-16/10 | Vanderbilt Mortgage v. Clayton Homes<br>Case No. 09-08-48240-CV | Corpus Christie, TX |
| 10-11-300 | 1/31-2/1/11 | Shlimovich v. Cheban<br>LASC Case No. BC408095 | Beverly Hills, CA |
| 10-11-300 | 2/23/11 | Shlimovich v. Cheban<br>LASC Case No. BC408095 | Beverly Hills, CA |
| 10-11-300 | 3/24-25/11 | Shlimovich v. Cheban<br>LASC Case No. BC408095 | Los Angeles, CA |
| 10-11-300 | 4/1/11 | Shlimovich v. Cheban<br>LASC Case No. BC408095 | Los Angeles, CA |
| 11-03-100 | 5/3/11 | Rivera v. Costco<br>003632-248049-PL-01 | Irvine, CA |
| 10-12-300 | 5/31-6/1/11 | Masood v. Safeco<br>Circuit Court<br>CV 0907 0070 | Oregon City, OR |
| 11-03-400 | 7/11/11 | Nevis v, Nevis<br>Superior Court<br>FL 06-1500 | San Luis Obispo, CA |
| 12-01-300 | 1/24/12 | Richard S. Backlund Family Trust<br>Superior Court<br>PR 10 0312 | San Luis Obispo, CA |
| 11-03-100 | 2/1/12 | Rivera v. Costco<br>Superior Court<br>003632-248049-PL-01 | Santa Ana, CA |
| 11-01-300 | 2/15/12 | Estate of Eileen Mochson<br>SP 007 890 | Los Angeles, CA |
| 11-03-500 | 2/28/12 | People v. Juan Rios | Sacramento, CA |

| | | | |
|---|---|---|---|
| | | 10F03778 (sworn declaration submitted in lieu of testimony) | |
| 11-12-200 | 4/17/12 | FL v. Gerald Murray<br>Circuit Court<br>Case No, 92-3708 CFA | Jacksonville, FL |

# Exhibit 2

http://www.opticsinfobase.org/as/abstract.cfm?id=123812

http://www.rmimaging.com/information/fine_art_paper.html

http://www.gcrio.org/UNEP1998/UNEP98p62.html

# Suspect Documents

## THEIR SCIENTIFIC EXAMINATION

Second Impression with Supplement 1966

BY

WILSON R. HARRISON, M.Sc., Ph.D.

*Director, Home Office Forensic Science Laboratory, Llanishen, Cardiff*

LONDON

SWEET & MAXWELL LIMITED

bacterial action as it is a volatile disinfectant, although it is of doubtful efficiency against moulds.

A new and most promising development in the protection of documents against the destructive effect of insect and microbiological attack is the use of either pentachlorphenol or its sodium salt. These compounds were first manufactured in 1936 and distributed by the Monsanto Chemical Company and were marketed under the names of Santophen 20 and Santobrite. Santophen 20 is nowadays sold under the trade name of Monsanto Penta.[4] These products are toxic to a wide range of micro-organisms. They are low in cost and their physical and chemical properties enable them to be used for the preservation of documents.

Work in this connection has been carried on by the experts at the British Museum in conjunction with the Record Office, House of Lords.[5] Their recommendations include the use of tissue paper impregnated with Pentachlorphenol as an interleaving for any documents which are susceptible to attack. There is no need to introduce the tissue between each page of a book—the normal usage is to have one sheet of tissue to approximately every eight pages. The protective agent is sufficiently volatile to impregnate the book sufficiently to check the growth of fungus and bacteria, and also to check insect attack at the same time. The impregnated tissue should be prepared by first soaking tissue paper in a 10 per cent. aqueous solution of Santobrite, and then draining and drying. John Dickinson, the well-known paper makers, supply double crown 9 lb. tissue paper impregnated with Santobrite to H.M. Stationery Office for this purpose. This material has proved of considerable assistance in preserving documents in hot humid climates.

There is no reason why envelopes made of stout paper which has been impregnated in this way should not be used for the storage of documents under difficult conditions of heat and humidity.

Glue or paste is protected by including about one part in two hundred of Santobrite, whilst glue-size or parchment-size is adequately protected by half this concentration. If there has been a serious attack these concentrations may be increased. Incidentally, experiments have shown that the paste and glue are better made up with distilled water. If used in the concentration stated, there should be no danger to health in the handling of these chemicals, which seem to confine their toxicity to vegetable and insect life. The odour associated with these substances is so slight as to be unnoticeable, even when they are used in the maximum concentrations advised.

### Action of Light on Documents

Very few materials of either animal or vegetable origin are unaffected, either in colour or strength, by exposure to sunlight; paper and ink are no exceptions. The deep yellowing of the cheaper grades of paper and the rapid fading of coloured inks, especially those used in typewriter ribbons, when they are exposed to sunlight immediately spring to mind in this connection. Eventual deterioration is experienced by the best qualities of paper and the majority of inks, only the process takes longer.

[4] " Monsanto," Technical Service Bulletins, Nos. 12D/5, 2D2.
[5] The Record Office, House of Lords. Reports for 1951–52, –53.

It follows from this that the exposure to strong sunlight of important documents should be restricted to the absolute minimum, especially if the documents bear coloured ink or typescript.

In the course of laboratory examination, documents may have to be exposed to powerful sources of ultra-violet light or infra-red radiation. It should be borne in mind that a short exposure to a powerful source of ultra-violet radiation is likely to do far more harm than months of exposure to ordinary daylight. Infra-red sources will cause a serious rise in the temperature of a document unless suitable precautions are taken with respect to ventilation. It should be a matter of routine to mask as much of the document as possible and to use all possible means to decrease the time of exposure.

Exposure to strong light also tends to make paper brittle. If the temperature of paper is raised even to the boiling point of water it soon becomes very fragile, and may even crumble to dust on being handled after some hours of exposure to these conditions.

## Photographs

Photographic reproductions on a paper base are even more subject to deterioration than other documents because of the heavily loaded paper and the presence of a layer of gelatine which holds the image-forming material. This is why the conditions under which photographs should be stored are dealt with in some detail in Chapter 6.

## Protection of Documents from the Effects of Handling

Being an excellent absorbent of both oil and water, paper is profoundly affected by perspiration; the deleterious effects of constant handling on paper may be seen by examining a reference book which is in fair demand. As important documents should be subjected to the minimum of contact with the hands, they should be kept in transparent envelopes of ample size. In this recommendation, the word " ample " is significant, because nothing is worse for a document than being thrust in and out of an envelope which is just about large enough to accommodate it.

The celluloid map-cases used by the Armed Forces make excellent temporary containers for documents which are subjected to the unavoidable handling involved in the course of court proceedings. Their disadvantages are bulk, expense and fire-risk, but these are outweighed by their unrivalled strength and transparency.

Where these rigid containers are not available, envelopes made of heavy-gauge polythene or cellophane make good substitutes.

Whilst plastic containers are excellent for the temporary protection of documents, they should never be used for permanent storage. Many plastics slowly evolve vapour, generally from the plasticiser almost invariably present, and this has been blamed for the deterioration of documents after long storage in such containers. With celluloid there is an added risk; not only is this plastic extremely inflammable, but it evolves dangerous fumes at temperatures considerably below those which cause paper to char.

For more permanent storage, box files should be used. The Record Office, House of Lords Library, uses box files of the following specifications. Two sizes

**Applied Spectroscopy**
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# Depth Profiling of a Photochemically Yellowed Paper. Part II: FT-IR Techniques

Ingegerd Forsskåhl, Eija Kenttä, Pirjo Kyyrönen, and Olavi Sundström

Applied Spectroscopy, Vol. 49, Issue 2, pp. 163-170 (1995)

View Full Text Article

Acrobat PDF (818 KB)



## Abstract

A strongly photo-yellowed paper, whose surface had been ground off to different depths, was subjected to various Fourier transform infrared (FT-IR) techniques, including attenuated total reflectance (ATR), diffuse reflectance (DRIFT), photoacoustic (PA), and potassium bromide pellet (KBr) spectroscopy. Depth profiling of the paper was accomplished by monitoring specific infrared bands which showed systematic and consistent changes caused by irradiation. The results from the different Fourier transform infrared techniques were compared.

**Citation**
Ingegerd Forsskåhl, Eija Kenttä, Pirjo Kyyrönen, and Olavi Sundström, "Depth Profiling of a Photochemically Yellowed Paper. Part II: FT-IR Techniques," Appl. Spectrosc. **49**, 163-170 (1995)
http://www.opticsinfobase.org/as/abstract.cfm?URI=as-49-2-163



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# UV Damage to Polymers

The chemical pathways by which common polymers photodegrade are fairly well known, but various aspects of the mechanisms involved remain unelucidated. However, it is important to take into account very significant influence of compounding additives in modifying these pathways (Gugumus, 1993). Typically, these are pigments, extenders, photostabilizers and thermal stabilizers. For instance, the effect of flame-retardant additives on the photodegradation of several common polymer compositions was reported recently (Torikai et al. 1998, 1993a-c). Virtually all plastics products are manufactured using extrusion, injection molding, or extrusion blowing. The processing of polymers using heat and high shear into useful end products introduces impurities and reaction products that make them susceptible to photodegradation. Because of these complications, the extrapolation of research findings on UV-induced degradation of pure polymer resins to compounded and processed products of the same polymer, is often unreliable. Photodegradation data generated on the actual polymer formulations used in practice, processed in the conventional manner are the most useful for assessment of damage.

The many concurrent chemical processes taking place in polymers exposed to UV radiation result in several different modes of damage, each progressing at a different rate. It is usually the critical first-observed damage process that determines the useful service life of the product. For instance, poly(vinyl chloride), PVC, window frame exposed to sunlight undergoes discoloration, chalking, loss of impact strength, and a reduction in tensile properties as well as a host of other chemical changes. It is, however, the discoloration (or the uneven yellowing) of the window frame that generally determines its service life [Ho, 1984]. The consumer may demand its replacement based on this criterion alone. In most developing countries, however, these products often continue to be used despite changes in appearance or evenfal stages of damage becomes apparent. With continued use, however, other damage such as chalking and eventually loss of impact

resistance (leading to cracking) can occur making the product even more unacceptable. The two critical modes of photodamage applicable to most natural and synthetic materials are yellowing discoloration and loss in mechanical integrity.

*Yellowing Discoloration.* Both natural biopolymer materials and synthetic polymers undergo UV induced discoloration, usually an increase in the yellowness on exposure. Lignocellulosic materials such as wood and paper readily undergo light-induced yellowing (Hon et al., 1991). While both cellulose and lignin constituents of wood can photoyellow, it is the latter that is mostly responsible for the phenomenon. Lignin, which comprises 29-33% by weight of softwood, contains numerous chromophores that efficiently absorb UV radiation (Heitner, 1993). As much as 80-95% of the absorption coefficient of wood can be ascribed to the lignin fraction. The complex photochemistry of yellowing in lignin-containing materials is not completely understood; the present understanding of the process was succinctly summarized recently (Forsskåhl et al., 1993) and at least four pathways of photodamage have been recently discussed. The practical interest in discoloration relates specially to newsprint paper made of groundwood pulp that yellows rapidly on exposure to sunlight. Action spectra for photoyellowing of these pulps have been reported, and a recent study (Andrady et al., 1991) confirms the solar UV wavelengths to cause yellowing while the wavelengths in the region of 500 nm to 600 nm was shown to photobleach the pulp. The cellulose fraction in wood also undergoes a free radical mediated degradation on exposure to wavelengths < 340 nm.

The photodamage to wool has serious economic implications in large producer countries. Exposure of wool keratins to sunlight is well known to cause yellowing, bleaching, and main-chain scission of the proteins (Lennox et al., 1971). Launer (Launer, 1965) established that visible radiation in sunlight causes photobleaching of wool while the UV wavelength causes photoyellowing. Based on Lennoxdata (Lennox et al., 1971), the most effective yellowing wavelengths were in the UV-A region (340 -420 nm). As ozone layer depletion results in an increase in both UV B as well as UV A content of sunlight, wool appears to be a material that might be particularly affected.

Preliminary data on the photostability of Chitosan, another commonly found biopolymer, were recently reported (Andrady et al., 1996). While not

used commercially in high volume, the biopolymer occurs widely in nature in fungal cell walls, crustacean exoskelton and in insect tissue. Ultraviolet radiation in the wavelength range 250 nm to about 340 nm was reported to cause changes in the average molecular weight as determined by solution viscosity as well as the absorbance (at 310 nm) in chitosan derived from crab shells. The damaging role of UV-B in creating free+radicals in human hair has also been reported (Jahan et al., 1987) but no quantitative spectral sensitivity data are available.

Of the synthetic polymers, poly(vinyl chloride), PVC, is best-known for its tendency to undergo photoyellowing. The photothermal mechanisms leading to the formation of conjugated polyenes that causes yellowing, is well understood (Decker, 1984: Gardette et al., 1991). An opacifier (generally rutile titania) is used to slow down the rate of yellowing in white profiles widely used in siding, window frames and pipes (Titow, 1984 ). The reaction is localized in the surface layers of the polymer specially in opaque formulations used in building applications. The activation energy for dehydrochlorination is reported to have a temperature coefficient of 8-18 kJ mol-1 suggesting this process to be readily enhanced at high temperatures (Owen, 1984). As with wool and paper, while the UV-wavelengths cause yellowing of PVC the visible radiation >400 nm tend to cause photobleaching. Several possible photobleaching mechanisms are reported in the literature but the process is little understood.

A second polymer used in building applications, mainly as glazing, is polycarbonate. When irradiated with short wavelength UV-B or UV-C radiation polycarbonates undergo a rearrangement reaction (referred to as a photo-Fries rearrangement). At low oxygen levels this reaction can yield yellow-colored products such as o-dihydroxy-benzophenones (Rivaton et al., 1988). But when irradiated at longer wavelengths (including solar visible wavelengths) in the presence of air, polycarbonates undergo oxidative reactions that result in the formation of other yellow products (Factor et al., 1987). However, neither the detailed mechanisms nor the specific compounds responsible for the yellow coloration have been fully identified (Factor, 1995). Monochromatic exposure experiments on the wavelength sensitivity of several degradation processes of bis-phenol A polycarbonates have been reported recently (see Table 7.2).

Polystyrene, widely used in both building and packaging as expanded

foam, also undergoes light-induced yellowing· The presence of air retards the process and the origin of the coloration is again not clear. It is variously attributed to conjugated polyene, various oxygenated species, or products of ring-opening reactions (Rabek et al., 1995).

Table 7.2 Spectral sensitivity data from monochromatic exposure experiments.

| Material Type | Damage Studied | B | $r^2$ | Ref |
|---|---|---|---|---|
| 1. Poly(vinyl chloride) | | | | |
| 1.1 rigid compound - 0% TiO2 | Yellowing | -0.035 | 0.95 | 1 |
| - 0% TiO2 | | -0.048 | 0.99 | |
| - 2.5% TiO2 | | -0.058 | 0.98 | |
| - 5.0% TiO2 | | -0.073 | 0.99 | |
| 1.2 plasticized compound | Stiffness change | -0.02 | 0.83 | 2 |
| 2. Polycarbonate | | | | |
| 2.1 rigid sheets | Yellowing | -0.082 | 0.99 | 3 |
| 2.2 films | Quantum Yield of chain scission | -0.044 | 0.99 | 4 |
| | Change in Absorbance | -0.059 | 0.88 | 5 |
| 3. Poly(methyl methacrylate) | Quantum Yield of chain scission | non-linear | | 6 |
| 4. Lignocellulose | | | | |
| 3.1 mechanical pulp | Yellowing | -0.011 | 0.99 | 7 |
| 5. Chitosan | | | | |
| 5.1 Chitosan films | Absorbance at 310 mm. ( 260 -320nm) | -0.017 | 0.89 | 8 |

| | | | | |
|---|---|---|---|---|
| | Viscosity | non linear | | |
| 6. Wool | Yellowing | -0.025 | 0.95 | 9 |

Note: r is the correlation coefficient

References 1- [Andrady, 1989] 2- [Warner et.al., 1966] 3- [Andrady et.al., 1992]

4- [Torikai et.al., 1993a] 5- [Fukuda et.al. 1991] 6- [ Mitsuoka et.al., 1993]

7- [Andrady et.al. 1991] 8- [Andrady et.al., 1996] 9- [Lennox et.al 1971]

*Loss of Mechanical Integrity*. The loss of strength, impact resistance, and mechanical integrity of plastics exposed to UV radiation is well known. These changes in bulk mechanical properties reflect polymer chain scission ( and/or cross linking) as a result of photodegradation. Changes in solution viscosity and the gel permeation characteristics of polymers have been used (Torikai et.al.; 1993) to establish molecular changes during photodegradation.

With polyethylene and polypropylene, the loss of useful tensile properties on exposure to solar radiation is a particular concern. These are used extensively in agricultural mulch films, greenhouse films, plastic pipes, and outdoor furniture. Polyethylene films exposed to solar UV-B radiation readily lose their extensibility and strength (Hamid et al. 1991, 1995) as well as their average molecular weight (Andrady et. al., 1993). General features of the mechanism of photodegradation in both polyethylene and polypropylene is fairly well understood (Allen, 1983: Rabek, 1995). The mechanism is one of thermooxidative or photooxidative degradation rather than of direct photolysis, and is catalyzed by the presence of metal compounds. The free radical pathways that lead to hydroperoxidation and consequent chain scission are fairly well understood (Shlyapnikov et al., 1996). Of the polymers used worldwide, polyethylene enjoys the largest annual volume. Research interest in understanding and controlling the photdegradation process of this polymer is therefore continuing. Efficient classes of light stabilizers such as the hindered amine light stabilizers (HALS) are used to ensure that adequate lifetimes are obtained in polyolefin products intended for outdoor use under a wide range of UV environments.

Poly(vinyl chloride) PVC, is used widely in building applications where the impact strength of the material is an important requirement. The projected consumption of PVC in the near future (1995 -2010) is much higher in the developing world and cin countries in transition. Estimated demand for Asia alone is more than that for the US, Canada and the European community combined(Gappert, 1996). Exposure to solar UV radiation is well known to decrease the impact strength of the polymer (Decker, 1984). As the surface layers of the plastic material degrades the titanium dioxide powder used as an opacifier is gradually released and may even form a surface layer loose enough to be rubbed off. This is responsible for "chalking" of extensively exposed PVC siding materials. Both the tensile strength and the extensibility of rigid PVC samples also decrease with the duration of exposure to solar UV radiation and the material finally embrittles (Decker, 1984). Similar changes also take place on exposure of plasticized PVC formulations used in membrane roofing applications and cable coverings (Matsumoto et al., 1984).

Other common polymers shown in Table 7.1 also undergo a loss in mechanical strength on photodegradation. A rapid change in the mechanical integrity of polystyrene caused by extensive chain scission during the photodegradation has been reported (Ghaffar et al.,1976).

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Home TOC

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# Paper for Fine Art

Once you have a fine art image ready for printing you are faced with the decision of which paper to use. Assuming you already have a printer, the selection of ink is usually made for you, just get the printer manufacturer's inks. So the decision is which paper to use with your printer's inks. When it comes to fine art printing there are two major criteria for selecting a paper; the longevity of the paper/ink combination and whether the paper has optical brighteners.

## Longevity

When a print is exposed to light a process of change begins. This can be a fading of the ink, a yellowing of the paper, or a variety of other effects. Atmospheric agents such as ozone, sulfur and other chemicals can also effect the print. The lifetime of a print is measured by comparing prints exposed to various factors such as visible light, UV light, heat, ozone and other agents, against reference prints kept in the dark. Measurements are made of the inks and paper, compared to visual tolerances and a lifetime prediction is made. This lifetime represents the amount of time the print can be exposed under normal conditions before it changes objectionably. Since all the artists I've known want their art to last, paper and ink combinations should be selected with long lifetimes.

There are two places to check paper/ink ratings. The first is with Wilhelm Research. His website has ratings for most of the printer inks and many of the available papers.

The second place for paper/ink ratings is Aardenburg Imaging & Archives. This is a newer site with some interesting methods of testing archival qualities in the

laboratory and in situ.

# Brighteners

Everyone likes white things bright. At least this is what the soap and bleach manufacturers have been telling us for decades in their advertisements. Paper naturally has a yellowish color, due to the materials used in its construction, such as wood pulp or cotton fibers. To counteract this natural yellowness, paper makers add optical brighteners, also called fluorescent whitening agents, to the paper. Their effect is to make the paper look whiter and brighter by converting invisible ultraviolet light to visible blue light. The extra blue reflected light added to the natural yellow paper color makes the paper looks brighter and whiter.

Another benefit to using paper brighteners is to even out the variations between paper batches, making the paper consistent and predictable.

So if optical brighteners and fluorescent whitening agents make the paper whiter and brighter, what is so bad about using them in papers for fine art printing?

Artists want their works to last for a long time. They go to great lengths to select long lasting inks and papers for their reproductions. Some optical brighteners fade after a few months, changing the appearance of the print. If the brightener does not fade, then the whiteness of the print will appear differently depending on the amount of ultraviolet light present in the illumination. If a print is prepared by the photographer and printer for one type of lighting, but ultimately displayed by the customer in a different lighting, the paper's optical brighteners may make the print no longer match the original or the artist's intention.

In my opinion, when it comes to optical brighteners in fine art prints, **"Just say No!"**.

# Detecting Brighteners

The question then becomes how to check if your paper has these brighteners?

Method 1, Check with an Expert.

One way is to check the Wilhelm Research or the Aardenburg Imaging & Archives websites. Their longevity ratings of printer paper and ink combinations now include information about brightening agents.

Method 2, Measure with a Colorimeter.

Some people measure the paper with a colorimeter or spectrometer that gives colorimetric data, looking for a negative b* in the L*a*b* colorimetric values. This method works for some papers, but not for all since the brightening effect depends on the measuring instrument and the amount of paper brightener. An instrument with low UV light output combined with a paper having a small amount of brightener might produce too small an effect in the b* value. It is even possible to have a small positive b* value and still have a brightener in the paper (see the example below).

Method 3, Measure the spectrum.

A more accurate way is to measure paper samples with a spectrometer both with and without a UV light blocking filter. Comparing the difference in the two spectra will show how much brightener effect is present. When looking at a spectral graph of the two measurements, brighteners usually show a peak about 430 nm. This method can easily detect small amounts of brightening agents.

Method 4, Use a UV LED flashlight.

Of course, none of the first three methods work when you are in the store shopping for papers. To make a quick judgement in the store, a small UV LED flashlight can be used. When the paper is illuminated by the UV LED, the paper will appear violet if there are no brighteners present, blue if there are brighteners.

One source for an LED flashlight is Photon Light. Another source is a counterfeit money detector which uses UV LEDs to check money for their fluorescent anti-counterfeiting measures. For example, in the US $5 and greater denominations, there is a fluorescing strip embedded in the paper. Sometimes the counterfeit detectors are available as pens, which makes a convenient way to carry the flashlight.

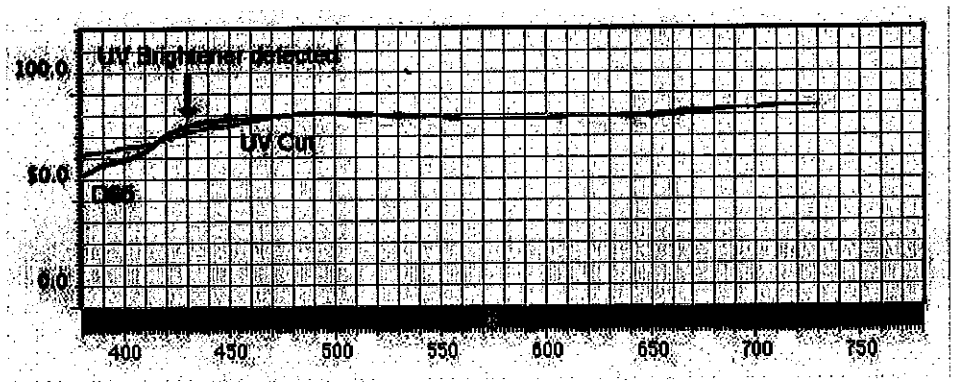
I usually carry a Photon Micro-Light when I go shopping for fine art papers. The UV Micro-Light is available in a variety of models, but be careful, some Micro-

Lights have push on, push off modes which sometimes result in accidentally turning it on in a pocket when it pushes against keys and things, resulting in a fully drained battery when you need it. Their UV Micro-Light I has a simple push on, release off mechanism that reduces this problem. Another nice feature of the Micro-Lights is that a range of accessories such as lanyards and magnetic clips are available for mounting the lights in interesting ways.

Example

Here is an example of a paper checked using Methods 2, 3 and 4.

Epson Proofing Paper measured with a Spectrolino equipped with the D65 filter, L*a*b* values calculated using the 1931 2 degree observer with a D65 illuminant gives L* = 95.52 a* = -1.25 b* = 1.11. With a positive b* value you might conclude that there is no brightener in the paper. Graphing the spectral measurements made with a Spectrolino with a D65 filter and with a UV Cut filter shows that there is brightener present.




Using the UV Micro-Light on this paper showed a definite blue color, corroborating the spectral measurements.

# Papers and Media Tested

| Company | Line | Paper | OBA |
|---|---|---|---|
| BF Inkjet | Fine Art Paper | UC-315 Ultrasmooth Cotton - Radiant White 315 gsm | • |
| bfinkjet.com | | FT-315 Fine Art Textured - Natural White 315 gsm | |
| | | ST-315 Soft Touch - Natural White 315 gsm | • |
| | | | |

| | | | |
|---|---|---|---|
| | | ST-280 Soft Touch - Natural White 280 gsm | |
| | | PG-300 Photo Art Glossy 300 gsm | • |
| | | PGW-300 Photo Art Warm Tone Glossy 300 gsm | |
| | | PM-280 Photo Art Matte 280 gsm | • |
| | | PL-300 Photo Art Luster 300 gsm | • |
| | Legacy | C-10 Premium Art Giclee Canvas All Cotton | • |
| | | C-11 Premium Art Giclee Canvas Satin | • |
| | | MC-12.1 Premium Waterfast Art Giclee Canvas Matte | • |
| | | CG-15.2 Premium Art Giclee Canvas Glossy | • |
| | Grand Photographer | PC-11 Premium Digital Photo Canvas Satin | • |
| | | PC-12.1 Premium Waterfast Digital Photo Canvas Matte | • |
| | | PC-15.2 Premium Digital Photo Canvas Glossy | • |
| | Art Weave | AW 1.0 Digital Watercolor Paper Eggshell | • |
| | | AW 2.0 Digital Watercolor Paper Matte | • |
| Canson | Infinity | Mi-Teintes 170 gsm | |
| cansoninfinity.com | | Montval Aquarelle 310 gsm | |
| | | Arches Aquarelle 240 gsm | |
| | | PhotoSatin Premium RC 270 gsm | • |
| | | PhotoGloss Premium RC 270 gsm | • |
| | | Rag Photographique 210 gsm | |
| | | Edition Etching Rag 310 gsm | |
| | | Arches Velin Museum Rag 250 gsm | |
| | | B F K Rives 310 gsm | |
| Crane & Co. | Museo | Museo Silver Rag | |
| crane.com | (now produced by Intellicoat | Museo Maestro | |

| | | | |
|---|---|---|---|
| | Technologies) | | |
| | | Museo Portfolio Rag | |
| | | Museo Max | |
| | | Museo II | |
| Epson | Photographic Paper | Premium Luster Photo Paper | • |
| epson.com | | Premium Semimatte Photo Paper | • |
| | | Premium Glossy Photo Paper | • |
| | Coated Paper | Photo Semigloss Paper | • |
| | | Photo Glossy Paper | • |
| | | Semigloss Paper Heavyweight | • |
| | | Glossy Paper Heavyweight | • |
| | | Posterboard Semigloss | • |
| | | Enhanced Matte Paper | • |
| | | Enhanced Matte Posterboard | • |
| | | Doubleweight Matte Paper | • |
| | | Singleweight Matte Paper | • |
| | | Presentation Matte Paper | • |
| | | Photo Quality Ink Jet Paper | • |
| | | Watercolor Paper - Radiant White | • |
| | Proofing Paper | Proofing Paper Commercial Semimatte | • |
| | Fine Art Paper | UltraSmooth Fine Art Paper 250 gsm | |
| | | UltraSmooth Fine Art Paper 325 gsm | |
| | | UltraSmooth Fine Art Paper 500 gsm | |
| | | Somerset Velvet for Epson 255 gsm | • |
| | | Somerset Velvet for Epson 505 gsm | • |
| | | Textured Fine Art Paper 225 gsm | |
| | | Textured Fine Art Paper 425 gsm | |
| | | Epson Velvet Fine Art Paper | • |
| | | Canvas | |
| | | PremierArt Water Resistant Canvas for Epson | |
| | | Piezo Pro Matte Canvas for Epson | |
| | Signage Media | Enhanced Adhesive Synthetic Paper | • |
| | | Adhesive Vinyl | • |
| Hahnemuehle | Lumijet | Photo White 270 gsm | • |

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|---|---|---|---|
| hahnemuhle.com | | Photo White Satin 280 gsm | • |
| | | White Velvet 270 gsm | • |
| | | Museum Parchment 210 gsm | • |
| | | Photo Art 210 gsm | |
| | | Masters Canvas 350 gsm | |
| | | Glossy Two Sides 265 gsm | • |
| | | Genuine Pearl II 255 gsm | • |
| | | Ultra Gloss II 255 gsm | • |
| | | Matte Two Sides 180 gsm | • |
| | Fineart | William Turner 310 gsm | |
| | | Torchon 285 gsm | • |
| | | Photo Rag Satin 310 gsm | • |
| | | Photo Rag Bright White 310 gsm | • |
| | | Photo Rag 308 gsm | • |
| | | Natural Art Duo 216 gsm | |
| | | Museum Etching 350 gsm | |
| | | German Etching 310 gsm | • |
| | | Fine Art Pearl 285 gsm | • |
| Hewlett-Packard | Fine Art Paper | Hahnemühle Smooth Fine Art | • |
| hp.com | | Hahnemühle Textured Fine Art | |
| | | Hahnemühle Watercolor | |
| | | HP Aquarella Art | |
| | | HP Canvas Paper | • |
| | | HP Matte Litho-realistic | |
| | Fine Art Canvas | HP Collector Satin Canvas | • |
| | | HP Professional Matte Canvas | • |
| | | HP Artist Matte Canvas | • |
| | | HP Universal Matte Canvas | • |
| | Photographic Paper | HP Professional Satin Photo | • |
| | | HP Premium Instant-dry Gloss Photo | |
| | | HP Premium Instant-dry Satin Photo | |
| | Proofing Paper | HP Professional Hi-gloss Contract Proofing | • |
| | | HP Professional Semi-gloss Contract Proofing | • |
| | | HP Proofing Matte | • |

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|---|---|---|---|
| InteliCoat Technologies | Magiclée | Torino 17M Canvas | • |
| magicleeinkjet.com | | Torino 20M Canvas | • |
| | | Torino 20S Canvas | • |
| | | Torino 21G Canvas | • |
| | | Verona 250HD Fine Art Paper | |
| | | Verona 300 RAG Fine Art Paper | |
| | | Novara Backlit Film | |
| | | Palermo White Film | • |
| | | Siena 200L PSA Photobase | • |
| | | Siena 250L Photobase | • |
| | | Firenze 170 Matte Paper | • |
| | | Mural Pro Vinyl | • |
| | | FAB-6 Polyester Fabric | |
| Moab | | Colorado fiber gloss 245 | • |
| moabpaper.com | | Colorado fiber satine 245 | • |
| | | Lasal photo gloss 270 | • |
| | | Lasal photo luster 270 | • |
| | | Lasal photo matte 235 | • |
| | | Anasazi canvas premium matte 350 | • |
| | | Somerset enhanced velvet 225 | • |
| | | Somerset enhanced textured 225 | • |
| | | Entrada rag natural 190 | |
| | | Entrada rag natural 300 | |
| | | Entrada rag bright 190 | • |
| | | Entrada rag bright 300 | • |
| Strathmore | | Vellum Bristol | • |
| strathmoreartist.com | | Smooth Bristol | • |
| | | Canvas | • |
| | | Textured | • |
| | | Watercolor | |
| | | Illustration Board | |
| | | Acrylic | |
| Superior Specialties | Wide Format Media | SS 120 gsm Paper | • |
| superspec.com | | SS 450 Scrim Banner 18 mil | • |
| | | SS 180M | |

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|---|---|---|---|
| | | SS 180S - Semi Gloss | • |
| | | SS 180G - Gloss | • |
| | | SS 5545 Scrim Banner | • |
| | | SS 2330 Polyester Scrim Banner | • |
| | | High Gloss Backlit Polyester | • |
| | | 1212 9 oz. Mesh | • |
| | | BLO0040 13 oz. Block Out | • |
| | | C0810M - Matte Cold Overlam Film | • |

Updated 10.3.2012

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# Exhibit 3

http://www.freeprocesscontrol.com/bright.html

http://www.ncbi.nlm.nih.gov/pubmed/12633982

# Optical Brighteners and Paper: What's the Problem

By Ron Ellis

Nearly everyone in printing deals with the issue of optically brightened papers. Almost all papers produced for the commercial segment of the market have some level of optical brighteners included, with many papers being so bright that they have a slight blue cast to them. Even lower grades of paper are getting lighter and lighter, now taking on the brightness of more expensive grades of paper. There are of course numerous problems we face from using brighteners in papers, such as the fading of the brighteners and yellowing of the paper of time as well as the environmental impacts of using brighteners. There is another problem caused by optical brighteners as well, and this problem relates to standards and measurements.

Most coated papers right now have a b* measurement of -4 to -10. (The b* measurement is the blue-yellow axis of the L*A*B* measurement. The higher negative the measurement is, the bluer the paper is). For uncoated papers these measurements can be even further along the blue axis. This first started with commercial papers and has continued into pub papers. Optical brighteners are now even common in some newsprint.

Optical brighteners are not a static phenomenon – many papers seem to keep getting bluer and bluer. This contrasts with international standards such as ISO, and US print standards. Many of these print standards specify a paper with a neutral white. In many cases it can be difficult to get a paper that is neutral enough to adhere to these standards.

The problem isn't so much that the paper looks too white, it is that the ever brightening papers are hard to measure. To a spectrophotometer or densitometer the bright papers appear to be blue. To our eyes these same papers appear to be bright white. It probably doesn't seem like a big deal. It is very problematic however, especially as it related to modern print standards as well as color management. Modern print standards such as GRACoL 7 and SWOP 3 & 5 are based on spectrophotometers. These measurements work well when performed on neutral papers such as those specified by ISO 12647-2. When the paper uses optical brighteners the measurements are no longer accurate. Because these papers are bright white, they read blue when measured. When we view them they look white. What happens when we calibrate a paper using these bogus measurements? Typically we end up with a proof or press sheet that is less accurate – most often

having an extreme yellow cast. If we are using a calibration method such as G7 using an optically brightened paper may skew our gray balance, giving us the impression that we have mathematically achieved gray balance. In reality the gray balance will not be correct, and depending on other papers may be even worse. On the proofing end it can be a problem because not only can the target data set be measuring incorrectly, but the paper can also contain brighters, this skewing the proof from it's intended position.

Why is this such a big deal? Why not just edit the proof to match? It is important because modern print standards are based on printing to the numbers to achieve a common visual appearance. With non-optically brightened papers readings are similar to each other, but with optically brightened papers the readings are very different depending on the amount of optical brighteners in the stock. If printing to the numbers does not take you to the same point then it means that printing to the numbers does not work – that you do not get to a common visual appearance based in printing to these numbers. At that point you have to begin to make visual alterations in order match the visual appearance of the standard, and the minute that you start making visual edits then it is no longer a standard. Think about it – every thing about a print specification such as G7, GRACoL or ISO is about printing to the numbers. If you can't trust the numbers then it brings into question the validity of these methods. In addition the constantly changing brightness of papers threatens to make printing a moving target.

How do you tell the amount of optical brighteners in a stock? In addition to reading the specifications from the paper manufacturer there are several methods. One method is the measure the L*A*B* values of the paper. A high L* reading (greater than about a b* reading of -3, for example a -6 b*) means that the paper has optical brighteners in it. Another method includes using a blacklight to view the amount of optical brighteners in a stock.

There are several options for dealing with optical brighteners. The first method is to ignore the optical brighteners. Using this method you measure with UV included and then perform the color match under controlled lighting conditions though the match will not look correct when not under controlled lighting conditions.

The second method would be to rewrite the print specifications, basing them on the current optically

brightened paper. This however would be impractical because the paper and specification would be constantly changing – and constantly problematic.

The third method would be to advise users on how to compensate. If the problem is unsolvable due to brighteners then is it possible to calculate custom aim points for that paper. Of course doing that in technically breaks the standard, but it gives the user a realistic chance of using the paper and matching the proof. IDEAlliance, the organization that has developed GRACoL and SWOP is developing a custom aimpoint spreadsheet for use when calibrating papers with extreme optical brighteners. This approach is designed for users with unsolveable print problems. Most users will probably choose to use the current aim points.

Anyone who prints knows that day to day you will come across all types of papers and you have to make them work. Most plants have only one type of proof, and are tasked with matching a variety of papers to these common proofs. By moving solid ink densities up and down many printers can match the proof sufficiently on a variety of papers. Often when I calibrate I work to make sure that I am calibrating on a neutral paper with few optical brighteners so that the initial curves are accurate, and then tail in the customers normal and optically brightened stock to make sure we can match this as well. Dealing with optical brighteners is a major issue-facing printer. Knowing how it skews the measurements, and working within the limitations of the technology helps us to be able to avoid bogus measurements and understand how to best calibrate in these situations.

J Photochem Photobiol B. 2003 Feb;69(2):97-105.

# Yellowing and IR-changes of spruce wood as result of UV-irradiation.

Müller U, Rätzsch M, Schwanninger M, Steiner M, Zöbl H.

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## Abstract

The yellowing and IR-changes of spruce wood as a result of UV-irradiation were studied using two different types of xenon lamps (lambda>300 nm; I(o)=50 mW cm(-2) and lambda>280 nm; I(o)=17.5 mW cm(-2)). Changes in the IR spectra as well as the yellowing of the irradiated wood surfaces show the influence of UV light on the wood modules. The UV-irradiation (72 h; lambda>300 nm; I(o)=50 mW cm(-2)) decreased the lignin content on the surface by up to 20% of the original values. The colour difference of yellowing (deltaE) exhibited a systematic trend to higher values with increasing irradiation time. Our results show that the photoyellowing (UV-Vis detection) correlates very well with lignin degradation (IR detection). This result is in agreement with the quinone formation as the chromophoric reaction product of lignin decay. The degradation, yellowing, and oxidation kinetics differed only little using different light sources. The absorbed light intensity, which depends on wavelength, the intensity distribution of the light source and the absorption spectrum of lignin, influenced the degradation rate. Under the current experimental conditions, the absorption spectrum of lignin was the most important factor. Therefore, irradiation with lambda>280 nm is useful for rapidly monitoring the UV-degradation of wood



PMID: 12633982 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

## LinkOut - more resources

# Exhibit 4

# CASE REPORT

*L. F. Stewart,*[1] *B.S.*

# Artificial Aging of Documents

**REFERENCE:** Stewart, L. F., **"Artificial Aging of Documents,"** *Journal of Forensic Sciences,* JFSCA, Vol. 27, No. 2, April 1982, pp. 450-453.

**ABSTRACT:** A case is presented involving a number of original documents prepared by a medical doctor to authenticate claims for Medicaid reimbursement. Through an adaptation of conventional laboratory techniques, evidence was found of artificial (accelerated) aging.

**KEYWORDS:** questioned documents, inks, papers, artificial aging

Classical methods for detecting backdating fraud by using typewriter, printing, handwriting, and paper analyses have been known for many years [*1*]. The chemical analysis of ink and paper is a relatively new technique [*2-5*] that is still evolving.

## Case Presentation

Thirty-three original letters bearing the letterhead and handwriting of a doctor were submitted to the National Laboratory Center of the Bureau of Alcohol, Tobacco, and Firearms (ATF) for ink and paper analysis. The documents were dated between January 1978 and June 1979. The pages consisted of handwritten notes dealing with Medicaid patients. The case investigator felt that the documents were actually prepared a few weeks before they were confiscated and sent to the laboratory. Proof of this would indicate Medicaid fraud.

## Paper Analysis

### *Visual Examination*

Initial observation of the 33 pages showed that one page had a different watermark. This watermark could not be clearly visualized under white or ultraviolet light. The watermarks on the remaining 32 documents were easily seen and were found to be the same. An attempt to determine the manufacturer of this watermark was unsuccessful. However, it was found that the watermark has never been manufactured in the United States.[2]

Received for publication 13 July 1981; accepted for publication 21 Sept. 1981.

[1]Forensic chemist, National Laboratory Center, Bureau of Alcohol, Tobacco, and Firearms, U.S. Treasury, Rockville, MD 20850.

[2]Personal communications from Dandy Roll Manufacturers (Wisconsin, Massachusetts, and Maine) and the Institute of Paper Chemistry, Appleton, WI, 1981.

The letterhead on the one page was stamped; the other 32 pages had a printed letterhead. The pages were all of the same size and approximate weight. The top of each document had markings consistent with those that would be made by a paper clip. When these pages were stacked in chronological order, the markings did not line up, indicating that the pages had never been attached as a group.

Some of the pages were bright (white), while the others were of varying degrees of brownness. In paper analysis, "bright" refers to the lack of yellowing [*6*]. These differences in color did not follow a recognizable pattern. Some of the pages dated earlier were brighter than some of those dated later. The documents, except for those that were bright, were very brittle. Along folds the paper was broken and crumbled. Certain studies show that paper is the most durable and easy to use when it contains approximately 7% of its weight in water. If it contains less than 7% water, it becomes harsh and brittle [*1*].

The pages were inconsistent in the degree of brownness throughout each page. Some of the pages were darker at the corners while others were darker at the center of the page or in patches. Certain pages had a pattern of dark and light streaks. Under ultraviolet light, these documents had markings on the back in the form of parallel lines or bars. These bar markings did not consistently appear in the pages. On one document the first bar was approximately 20 mm from the left side of the page and on another page the first bar was approximately 10 mm from the left side. On most of these pages the bars ran lengthwise but on one page the bars were essentially horizontal. These inconsistencies tended to rule out the possibility that the bars resulted from a manufacturing process.

Although the earliest alleged date was January 1978, the appearance of extreme age in some of the documents indicated that the pages had been artificially aged. The bar marks on the back of the pages were similar to what would be expected to occur by heating the document on an oven rack. Studies comparing artificial aging by use of an oven with aging under normal conditions have led to the conclusion that oven aging at 100°C (212°F) for three days is approximately equal to 25 years of normal aging [*6*].

### *Test for Artificial Aging of Paper*

To test the above theory, paper of equivalent type and quality was heated at various temperatures for different lengths of time in an attempt to duplicate the bar markings and the brownness of the pages. Steam heating was also examined. Pages were heated in a household oven for 1 to 4 h at 93 to 204°C (200 to 400°F). In every instance a pattern was produced that matched that on the questioned pages (see Fig. 1). These pages were also very brittle and crumbled upon folding. The pages wrinkled when steam heat was used. A spot check of 20 ovens at a home appliance store revealed that all had racks with equidistant bars of the same approximate distance noted on the questioned pages.

## Ink Analysis

The inks used to prepare the documents were analyzed using the conventional ATF procedure [*4*]. Six different ink formulations were used to prepare the questioned documents. All were glycol-based ball-point pen inks. The inks found on the bright sheets, although glycol-based, had the spreading appearance of the old oil-based inks. This suggested the possibility of induced aging through wet heat.

After attempting to match the six questioned inks to formulations from the standard ink library, it was found that five of the formulas were available at the alleged dates of writing. The remaining formula, found among the nonbright documents only, did not match any ink in the library, although it closely resembled one particular ink formula, Formulation A. The questioned ink had all the thin-layer chromatographic characteristics of Formulation A plus others. The manufacturer of Formulation A (a unique two-dye component system) claimed

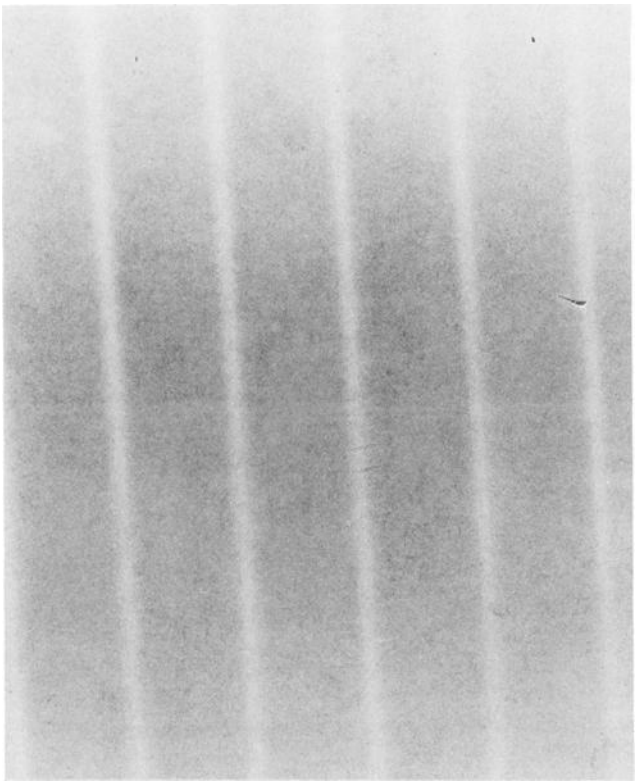

FIG. 1—*Known bond-type paper heated 1 h in a 204°C (400°F) oven.*

that the components of the ink are sold to that company only for use in their ink. If the questioned ink did match Formulation A, backdating would be shown, since the formula was not available at the alleged dates of writing.

Because evidence had been found to suggest that the documents had been artificially aged by using heat, Formulation A was subjected to heat to determine whether it thermodegrades into an ink similar to the unmatched questioned ink. Using the standard procedure, a Merck thin-layer chromatographic plate was used to chromatograph the questioned ink versus the standard Formulation A, unheated as well as artificially aged at 204°C (400°F) for 1, 2, and 3 h (see Fig. 2). Formulation A changed when subjected to heat. Each of the heated inks resulted in a different chromatogram from the unheated standard ink. The questioned ink matched the standard Formulation A that was heated at 204°C (400°F) for 1 h.

## Conclusions

On the basis of the accelerated aging tests of both ink and paper, it was concluded that the doctor had artificially aged the 33 pages in question. This could have been accomplished as follows: The documents were first heated with steam in one of two ways. Either they were hung on a line and steam heated (for example, in a large autoclave), or they were steam heated by use of a steam iron and hung up to dry. This could account for the spreading of some of the inks. Ink spreading as a result of water or heat is formula-dependent and thus certain inks are resistant. The paper clip markings could have been caused by the hanging

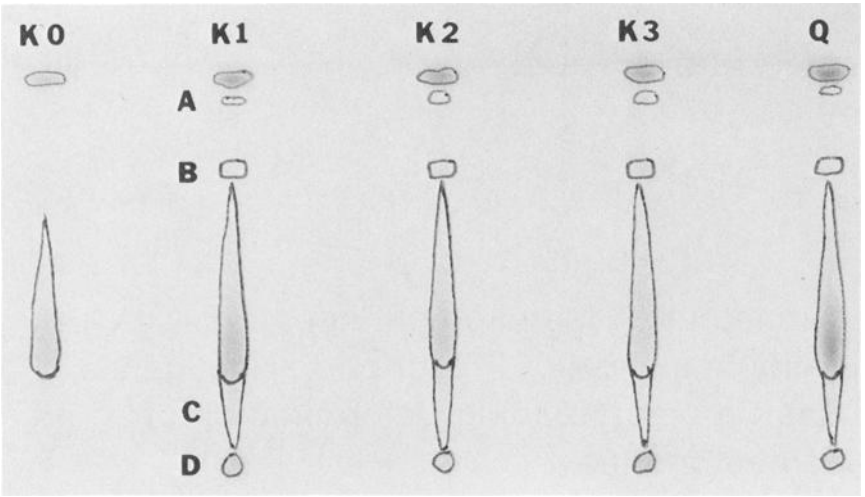


FIG. 2—*This chromatogram was enhanced for clarity. K0–K3 correspond to standard Formulation A that was heated for 0, 1, 2, and 3 h, respectively. Q corresponds to the questioned ink. A–D are points of differentiation between the chromatogram of K0 and those of K1, K2, K3, and Q.*

process. Next, those pages that did not appear old enough were probably placed in an oven for additional heating. This would explain the bar markings, variations in the brownness, loss of water (brittleness), and degradation of the ball pen ink.

*Acknowledgments*

This work was greatly assisted by the ink and paper manufacturers and Antonio A. Cantu and Claude E. Eaton of the ATF laboratory.

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# Exhibit 5

FORENSIC DOCUMENT EXAMINATION/Dating Documents Part I: 54-11-960101/960701(P)

# A SKETCH OF ANALYTICAL METHODS FOR DOCUMENT DATING[1] PART I. THE STATIC APPROACH: DETERMINING AGE INDEPENDENT ANALYTICAL PROFILES

*Several analytical methods for dating documents are described*

by Antonio A. Cantu[2]

**REFERENCE:** Cantu, Antonio A., **"A Sketch Of Analytical Methods For Document Dating Part 1. The Static Approach: Determining Age Independent Analytical Profiles,"** *International Journal of Forensic Document Examiners,* Vol. 1, No. 1, 1995, pp. 40-50.

**ABSTRACT:** A sketch of several analytical methods for dating documents is provided. These methods analyze items in or on documents; such items include inks, papers, and their components. These methods take two major approaches to dating: the static approach and the dynamic approach. The static approach determines when items in or on a document first came into existence. This approach depends on comparison with reference standards. The dynamic approach involves the aging process. This approach compares the relative aging of items of the same composition and, in most cases, on the same document. Both approaches, analytical and otherwise, have historical origins dating to when documents were suspected of being fraudulent.

**KEYWORDS:** Dating, documents, inks, paper, analytical methods.

## I. PRELIMINARIES

### Introduction

This sketch is based on presentations made before several professional groups[3]. What will not be covered here are sketches of the traditional methods for dating documents. These take primarily the static approach - the approach that detects fraud when an item on or in the document is found not to be in existence at the alleged or purported date of the document (an anachronism). Some of these traditional methods are listed in Table 1. The two approaches taken by methods for dating documents are called static or dynamic, since they determine characteristics that do not change (static) or do change (dynamic) with age, respectively.

Table 1

Some Traditional Methods for Dating Documents

1. Handwriting - Handwriting Identification and Comparison; Detection of Handwriting Changes over Time
2. Indented Writing - Identification of Indentations within two or more Questioned Documents
3. Intersecting Lines - Determination of Sequence
4. Typewriting - Typewriter Identification and Comparison
5. Printing - Printing Method Identification and Comparison
6. Photocopier - Comparison of Photocopy Identifying Marks
7. Paper
   * Watermark Identification
     - manufacturer identification through directories
   * Fibre Identification
     - microscopic examination and comparison with standards
   * Optical Fluorescent Whiteners Identification
     - first used ca. 1950 and detected with a UV lamp
8. Ink
   * Identification of Writing Instrument Type
     - fountain pen
     - ballpoint (introduced ca. 1945)
     - felt tip (introduced ca. 1963)
     - rolling ball (introduced ca. 1967)
   * Identification of Oil and Glycol-Based Ballpoint Ink
     - change to glycol occurred ca. 1950
   * Identification of Ballpoint Inks with Copper Phthalocyanine Dye
     - dye was first used ca. 1955

What will be covered are sketches of analytical methods for dating mostly writing ink and paper. These methods take either the static or dynamic approach to dating. Details of the methods are provided in the references.

[1]Disclaimer - The methods and techniques presented in this sketch are not necessarily employed by the U. S. Secret Service (USSS) unless specifically indicated.

[2]U. S. Secret Service, Forensic Services Division, 1800 G St., NW, Washington, DC, USA 20223.

[3]Material for this sketch is taken from presentations made to the combined meeting of the Asociacion de Criminalistica de la Republica Argentina (sixth meeting) and the Asociacion Latinoamericana de Criminalistica (first meeting) held in Mar del Plata, Argentina, in Nov. 1993; the Institut de Police Scientifique et de Criminologie, Universite de Lausanne in Lausanne, Switzerland, in Jan. 1994; and the Department of Chemistry, George Washington University, Washington, DC, in April 1994.

**The Two Approaches to Dating**

**A. The Static Approach** - The methods involving the static approach are based on two requirements: one must have a collection of reliable and stable standard reference samples (each with known manufacturer and date of first production) and a discriminatory method that sorts or distinguishes these samples. It is important to know the general composition of the material being analyzed, its *method of production,* and the quality control during production. Some of these methods determine chemical compositional profiles while others determine elemental profiles. One new novel method sketched determines the level of carbon 14 radioisotope. The latter is related to the increase and subsequent decrease of carbon 14 levels caused by atmospheric detonation of large nuclear devices. Another novel "elemental" method mentioned involves stable isotopes of C, N, O, and H.

1. *Comments on the Use of Collection of Standards* - When a questioned sample is compared against the standards in the collection using a discriminatory method and a match is found, the matching standard provides a possible manufacturer and introductory date for the questioned sample.

   a. One can readily see that there is a strong relationship between the meaning of a match, the size of the collection, and the degree of discrimination of the method. More on this later.

   b. For a reference collection to be of forensic value, the *reference standards must vary with sufficient frequency.*

   c. When a questioned ink matches a standard having only a date of purchase available, the date of introduction can be obtained from the manufacturer once it is identified and contacted. Labels are useful here.

2. *Comments on the Reliability of Samples* - A standard reference sample is a representative sample of a product being produced under some quality control. Quality control assures that a product is "up-to-standard" in that a set of performance standards, compositional requirements, or other standards are met. In the case of inks, like most cases, such a standard is called a formula.

3. *Comments on Stability of Samples* - A given method for discriminating a collection of standard samples provides a set of measured properties, called a profile, for each standard and questioned sample. To be stable with age, these profiles should be protected from age-inducing environments. There is no control of age-inducing conditions on questioned samples, and these could change with age; ink fading under prolonged exposure to light is an example. If the profile of a questioned sample does change with age, it may not match a collection of stable reference standards, or it may match a wrong one (false match); furthermore, two samples known to be the same can differ in their profile and be considered different (false elimination). This impacts on the treatment of aging (dynamic approach) where samples being compared are required to have the same (static or stable) profile.

**B. The Dynamic Approach** - The methods involving the dynamic approach center more on the dynamic aging of inks rather than of paper. Their goal is to distinguish inks that *only differ in their age.* That is, these methods attempt to determine the relative age of inks (or when one was written relative to another); however, to do so, these inks must meet two very necessary and critical required conditions: they must be of the same formula [same static (stable) profile] and on the same document. In those cases where a questioned ink is being compared with inks (of the same formula and on the same document) of different known dates of entry, the known inks can be thought of as standard reference inks.

1. *Comment on The McNeil Method* - The two stringent required conditions mentioned above do not appear to be necessary for most cases involving the McNeil iron ion migration method. This indicates that, in most cases, this method determines absolute rather than relative ages.

2. *Comment on Paper Aging* - Although much has been written on paper aging, particularly in the paper conservation field, not much has been done in the forensic area, probably because of the difficulty of knowing the paper's storage conditions. In paper conservation, accelerated or induced aging is a major study as well as methods to reduce paper aging. Some of the "kinetic" studies that ensued in this field from the induced aging studies can be used to study natural and induced aging of inks.

**C. Statistical Treatment of Data** - To determine if two samples are significantly different or the same, more than one measurement is required per sample. The resulting data is analyzed statistically to determine the reliability of the measurements and then to determine if any differences exist between the samples [1]. The analysis applies to all methods involving the dynamic approach, since these always involve numerical values. The analysis also applies to those methods involving the static approach that yield numerical values. Such methods include chemical and elemental profiles obtained from instruments that give numbers. For these, Kowalski's [2] chemometric statistical techniques, all involving pattern recognition methods, assist in determining which measurements are the most important for distinguishing samples. For example, Duewer and Kowalski [3] took elemental compositional data from the analysis of paper samples and showed which elements were most responsible for achieving discrimination among papers.

## II. METHODS INVOLVING THE STATIC APPROACH

**Background**

These methods involve determining profiles ("fingerprints") of items on documents (such as inks or paper) and comparing these against profiles of similar standard items each having a known manufacturer and first date of production. A profile of an item is a set of characterizing features such as physical properties, optical properties, or analytical measurements of a major, minor, or trace components of the item. Obviously improving or increasing these characterizing features increases the uniqueness of the profile or, equivalently, the degree of discrimination (selectivity or specificity) of the method used to obtain the profile. But to test this increase in uniqueness of the profile (measurements) or degree of discrimination of the method, one needs to work with an increased number of standard samples. The meaning of match between a questioned sample and a sample from the set (or library) of standard items clearly depends on this uniqueness/degree of discrimination - the higher this is, the more positive is the identification of the item, its manufacturing source, and the date of first manufacturing.

## Purpose of Reference Standards and Their Methods of Discrimination

**A. Purpose** - As may be inferred from above, a data base or library of reference standards serves to test the discriminating ability of a method or set of methods. In practice, however, the

data base and discrimination methods serve three main purposes:

1. *To Determine Similarities/Differences* - Questioned or known samples can be compared with each other to determine similarities or differences. No data base is required for eliminations; it may be needed for similarities if information is needed on a matching standard (e.g., volume of sales).

2. *To Determine/Eliminate Source* - The data base can be used to determine for a questioned sample those sources that cannot be eliminated (if the questioned sample matches standard samples in the data base) or those sources that can be eliminated (if the questioned sample does not match any standard).

3. *To Determine Date* - If a questioned sample matches a standard sample for which there is a date of first introduction, then there is evidence to suggest the questioned sample was first introduced on that date. Though date determination is the main focus of this paper, the first two are also important to document examination. Again, the higher the uniqueness/degree of discrimination, the more certain one is in identifying the sample, its source, and date.

**B. Comment on Limited Data Bases** - Limited data bases exist for items such as typewriter ribbon inks, printing inks, pencils, and opaquing fluids. These, like any limited data base, provide source elimination (non-match) or source non-elimination (match) and date non-elimination (match). However, as more samples are collected and their method of analysis becomes more specific, the certainty of identification increases.

## Determination of Chemical Compositional Profiles

**A. Writing Inks** - Since writing inks are numerous and change frequently, they are tractable to forensic scientists. Over the years, several researchers have been collecting samples of writing for the purpose of determining the date and source of documents. Following is a historical sketch of some collections and their method of analysis [4,5,6].

1. *Zurich Police Reference Ink Collection & Their Discrimination* - In the 1960s Werner Hofmann from the Zurich Cantonal Police, Zurich, Switzerland, began the first systematic collection of inks for the purpose of dating inks. He obtained his collection of inks from pens acquired from local and foreign collectors, vendors, and ink manufacturers. He documented purchasing dates of purchase and, when available, their manufacturing dates. From the ink he made standard entries (series of parallel lines) on paper. Optical properties [ultraviolet (UV) fluorescence and near infrared (IR) reflectance and luminescence] were determined from these and recorded. Finally, he separated their dye composition through thin-layer-chromatography (TLC). The total profile consisted of the optical properties and the TLC pattern. TLC offered the greater discrimination. The date and source of a questioned ink was inferred or implied from the date and source of the ink it matched from the collection. That is, when a match was made, evidence existed to suggest that the questioned ink was the standard ink; this possibility could not be eliminated.

2. *ATF's Reference Ink Collection & Their Discrimination* - In 1968 Brunelle, from the Internal Revenue Service Forensic Laboratory [which later became part of the Bureau of Alcohol, Tobacco, and Firearms (ATF)], obtained a similar collection in the U.S. His approach, however, centred on ink formulas, since by that time it was known that ink formulas could generally be distinguished by their optical and TLC characteristics. His approach also focused on obtaining samples directly from the ink industry. (This approach, in forensic science terminology, is similar to obtaining requested samples from an individual, rather than acquired or collected samples made by the individual.) Also, to make the collection more complete and to test the discriminating ability of the method, he requested all previously made formulas. Some of these go back to the 1900s. Samples of the Hofmann collection were also obtained. The entire collection, or library of standard inks, was kept up to date through yearly requests to the ink industry. Stamp pad inks were also included.

3. *Expansion of ATF's Reference Ink Collection* - In the mid-1970s a world wide request for writing ink formula samples and their first manufacturing dates was made to foreign ink makers. It was discovered from this that most writing inks are made in the U. S., Japan, and Germany, and in other countries that license from these nations. Also, following Hofmann's approach, collected off-the-shelf pen samples from local and foreign collectors, stationary stores, and vendors were entered into the collection and their purchasing dates were recorded. If it is necessary to date these - as when one of these collected inks matches a questioned ink - the pen maker can be contacted for further information. Collected samples from the FBI and the U. S. Postal Service were also added.

4. *Advanced Method of Discrimination* - Also in the mid-1970s the discrimination of inks was extended to include other TLC systems, semi-quantitative TLC (use of densitometer), HPLC [7,8], FTIR, GC (for volatile components and derivitized resins), and laser fluorescence. These more advanced methods are used to distinguish inks which could not be easily distinguished by the standard methods involving optical and TLC determinations.

5. *Stability Studies* - Also during the mid-1970s it was observed that some inks are more stable in the dried form on paper than in the liquid form. This supported the practice of comparing questioned inks with a library of dried inks on paper. Also observed was that when a questioned ink does not match a standard ink, it is because the matching standard is missing from the library, or the questioned ink has changed with time - usually through the fading of some of its dyes. Careful fading studies have identified several inks which can still be associated with a standard ink with the difference being attributed solely to fading.

6. *Yearly Ink Tagging and Positive Identification* - ATF recognized early on that frequent formula changes could enhance the chances of detecting back-dating fraud. Furthermore, as stated above, to increase the positive identification of a match, one needs to increase the size of the library and the ability of the method to discriminate its inks. To address these two needs, this author, while at AFT, developed in the mid-1970s a yearly ink tagging program. For those manufacturers that participated in the tagging program, two systems were developed: one involved trace rare earth organometallic compounds and the other involved trace optical whiteners. The rare earth tags are detected by preparing a $SrWO_4$ phosphor from an organic extract of the tag and analyzing it by x-ray optical

fluorescence. The optical whitener tags are detected by a TLC method which separates the tags without separating the dyes.

7. *USSS Reference Collection & Methods of Discrimination* - Since July of 1988, the ATF collection, or International Ink Library as it is now called, has been with the U.S. Secret Service (USSS). The USSS is continuing to maintain contact with the ink industry (U.S. and most foreign); is working with foreign forensic laboratories with writing ink collections; and is continuing to collect off-the-shelf pens. This library is shared with the Internal Revenue Service National Forensic Laboratory in Chicago. In 1992 the USSS chaired an ASTM committee on ink analysis and the committee prepared a guide for the forensic analysis of writing inks [9]. The document is written primarily for those performing comparisons of writing inks to establish if they match or do not match. The document also addresses what a match or non-match means. This document details the methods employed by the USSS not only for comparing several inks among themselves but for comparing a questioned ink with the standard inks in the library. The latter is, of course, done to associate a date of first production or a manufacturing source with a questioned ink.

8. *Recent Developments* - Recent advanced techniques for discriminating inks include Diffused Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) [10], HPLC with a diode array detector [11] , and Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) [12].

**B. Typewriter Ribbon Inks, Printing Inks, and Pencils:** - As indicated in a comment above, data bases of standards for these items are limited and only weak conclusions can be made when a questioned item matches a standard.

1. *Typewriter Ribbon Inks [13]* - Their method of analysis almost parallels that used for writing inks - particularly the use of TLC. As little as two typewritten letters can be analyzed. Presently, no attempts have been made to analyze the binder (usually resins and waxes). The USSS has the limited collection originally obtained by ATF. Most of these are from known manufacturers who, upon request, may provide their date of introduction.

2. *Printing Inks* - These are analyzed by determining their pigment composition, vehicle composition, and their trace elemental profiles (treated later).

   a. *Vehicle Composition* - This is rather difficult to obtain so the type of vehicle is usually attempted. This is done by applying several chemical resistant tests. For example, water wipe and paper wipe intaglio inks can be distinguished using a 2.5 N NaOH resistant test[4]. Such determinations assist in determining which machinery is being used to print.

   b. *Pigment Composition* - One successful method to determine this composition is the Billmeyer, et. al. [14] sequential solvent extraction method. Here different pigment classes are sorted out by their solubility in methanol, chloroform, dimethyl formamide (DMF), and concentrated sulfuric acid. TLC of these extracts further characterize the pigments. Recently Lofgren and Andrasko [15] described an elegant and practical HPLC technique. At present the USSS has a limited collection of printing inks of known manufacturers; these could supply dating information upon request.

3. *Pencils* - Pencil "lead" consists of waxes, fillers (clay), and graphite or coloured pigments (for coloured pencils). Wax pencils or crayons also contain coloured pigments. Pencil marks can be characterized by their binder composition (waxes) and trace elemental profiles (clays) [16]. Zoro and Totty [17] used GC-MS to analyze the binders. The USSS has a limited data base of pencils. Presently it is not possible to date pencil entries since their composition seems not to vary sufficiently.

**C. Paper** - Many papers bear a watermark that may lead to a manufacturer. When this is the case, one can obtain very useful information and collect samples for comparison. However, most papers do not contain a watermark. To obtain dating information on these, one often relies on historical records.

1. *Paper without Watermarks* - Chapter 25 of B. L. Browning's book on paper analysis [18] is titled, "Paper in Forensic Science." This chapter has a Table (his table 25-1) which provides the date when particular paper components were first used in the paper industry. These components are grouped into fibrous raw materials; sizing and coating materials; fillers and white pigments; and dyes and colours. Table 2 contains some of this information. Browning also provides in his book the methods of analysis for these paper components and their degree of specificity.

Table 2

Some Components of Paper & their First use in Papermaking
Obtained from B. L. Browning, "Analysis of Paper"

| Component | Introductory Date |
|---|---|
| *Fibrous Raw Material* | |
| esparto grass | 1857-1890 (England) |
| bleached sulfate wood pulps | after 1930 |
| organic synthetic fibres | 1953-1954 |
| *Sizing and Coating Materials* | |
| soya protein | 1937 |
| urea-formaldehyde resin | 1940-1941 |
| dialdehyde starch | (1947) 1959 |
| *Fillers and White Pigments* | |
| barium sulfate | 1820 |
| calcium carbonate | about 1925-1927 |
| zinc sulfide | after 1932 |
| diatomacious earth | about 1938 |
| *Dyes and Colours* | |
| ultramarine | 1828 |
| synthetic organic pigments | about 1901 |
| optical whiteners | about 1950 |

   a. *War Crime Cases* - In many Nazi war criminal cases, the authenticity of document evidence is often in dispute. This author has used Browning's information and tests to ascertain if paper in question contains any components that were not available during the purported date of the document. If any exist, then there is evidence to suggest

[4]Private Communication - Robert W. Bassemir, Sun Chemical & Inktec Consultations.

that the document was prepared later than purported; but if none exist, there is no such evidence.

b. *The Hitler Diaries* - One of the most celebrated cases involving the use of tabulated historical information on paper components is the case of the Hitler Diaries. These surfaced around 1984 and were purchased by the German Stern magazine for several million dollars. The diaries allegedly portrayed Hitler as not as bad as history depicted him. Several examiners performed handwriting and other analyses on them. One was Julius Grant who, with a simple UV lamp, showed that they were fake [19]. He observed traces of fluorescent fibres in the make up of several pages and, being a noted paper expert, concluded that these contain an optical fluorescent whitener - a class of substances first introduced into paper around 1950. Analytical methods were then applied to confirm the whitener and to analyze other substances, such as inks, to support the fraud.

Like any other item involving the static approach to dating, an empirical way to date paper involves obtaining the "natural profiles" of samples from known sources and date of production. This amounts to building a data base of samples. This has been done and the samples are discriminated by an elemental analysis method. This is treated later.

2. *Paper with Watermark* - Paper containing a watermark can usually be traced to its paper manufacturer. The yearly published Lockwood-Post's Directory [20], for example, has a section that associates watermarks with their users. Also, dandy roll manufacturers, who manufacturer the watermarks that go on the roll, can identify which paper manufacturer uses their watermark (dandy roll). When a paper manufacturer is identified, one first obtains dating information on the watermark to see if this can detect back-dating[5]. If this does not detect any fraud, one can request information on dates of detectable chemical changes. This is where chemical or analytical methods assist the examiner. Some of these changes could be in types of starches, resins, sizers, fillers, etc. When these do not detect any back-dating, then samples of paper from different production runs are requested so that elemental profiles can be obtained for comparison with that of the questioned paper. This is treated later.

**D. Photocopy Toner [21]** - The type of photocopier and toner used to produce a photocopied document can sometimes be determined and dated. This, as mentioned, depends on the existence of a data base of standard samples, their profiles, and their dates of introduction.

1. *Initial Characteristics* - Class characteristics of toners from a photocopied document consists of magnetic determinations, microscopic examinations, and scanning electron microscope (SEM) imaging. Such characteristics determine if the toner is mono-component or dual component (with carrier beads) and if the toner is transferred through a radiant heat, hot roll (soft or hard), or cold press process. Once these characteristics are determined, toners are further characterized by their chemical properties. In some cases black toners contain extractable dyes mixed with the carbon black pigment. These dyes are separated and characterized by TLC. However, most of the chemical information in black toners is in the organic resins used. Coloured toners, by their multi-coloured nature, contain more characterizable components - organic resins, coloured dyes, and coloured pigments.

2. *Instrumental Infrared Methods* - Many analytical methods for analyzing photocopy toners have been developed over the years. Infrared (IR) spectroscopy was one of the early methods founds to be highly discriminating. It analyses the organic resins which are added in different proportions by different manufacturers. It sorts a collection of standards samples into distinct groups.

3. *Pyrolysis Gas Chromatography* - Pyrolysing (burning) toner samples and separating the emitted gas with gas chromatography (GC) was also found to be very selective. This technique, called pyrolysis GC, also analyses the organic resins. It often discriminates standard samples not sorted by IR. When this technique is coupled with mass spectroscopy (MS) greater specificity is achieved.

4. *X-Ray Fluorescence*[6] - Coloured inorganic pigments (used in some coloured toners) can be characterized by their elemental composition. This elemental compositional profile can be determined by X-ray fluorescence (XRF) and is easily accomplished by using an SEM with x-ray microanalysis capabilities.

**E. Correcting or Opaquing Fluids** - Harris and MacDougall [22] performed an elegant study on correction fluids. They first noted that their composition is sufficiently varied to be characterized or even identified - and thus, amenable for forensic analysis. There are as many as ten different groups of substances in these fluids besides the pigments (which provide efficient hiding power). Among these groups are resins and, again, like photocopy toners, manufacturers vary resin-to-pigment combinations. They collected 21 standard samples from manufacturers and also from vendors (over-the-counter samples). These were sorted by IR methods. Though this is a relatively small data base, it serves the three useful purposes stated earlier: to determine similarities/differences, to determine/eliminate source, and to date.

1. *Reference Standards and Their Discrimination* - The 21 samples collected fall into two main classes: solvent-based and water-based fluids. The fluids were analyzed using a diamond cell on a Fourier Transform Infrared (FTIR) spectrometer in two ways: one involved a sample of dried composite fluid on a glass slide and the other involved only the dried binders. The latter were separated from the pigments by centrifuging with 1,1,1-trichloroethane (a freon) for solvent based-fluids and water for water-based fluids.

2. *Identification of Binders* - The IR spectra of each standard was compared with known spectra from the literature or from laboratory samples in order to sort out the composition of the binder. Identification of the inorganic pigments was also attempted by IR methods.

3. *Questioned (Unknown) Sample* - A small sample (about 0.05 mg) of dried opaquing fluid (of unknown origin and date) is removed from a document and placed on a glass slide. A drop of 1,1,1-trichlorotethane is added and, as it

[5] Manufacturers sometime change their watermark design and keep records of these changes. Other manufacturers date code their watermarks in addition to periodically changing their design.

[6] Though strictly speaking this technique provides an elemental profile (which are treated later) rather than a chemical profile, it is presented here to preserve continuity on methods for photocopy toners.

spreads, it carries the binder with it. As this dries it is removed and placed in the diamond cell for analysis. For water-based fluids, a centrifuged extraction is required to remove phthalate plastisizers.

## Determination Elemental Profiles

### A. Work Initiated by Guinn, et. al. [23] - Inks and Paper

In the late 1960s scientists at Gulf Atomic General (San Diego) evaluated the use of thermal Neutron Activation Analysis (NAA) for analyzing forensic materials such as glass, hair, paint, paper, and inks. For each material, they analyzed a large collection of samples and proved that the elemental composition of a material is rather specific to that material. Their work and subsequent work using NAA showed that the full profile of major, minor, and trace elements is highly specific with the specificity being mostly due to the trace elements.

1. *NAA and Paper Dating* - Brunelle, et. al. [24] were the first to use NAA for the purpose of dating. By collecting and analyzing samples from industry, they showed that paper could be sorted by its manufacture, type of paper, and batch (lot) or group of batches of production. With the latter, it became possible to date paper by determining the date of the batch or group of batches it matched. This technique was used in 1974 to date documents involved in the Watergate investigation.

2. *Other Elemental Analysis Methods* - Though the method initially used was NAA, it opened the door to the use of other elemental analytical methods - particularly the multi-elemental methods such as x-ray fluorescence [25] and atomic emission spectroscopy. Today these include the induced coupled plasma (ICP) optical emission spectrometry, ICP-MS, electron probe microanalyzers, and proton induced x-ray emission (PIXE) (treated next).

Table 3
Metal Content (in ppm) of Some Pigments used in Printing Inks

| | PTMA Green 15-2305 | Napthol Red 20-7515 | Diarylide Yellow 45-2555 | Diarylide Yellow 45-2685 | Phthalocyanine Blue 55-3754 | Iron Blue 0-4066 |
|---|---|---|---|---|---|---|
| Aluminium | < 64 | 760 | 98 | 1,230 | < 64 | 360 |
| Antimony | 2.1 | < 0.3 | < 0.3 | < 0.3 | < 0.6 | < 0.3 |
| Arsenic | 2.6 | < 6.1 | < 6.1 | < 6.1 | < 12.2 | < 6.1 |
| Cadmium | < 7.0 | < 3.5 | <3.5 | < 3.5 | < 7.0 | < 3.5 |
| Chromium | 1.0 | 1.6 | 6.9 | 0.8 | < 1.0 | 150 |
| Cobalt | < 0.4 | < 0.2 | < 0.2 | < 0.2 | < 0.4 | 10 |
| Copper | 6.0 | 18 | 3.4 | 62 | 95,000 | 4.2 |
| Iron | 240 | 850 | 1,260 | 320 | 350 | 349,000 |
| Lead | 170 | 28 | 3.1 | 23 | 13 | 63 |
| Manganese | 0.6 | 2.4 | 2.2 | 1.0 | < 0.4 | 26 |
| Mercury | < 1.0 | 5.8 | < 1.0 | < 1.0 | 1.3 | < 1.0 |
| Molybdenum | 8,600 | < 4.4 | < 4.4 | < 4.4 | 7.0 | < 4.4 |
| Nickel | 3.1 | 16 | 0.6 | 1.3 | 120 | 14 |
| Phosphorus | 1,200 | 140 | 110 | 210 | 9.0 | 460 |
| Selenium | < 5.0 | < 5.0 | < 5.0 | < 5.0 | < 5.0 | 12 |
| Silver | < 4.6 | < 2.3 | < 2.3 | < 2.3 | < 4.6 | < 2.3 |
| Strontium | < 9.0 | 53 | 11 | 41 | 63 | < 4.5 |
| Tin | < 0.4 | 0.2 | < 0.2 | < 0.2 | 1.4 | < 0.2 |
| Vanadium | < 9.4 | < 4.7 | < 1.2 | < 1.2 | < 2.4 | < 1.2 |
| Zinc | 15 | 8.0 | 8.9 | 1.6 | 51 | 22 |

3. *Elemental Profile of Printing Inks* - Printing inks are made up of pigments, vehicles, and additives. Of these, pigments are more tractable for forensic analysis due to their ease of analysis. Already mentioned is the extraction method for characterizing certain pigments. However, many pigments also contain metals (Cu, Fe, Mn, Mo, Al, P) as a major component and several other elements at the trace level. Table 3 shows the metal composition of some pigments used in printing inks [26]. They are taken from an American Cyanamid Co. report and the values are for those batches of American Cyanamid pigments analyzed for the report[7]. These were analyzed in bulk using x-ray fluorescence (XRF). For forensic samples one can use x-ray microanalytical methods or other microanalytical elemental analysis methods.

**B. Work of Cahill and Kusko [27] - Inks and Paper**

Given an old manuscript, these scientist, from the Crocker Laboratory at the University of California at Davis, can provide an approximate period of its manufacturing and a possible country or region of origin. They analyze the paper using a method called cyclotron Proton Induced X-ray Emission (PIXE). Their ability to date and source is based on the large data base of PIXE profiles they obtained from archival samples - mainly old (not current) manuscripts - in libraries and collections throughout the world.

1. *PIXE and Inks* - For archival inks, they have a more limited collection and cannot do as much as they can with paper. They can, nonetheless, date by associating questioned inks with inks of known date or authors. In an interesting case [28], they did spectacular work in sorting numerous written ink entries made by J. S. Bach in his bible - known as the Bach Calov bible - and comparing these with other ink annotations and underlines of unknown authorship. Since the bible has passed through several owners since Bach's times, it was uncertain which questioned entries were made by Bach. PIXE showed that the questioned inks were all the same and matched the most common of the known inks used by Bach. Both inks had the same major elements (iron and sulphur from iron-gall ink) and, particularly, the very same levels of trace elements (and, thus, due to the same impurities). This strongly indicates that Bach was the author of the unidentified annotations analyzed. This, among other things, will assist researchers in correlating musical compositions with Bach's biblical annotations.

2. *PIXE at the Louvre* - PIXE has been used to study several other historical documents (a) to determine the date and source of their paper or (b) to sort (associate/link) their inks or pages. Its usefulness was recognized by the Louvre (Paris, France) and recently it acquired a PIXE instrument, which is in place in the Louvre's basement, to date and source their manuscripts.

3. *PIXE and the Islamic Bodleian Collection* - Recently there was a conference at Oxford University (July 1994 in Oxford, England) devoted to the critical evaluation of the PIXE and other methods for sourcing and dating documents. The following is taken from an announcement of the meeting: "The purpose is to design a project, employing the dated (and/or signed or located) Islamic manuscripts in the Bodleian Library and the analytical techniques of the Oxford Scanning Proton Microprobe Unit, to test the theory that there are sufficient measurable differences between inks, pigments and paper of workshops at different locations and times to allow for meaningful differentiation between their products. If this is then demonstrated to be the case, the ultimate aim will be to establish a sufficient and usable data base by comparison with which undated and unsigned copies can then be assigned a given time or location or specific workshop." [29]. The proceedings of the meeting (not yet available to this author) should contain a wealth of information on this topic.

**C. Preliminary Work of Ehleringer [30] - Cotton Containing Paper**

The theory behind a plant's uptake of chemicals during its growth cycle is complex and fascinating. Soil, water, and air contribute such chemicals. These chemicals can potentially help characterize the geography of the plant's region of growth. Forensically, one is interested in the geographical location (geo-location) of the plant. Drug enforcement agencies, for example, are interested in linking drugs from illicit plants to their source; paper experts (our case) are interested in the source of paper fibres.

1. *C, H, O, and N Isotopic Ratios* - Researchers have evaluated chemical and elemental profiles of plants and found them to have insufficient specificity and large overlaps of profiles from different regions. Better specificity was found by considering the profiles of the stable isotopes (as opposed to radioisotopes) of C, H, O, and N. Apparently, plants discriminate the molecules containing these elements - an observation attributed to biochemical processes, such as photosynthesis, involved during a plant's growth period. Though stable isotope profiles are more specific, there are still some overlaps in profiles among geographical regions. They are, nonetheless, still useful, and Ehleringer used them to study paper made mostly of a single species: cotton[8].

2. *Results of Paper Studies* - Ehleringer was not only able to discriminate known samples of cotton-based paper but was able to correlate climatic conditions associated with the regions of growth. This assisted one of our counterfeit cases by indicating two very different geographical sources of the paper used. Though a formidable task, there are attempts being made to build a large data base of profiles of different natural plant fibre species.

3. *Stable Isotope Ratios and Dating* - For this sketch on dating one may ask how this stable isotope technology could help. Among other reasons, knowing where a paper did not come from eliminates regions known to make paper during a given period. However, in theory, if the stable isotope profile for a plant in a given region changes over time, these time-dependent profiles do not overlap among themselves, and these do not overlap with those time-dependent profiles from similar plants from other regions, then dating components of the harvested plant may be possible (besides actual sourcing). This has not been determined since data bases are still being amazed. Wine sourcing offer some support.

4. *Comments on the Appellation of Origin of Wines* - Using gas chromatography coupled with mass spectrometry (GC-MS), the relative levels of certain stable isotopes of C, H,

[7] Though there is insufficient data to say that profiles from other batches will differ or profiles from similar pigments made by other manufacturers will differ, the mere chemistry of their synthesis indicates that they should differ.

[8] In determining the source of cotton in paper, one could assume that the cotton was obtained from a single source. However, for comparative purposes this is not necessary.

O, or N, all found in wine grapes, gives information on region of growth. Data banks of these region-specific isotopic profiles (isotopic ratios) are being built using samples from world-wide wine growing regions. Some of these regional profiles also vary seasonably. The ultimate goal is to be able to assign a date and place to a sample of wine - this is called appellation of origin (the dating of wine is treated in the next section). Though GC-MS is more sensitive and specific, nuclear magnetic resonance (NMR) is used by some to make some of these measurements, particularly, deuterium and hydrogen. The date or vintage of wines is treated next.

**Detection of Levels of "Modern" Carbon 14 [31]**

**A. Nuclear Atmosphere Testing** - After the first atmospheric testing of a megaton nuclear bomb around 1950, the levels of the carbon 14 radioisotope in the atmosphere increased. This level continued to increase as more testing occurred, until the 1963 moratorium on atmospheric testing. The levels then began, and continues to decrease as the excess carbon 14 gets diluted by mixing into the biosphere (living plants and animals), oceans, and soil.

**B. Samples Reflecting the Carbon 14 Levels** - These levels have been recorded not only from collected clean air samples but from samples from tree rings and samples of wines. The latter two cases are based on the fact that any living species takes up carbon 14 during its normal intake of carbon. Furthermore, since terrestrial plants obtain their carbon from CO2 in the atmosphere, yearly fruit, like grapes, and trees which record their yearly growth in tree rings, have a record of the carbon 14 level during their year of growth. Figure 1 is a plot of a measure of bomb carbon, $^{14}C$ in the northern hemisphere, against years between 1950 to the present. It is properly called the Bomb Radiocarbon Curve.

**C. The Bomb Radiocarbon Curve** - The curve shows that any geographic variations in northern hemisphere atmospheric carbon 14 levels at a given time are equivalent to time shifts of just a few years. The data shows that, on the average, dating of materials from clean air sites should be accurate to within 1 or 2 years. The increasing and decreasing feature of the curve makes a test sample have two possible dates associated with it. One can often use historical facts of the test sample to see which is the correct date.

**D. Analytical Methodology** - Measurement of bomb radiocarbon levels in mg-sized samples involves the use of accelerator mass spectrometry (AMS) facilities such as the one found at the Lawrence Livermore Laboratory. Gram-sized samples can be measured by conventional decay counting using gas proportional or scintillation counters.

**E. Cotton Containing Paper** - Cotton is a yearly plant product. Cotton is often used in fine paper and currency paper. It often comes to the paper maker from cotton ginning facilities who purchase raw cotton that is fresh or no older than a year or two. In these cases the year of the cotton's growth can be determined.

1. Testing U. S. Banknotes - Samples from banknotes known to have been printed in 1963, 1969, 1977, 1985, and 1990 were submitted for analysis of their carbon 14 levels using AMS. These were first chemically cleaned to remove binders and sizers leaving pure cellulose. As can be seen from Table 4, there is a remarkable correlation with the bomb carbon curve. The last (skewed) result gives an estimated date of post-1993 for a sample printed in 1990 (It gives a lower bomb radiocarbon value than expected on the decreasing side of the curve.) This is attributed to possible inadequate removal of petroleum-based binders or sizers or to the presence of fossil fuel contaminants (from automobiles, burning fuel, etc.) during the growth period of the cotton.

Table 4
Radiocarbon Tests on US Currency

Obtained with permission from
Dr. John R. Southon
Center for Accelerator Mass Spectrometry
Lawrence Livermore National Laboratory
Livermore, CA 94551-9900

| Printing Date of Note | 14C value | Estimated Growth Year(s) using European Clean Air Curvea |
|---|---|---|
| 1963 | 311.1 + 7.4 | 1962 and 1988 + 1 |
| 1969 | 588.6 + 13.9 | 1963 and 1967 + 1 |
| 1977 | 329.3 + 7.5 | 1962 and 1976-1979 |
| 1985 | 195.4 + 6.7 | 1958 and 1986 + 1 |
| 1990 | 115.1 + 6.3 | 1957 and post-1993 |

a - The two dates are due to the increasing-decreasing nature of the bomb curve. The estimated growth year in bold face corresponds to the true estimate.

2. *A Counterfeit Case* - In a forensic case, this method was used to determine if a counterfeiter using cotton-based paper was producing his periodic production of counterfeits with the same batch of paper or with newly made paper. Bomb carbon levels showed it was the latter, and this provided valuable investigative leads on the papermaking operation.

**F. Wood Containing Paper** - Paper containing wood presents some difficulty for dating by this method since a tree is cut after many years of growth. Growth models and statistical methods are presently being investigated to tackle this problem. Also, methods for separating fibre species are being studied.

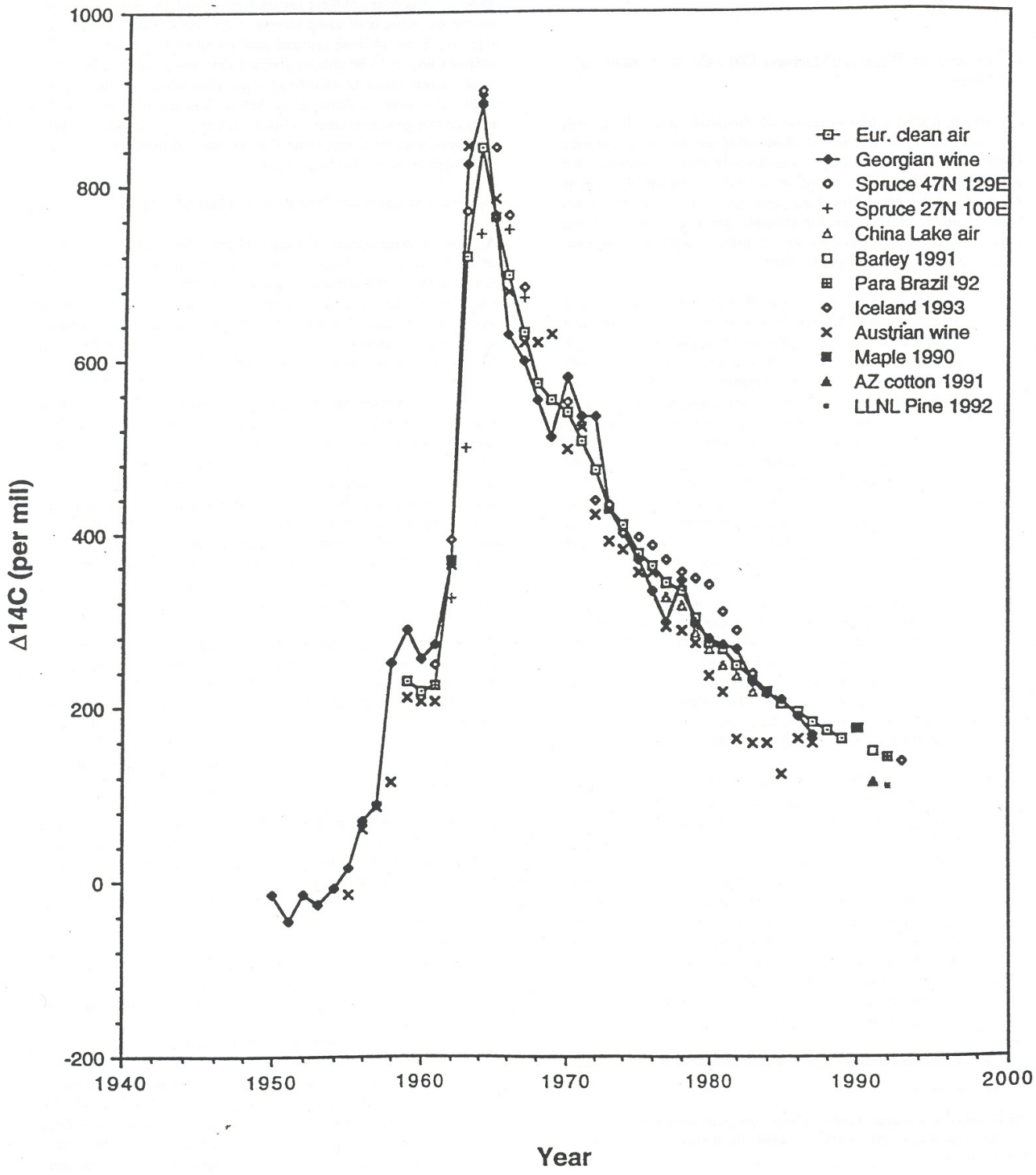
**G. Dating of other Materials** - Museums have used this concept for dating paintings done in canvas, since canvas comes from plant material. In many cases, authenticity tests include looking for bomb carbon. If the canvas of a painting allegedly done by Chagall in the 1930s contains bomb carbon, then the material in the canvas was not harvested until after 1950.

**H. Comments on the Date of Wines**- Enologist apparently have known for some time that carbon 14 levels assist them in dating their wines (vintage). This is one of the methods of choice and is being used by several laboratories for dating wines.

**Particle Analysis**

The methods mentioned so far have focused on macro and micro samples of items in or on documents. The smallest sample size is 1 $mm^2$ for the PIXE analysis. Particle analysis involves ultramicro samples (particles between 1 and 10 micron in size) in the documents. The microscope is the key instrument. This is followed by ultramicro analytical methods or analytical microscopy. It covers both compositional and elemental analysis.

Figure 1. Bomb curve Δ14C data.



**A. Analytical Protocol**

1. *Preliminary Examination* - The first instrument used to examine a document is the stereo microscope. The polarized light microscope is then used to examine items such as fibres, inks, stains, and particles at higher examination. Polarized light microscopy (PLM) addresses the behaviour and characterization of materials viewed under polarized light as well as the characterization of their morphological features. In many cases PLM characterization identifies materials. A third instrument sometimes used is the fluorescence microscope. This occasionally finds materials normally not found by PLM. Fluorescence microscopy characterizes materials (if they fluoresce and emission spectra are obtained) but does not always identify them.

2. *Ultramicro Analytical Examinations* - Analytical methods for such examinations include:

. Micro x-ray diffraction
. Scanning electron microscope (with EDAX)[9]
. Transmission electron microscopy
. Particle size measurement
. Electron microprobe analyzer
. Ion microprobe analyzer

**B. Application** - Scientists have recognized that particles trapped in paper, under printing, and in inks provided valuable clues on where and possibly when a document was executed. Also, particles adhered to materials give clues of where they have been or with what they have been in contact. (This concept is related to the Locard's Principle which, in essence, states that when two substances come into contact, there is an exchange of compositional matter between the two.)

1. *Biological Particle Analysis* - Frei [32,33], a Swiss botanist and criminologist, used the latter concept to trace the provenance of the Shroud of Turin through the analysis of pollen spore. Over two-thirds of those he analyzed were from plants that only grew in Palestine and the area of Istabul, Turkey - suggesting that the shroud had been exposed to air from Palestine and Turkey and thus had a pre-1357 existence (since it was known to be only in Europe after 1357). The BATF lab had a case involving trapped particles. With the help of entomologist from the Smithonian, BATF showed that an insect trapped in rice paper came from a certain geographical region. This confirmed the U. S. Customs' theory that this product came from a country under an embargo.

2. *Pigment Analysis* - Fake paintings are often detected through their pigments. This is also true for printed documents such as currency and historical manuscripts. One dating case of note involved the Vinland map bought by Yale University for a large sum of money. It was purportedly made in 1440. If authentic, it supports that Europeans visited the American continent before Columbus. McCrone [34] found evidence that it was made in this century. He found particles of modern anatase "titanium white" pigment ($TiO_2$) first manufactured in 1917. The reader may wish to read details of this work [35] and of those challenging it [36].

[9]Energy Dispersive Analysis by X-rays (EDAX) is an x-ray fluorescence (XRF) analysis done using an energy dispersive (as opposed to wavelength dispersive) spectrometer.

## III. CONCLUSION

This part of the sketch outlined certain methods for detecting fraudulent documents. These methods identify anachronisms or items on a document that were not in existence when it was allegedly executed. This involved comparing with a collection of known samples.

These methods detect fraud but cannot prove authenticity. Authenticity can sometimes be suggested if, for example, several different inks are involved in an old document, none of these proves backdating, and each has a discontinuance date close to the alleged date. The next part will address relative aging of ink. Here authenticity can be proved under certain conditions.

**Acknowledgments and Apologies**

Special thanks are given to Dr. James Ehleringer and Dr. John Southon for sharing their ideas and data and to Dr. Janet Dorigan for supporting their work. I have tried to capture in this sketch the major works of several contributors to the science of dating documents; however, if I inadvertently missed any, I sincerely apologize.

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# Exhibit 6

**D. Photocopy Toner [21]** - The type of photocopier and toner used to produce a photocopied document can sometimes be determined and dated. This, as mentioned, depends on the existence of a data base of standard samples, their profiles, and their dates of introduction.

# Exhibit 7

Designation: E 2388 – 05

# Standard Guide for Minimum Training Requirements for Forensic Document Examiners[1]

This standard is issued under the fixed designation E 2388; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide provides minimum requirements and procedures that should be used for the fundamental training of forensic document examiners (E 444).

1.2 This guide may not cover all aspects of training for the topics addressed or for unusual or uncommon examinations.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 444 Standard Descriptions of Scope of Work Relating to Forensic Document Examiners

E 1732 Terminology Relating to Forensic Science

E 2195 Terminology Relating to Forensic Document Examination

## 3. Terminology

3.1 *Definitions:*

3.1.1 *technical visit*, *n*—travel for the purpose of obtaining information, knowledge, or training, including interaction with or demonstration by pertinent manufacturers, businesses, and laboratories.

3.1.2 For definitions of terms in this guide, refer to Terminologies E 1732 and E 2195.

## 4. Significance and Use

4.1 The procedures outlined here are grounded in the generally accepted body of knowledge and experience in the field of forensic document examination. By following these requirements and procedures, an appropriate trainee (see 5.2) can acquire the scientific, technical, and other specialized knowledge, skill, and experience required to reliably perform the work of a forensic document examiner (E 444).

## 5. Equipment and Personnel

5.1 *Training Materials and Equipment*:

5.1.1 Access to texts, periodicals, papers, and other professional literature.

5.1.2 Access to equipment appropriate to each area of instruction.

5.2 *Requirements for the Trainee Candidate*:

5.2.1 An earned baccalaureate degree or equivalent from an accredited college or university.

5.2.2 Documented successful completion of a form discrimination test.

5.2.3 Documented successful completion of a color perception test.

5.2.4 Documented successful completion of near and distant visual acuity tests with best corrected vision within six months prior to commencement of training.

5.3 *Requirements for the Trainer(s)*:

5.3.1 Requirements for the principal trainer:

5.3.1.1 The principal trainer shall be a forensic document examiner;

5.3.1.2 Have successfully completed the equivalent of a minimum of 24 months full-time supervised training;

5.3.1.3 Have been trained in the topics of instruction in this guide (Section 7); and

5.3.1.4 Have at least five years of full-time post-training experience as a forensic document examiner.

5.3.1.5 All of the above should be documented.

5.3.1.6 The principal trainer should have successfully completed a course or seminar in instructor development.

5.3.2 The qualifications of any other trainers shall be approved by the principal trainer.

## 6. Procedure

6.1 The training program shall be the equivalent of a minimum of 24 months full-time training under the supervision of a principal trainer.

[1] This guide is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.02 on Questioned Documents.

Current edition approved Sept. 15, 2005. Published October 2005.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6.1.1 The training program shall be successfully completed in a period not to exceed four years.

6.1.2 Each area of instruction will have an objective(s) established by the principal trainer. Examination(s) (for example, written test, oral test, practical exercise) will be administered in order to measure the trainee's knowledge.

NOTE 1—Although attending meetings and presentations is useful as supplemental training, it does not replace the training outlined in Section 7 of this guide. However, the principal trainer may grant credit to the trainee for knowledge (as per Section 7) acquired at such meetings and presentations.

6.1.3 The principal trainer may grant credit for prior training or experience in Section 7 subject areas when the trainee can demonstrate and document such training or experience.

6.1.4 A training record for each trainee will be maintained and will document the following:

6.1.4.1 Instruction in each topic area.

6.1.4.2 A bibliography of relevant literature studied.

6.1.4.3 Examination(s) (for example, written test, oral test, practical exercise).

6.1.4.4 Case statistics (for example, number, type, items, reports).

6.1.4.5 Outside training, technical visits, courses, conferences, or workshops attended.

6.1.4.6 Research conducted.

## 7. Syllabus

7.1 A formal written training program will include specific topics of instruction. The order in which they are administered is discretionary; however, the amount of time must be adequate to ensure competency in all topic areas. The minimum specific topics are:

7.2 *Introduction and History of Forensic Document Examination*:

7.2.1 Ethical responsibilities.

7.2.2 Literature of the field.

7.2.3 Evolution of the field.

7.2.4 Historical cases.

7.2.5 Scientific method.

7.2.6 Research methodology.

7.3 *Evidence Handling Procedures*:

7.3.1 Procedures and protocols.

7.3.2 Relationship of forensic document examination to other forensic disciplines.

7.3.3 Collection and preservation.

7.3.4 Marking and documentation.

7.3.5 Chain of custody.

7.4 *Examination Procedures*:

7.4.1 Procedures and protocols.

7.4.2 Theory of individualization.

7.4.3 Case organization.

7.4.4 Note taking.

7.4.5 Conclusions and findings.

7.4.6 Report writing.

7.5 *Laboratory Instrumentation and Equipment*:

7.5.1 Procedures and protocols.

7.5.2 Physics of light pertinent to forensic document examination procedures.

7.5.3 Microscopy.

7.5.4 Measuring systems and devices.

7.5.5 Light sources.

7.5.6 Electrostatic detection devices.

7.5.7 Typewriter examination devices.

7.5.8 Computers and peripherals.

7.5.9 Other relevant laboratory equipment.

7.6 *Paper*:

7.6.1 Procedures and protocols.

7.6.2 History of paper.

7.6.3 Manufacturing processes.

7.6.4 Physical properties (for example, light-reactive, watermarks, dimensions, security features).

7.6.5 Physical matches (for example, fibers, tears, edge striations).

7.6.6 Tapes and adhesives.

7.6.7 Indentations.

7.7 *Writing Instruments and Inks*:

7.7.1 Procedures and protocols.

7.7.2 History of writing instruments and inks.

7.7.3 Properties of inks.

7.7.4 Destructive and nondestructive analyses of inks.

7.7.5 Writing instrument characteristics.

7.7.6 Sequence, direction, and pressure of strokes.

7.8 *Handwriting (including Cursive or Script Style Writing, Hand Printing, Signatures, Numerals, and Other Written Marks or Signs)*:

7.8.1 Procedures and protocols.

7.8.2 History and theory.

7.8.3 Physiology of handwriting and motor control.

7.8.4 Handwriting systems.

7.8.5 Handwriting comparison process.

7.8.6 Individualizing characteristics (individual and class).

7.8.7 Features of handwriting (for example, variation, line quality, skill level).

7.8.8 Distorted handwriting.

7.8.9 Factors affecting handwriting (internal and external).

7.8.10 Tracings and simulations.

7.8.11 Other handwriting problems.

7.9 *Alterations, Obliterations, and Erasures*:

7.9.1 Procedures and Protocols.

7.9.2 Types of alterations (for example, page substitution, insertion).

7.9.3 Types of obliterations (for example, opaquing fluid, over-writing, chemical).

7.9.4 Types of erasures (physical and chemical).

7.9.5 Detection and decipherment techniques.

7.10 *Typewriters*:

7.10.1 Procedures and protocols.

7.10.2 History of typewriters.

7.10.3 Fundamentals of typewriter examination (individualization and comparison).

7.10.4 Typestyle classification.

7.10.5 Typing and correction ribbon examinations.

7.10.6 Paper fiber transfer.

7.11 *Computer Printers*:

7.11.1 Procedures and protocols.

7.11.2 History of computer printers.

7.11.3 Fundamentals of computer printer examinations (individualization and comparison).

7.11.4 Computer printing processes (impact and nonimpact).

7.11.5 Font classification.

7.12 *Photocopiers*:

7.12.1 Procedures and protocols.

7.12.2 History of photocopiers.

7.12.3 Electrostatic and other imaging processes.

7.12.4 Fundamentals of examination (individualization and comparison).

7.12.5 Alteration and manipulation techniques.

7.13 *Facsimiles*:

7.13.1 Procedures and protocols.

7.13.2 History of facsimile machines.

7.13.3 Imaging processes.

7.13.4 Fundamentals of examination (individualization and comparison).

7.13.5 Alteration and manipulation techniques.

7.14 *Printing Processes*:

7.14.1 Procedures and protocols.

7.14.2 History of printing.

7.14.3 Typography.

7.14.4 Characteristics of printing processes.

7.14.5 Fundamentals of examination (individualization and comparison).

7.14.6 Security features.

7.15 *Mechanical Impressions*:

7.15.1 Procedures and protocols.

7.15.2 History of devices (for example, check writers, rubber and polymer stamps, paper binders, staples, embossing devices, seals and stamped impressions, fasteners, hole punchers).

7.15.3 Fundamentals of examination (individualization and comparison).

7.16 *Charred and Soaked Documents*:

7.16.1 Procedures and protocols.

7.16.2 Care and preservation.

7.16.3 Examination and decipherment.

7.17 *Photography and Digital Imaging*:

7.17.1 Procedures and protocols.

7.17.2 General photography.

7.17.3 Document photography.

7.17.4 Digital photography.

7.17.5 Digital imaging techniques.

7.17.6 Alteration and manipulation techniques.

7.17.7 Image editing software.

7.18 *Miscellaneous Examinations*:

7.18.1 Dependent upon the capabilities or requirements of the laboratory.

7.19 *Expert Witness and Legal Proceedings*:

7.19.1 Procedures and protocols.

7.19.2 Terminology.

7.19.3 Relevant law.

7.19.4 Adjudication systems.

7.19.5 Effective communication.

7.19.6 Courtroom demeanor.

7.19.7 Preparation and use of demonstrative exhibits.

7.19.8 Observation of pre-trial conferences and testimony of experts, actual or mock.

7.19.9 Participation as an expert witness in mock trials.

7.20 *Practical Experience*:

7.20.1 Supervised casework.

7.20.2 Training or observation at other forensic document laboratories is recommended.

7.20.3 Supplemental education (for example, courses, seminars, technical visits, workshops).

## 8. Keywords

8.1 forensic document examination; forensic document examiner; forensic sciences; questioned documents; training

# Exhibit 8

Designation: E 1658 – 04

# Standard Terminology for Expressing Conclusions of Forensic Document Examiners[1]

This standard is issued under the fixed designation E 1658; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This terminology is intended to assist forensic document examiners in expressing conclusions based on their examination.

1.2 This terminology is based on the report of a committee of the Questioned Document Section of the American Academy of Forensic Science which was adopted as the recommended guidelines in reports and testimony by the Questioned Document Section of the American Academy of Forensic Science and the American Board of Forensic Document Examiners[2,3].

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 444 Guide for Description of Work of Forensic Document Examiners

## 3. Significance and Use

3.1 Document examiners begin their handwriting examinations from a point of complete neutrality. There are an infinite number of gradations of opinion toward an identification or toward an elimination. It is in those cases wherein the opinion is less than definite that careful attention is especially needed in the choice of language used to convey the weight of the evidence.

3.2 Common sense dictates that we must limit the terminology we use in expressing our degrees of confidence in the evidence to terms that are readily understandable to those who use our services (including investigators, attorneys, judges, and jury members), as well as to other document examiners. We must be careful that the expressions we use in separating the gradations of opinions do not become strongly defined "categories" that will always be used as a matter of convenience; instead, these expressions should be guidelines without sharply defined boundaries.

3.3 When a forensic document examiner chooses to use one of the terms defined below, the listener or reader can assume that this is what the examiner intended the term to mean. To avoid the possibility of misinterpretation of a term where the expert is not present to explain the guidelines in this standard, the appropriate definition(s) could be quoted in or appended to reports.

3.4 The examples are given both in the first person and in third person since both methods of reporting are used by document examiners and since both forms meet the main purpose of the standard, *i. e.*, to suggest terminology that is readily understandable. These examples should not be regarded as the only ways to utilize probability statements in reports and testimony. In following any guidelines, the examiner should always bear in mind that sometimes the examination will lead into paths that cannot be anticipated and that no guidelines can cover exactly.

3.5 Although the material that follows deals with handwriting, forensic document examiners may apply this terminology to other examinations within the scope of their work, as described in Guide E 444, and it may be used by forensic examiners in other areas, as appropriate.

3.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 4. Terminology

4.1 *Recommended Terms:*

**identification (definite conclusion of identity)**—this is the highest degree of confidence expressed by document examiners in handwriting comparisons. The examiner has no reservations whatever, and although prohibited from using the word "fact," the examiner is certain, based on evidence contained in the handwriting, that the writer of the known material actually wrote the writing in question.

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[1] This terminology is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.02 on Questioned Documents.

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[2] McAlexander, T. V., Beck, J., and Dick, R., "The Standardization of Handwriting Opinion Terminology," *Journal of Forensic Science*, Vol. 36. No. 2, March 1991, pp. 311–319.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*Examples*—It has been concluded that John Doe wrote the questioned material, or it is my opinion [or conclusion] that John Doe of the known material wrote the questioned material.

**strong probability (highly probable, very probable)**—the evidence is very persuasive, yet some critical feature or quality is missing so that an *identification* is not in order; however, the examiner is virtually certain that the questioned and known writings were written by the same individual.

*Examples*—There is *strong probability* that the John Doe of the known material wrote the questioned material, or it is my opinion (or conclusion or determination) that the John Doe of the known material *very probably* wrote the questioned material.

DISCUSSION—Some examiners doubt the desirability of differentiating between **strong probability** and **probable**, and certainly they may eliminate this terminology. But those examiners who are trying to encompass the entire "gray scale" of degrees of confidence may wish to use this or a similar term.

**probable**—the evidence contained in the handwriting points rather strongly toward the questioned and known writings having been written by the same individual; however, it falls short of the" virtually certain" degree of confidence.

*Examples*—It has been concluded that the John Doe of the known material probably wrote the questioned material, or it is my opinion (or conclusion or determination) that the John Doe of the known material *probably* wrote the questioned material.

**indications (evidence to suggest)**—a body of writing has few features which are of significance for handwriting comparison purposes, but those features are in agreement with another body of writing.

*Examples*—There is evidence which *indicates* (or *suggests*) that the John Doe of the known material may have written the questioned material but the evidence falls far short of that necessary to support a definite conclusion.

DISCUSSION—This is a very weak opinion, and a report may be misinterpreted to be an identification by some readers if the report simply states, "The evidence *indicates* that the John Doe of the known material wrote the questioned material." There should always be additional limiting words or phrases (such as "may have" or "but the evidence is far from conclusive") when this opinion is reported, to ensure that the reader understands that the opinion is weak. Some examiners doubt the desirability of reporting an opinion this vague, and certainly they cannot be criticized if they eliminate this terminology. But those examiners who are trying to encompass the entire "gray scale" of degrees of confidence may wish to use this or a similar term.

**no conclusion (totally inconclusive, indeterminable)**—This is the zero point of the confidence scale. It is used when there are significantly limiting factors, such as disguise in the questioned and/or known writing or a lack of comparable writing, and the examiner does not have even a leaning one way or another.

*Examples*—*No conclusion* could be reached as to whether or not the John Doe of the known material wrote the questioned material, or I could not determine whether or not the John Doe of the known material wrote the questioned material.

**indications did not**—this carries the same weight as the indications term that is, it is a very weak opinion.

*Examples*—There is very little significant evidence present in the comparable portions of the questioned and known writings, but that evidence *suggests* that the John Doe of the known material did not write the questioned material, or I found *indications* that the John Doe of the known material did *not* write the questioned material but the evidence is far from conclusive.

See Discussion after **indications**.

**probably did not**—the evidence points rather strongly against the questioned and known writings having been written by the same individual, but, as in the probable range above, the evidence is not quite up to the "virtually certain" range.

*Examples*—It has been concluded that the John Doe of the known material probably did not write the questioned material, or it is my opinion (or conclusion or determination) that the John Doe of the known material probably did not write the questioned material.

DISCUSSION—Some examiners prefer to state this opinion: "It is unlikely that the John Doe of the known material wrote the questioned material." There is no strong objection to this, as "unlikely" is merely the Anglo-Saxon equivalent of "improbable".

**strong probability did not**—this carries the same weight as strong probability on the identification side of the scale; that is, the examiner is virtually certain that the questioned and known writings were not written by the same individual.

*Examples*—There is strong probability that the John Doe of the known material did not write the questioned material, or in my opinion (or conclusion or determination) it is highly probable that the John Doe of the known material did not write the questioned material.

DISCUSSION—Certainly those examiners who choose to use "unlikely" in place of "probably did not" may wish to use "highly unlikely" here.

**elimination**—this, like the *definite conclusion of identity*, is the highest degree of confidence expressed by the document examiner in handwriting comparisons. By using this expression the examiner denotes no doubt in his opinion that the questioned and known writings were not written by the same individual.

*Examples*—It has been concluded that the John Doe of the known material did not write the questioned material, or it is my opinion (or conclusion or determination) that the John Doe of the known material did not write the questioned material.

DISCUSSION—This is often a very difficult determination to make in handwriting examinations, especially when only requested exemplars are available, and extreme care should be used in arriving at this conclusion.

4.1.1 When the opinion is less than definite, there is usually a necessity for additional comments, consisting of such things as reasons for qualification (if the available evidence allows that determination), suggestions for remedies (if any are known), and any other comments that will shed more light on the report. The report should stand alone with no extra explanations necessary.

4.2 *Deprecated and Discouraged Expressions*:

4.2.1 Several expressions occasionally used by document examiners are troublesome because they may be misinterpreted to imply bias, lack of clarity, or fallaciousness and their use is deprecated. Some of the terms are so blatantly inane (such as "make/no make") that they will not be discussed. The use of others is discouraged because they are incomplete or misused. These expressions include:

**possible/could have**—these terms have no place in expert opinions on handwriting because the examiner's task is to decide to what degree of certainty it can be said that a handwriting sample is by a specific person. If the evidence is so limited or unclear that no definite or qualified opinion can be expressed, then the proper answer is *no conclusion*. To say that the suspect "could have written the material in question" says nothing about probability and is therefore meaningless to the reader or to the court. The examiner should be clear on the different meanings of "possible" and "probable," although they are often used interchangeably in everyday speech.

**consistent with**—there are times when this expression is perfectly appropriate, such as when "evidence consistent with disguise is present" or "evidence consistent with a simulation or tracing is present, but "the known writing is consistent with the questioned writing" has no intelligible meaning.

**could not be identified/cannot identify**—these terms are objectionable not only because they are ambiguous but also because they are biased; they imply that the examiner's task is only to identify the suspect, not to decide whether or not the suspect is the writer. If one of these terms is used, it should always be followed by "or eliminate[d]".

**similarities were noted/differences as well as similarities**—these expressions are meaningless without an explanation as to the extent and significance of the similarities or differences between the known and questioned material. These terms should never be substituted for gradations of opinions.

**cannot be associated/cannot be connected**—these terms are too vague and may be interpreted as reflecting bias as they have no counterpart suggesting that the writer cannot be eliminated either.

**no identification**—this expression could be understood to mean anything from a strong probability that the suspect wrote the questioned writing; to a complete elimination. It is not only confusing but also grammatically incorrect when used informally in sentences such as.“ I no identified the writer" or "I made a no ident in this case."

**inconclusive**—this is commonly used synonymously with no conclusion when the examiner is at the zero point on the scale of confidence. A potential problem is that some people understand this term to mean something short of definite (or conclusive), that is, any degree of probability, and the examiner should be aware of this ambiguity.

**positive identification**—This phrase is inappropriate because it seems to suggest that some identifications are more positive than others.

**[strong] reason to believe**—there are too many definitions of *believe* and *belief* that lack certitude. It is more appropriate to testify to our conclusion (or determination or expert opinion) than to our belief, so why use that term in a report?

**qualified identification**—An *identification* is not qualified. However, opinions may be qualified when the evidence falls short of an *identification* or *elimination*.

# Exhibit 9

# Suspect Documents

**THEIR SCIENTIFIC EXAMINATION**

Second Impression with Supplement 1966

BY

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will take the trouble to place the parts together and then examine them for continuity of wiremarks or for other evidence which will show that a strip has been removed.

A document vital to a case is sometimes produced in a torn and tattered condition to give colour to the story of the vicissitudes through which it is supposed to have passed. If examination shows that nothing of real importance has been lost or rendered illegible and that the damage has been done only to those parts of the document which are not very significant, the document should be regarded with suspicion. If this happy state of affairs proves to be the case with not one but with a whole group of documents, then it can safely be concluded that they are forgeries because the odds against this happening are too great for it to be fortuitous. In the literature there are many examples of forgeries being exposed after suspicion has been aroused in this way. One of the best known is that quoted by A. C. Mitchell, in which a series of forged letters, alleged to have been written by Burns, Scott, Thackeray and other celebrities, contained worm holes; but in every instance the worms had been careful to avoid damaging the writing! The more reasonable explanation, that the forger had avoided the worm holes, was subsequently proved to be true.

Most forgers of ancient documents are well aware of the importance of using genuinely old paper, the most convenient source of which is the fly leaves of old books. As one book can yield but a limited amount of material, leaves from a number of books must be collected when fabricating a document of any size and imperfect sheets may have to be pressed into service. With this in mind, any reputedly ancient document made up of a number of different papers must be regarded with suspicion. At the same time, the examiner will be on his guard for the appearance of variable spacing of the writing or of cramped and unnatural phraseology on a damaged document, which often indicate that the writer has used material which was already in a damaged state and has taken care to avoid writing anything of importance on the damaged or fragile portions of the sheet.

*Holes Made by Fastenings*

The tiny perforations made by wire stapling machines may easily be overlooked; often they can only be seen by holding the document up to a strong light. These holes occur in pairs and should more than one pair be present because more than one staple was used, it may be possible, from the relative position of the holes, to discover which of a number of separate documents had at one time been stapled together.

This is the basis on which the author has investigated thefts of pay-packets. It is the custom in many organisations to staple the bank notes to the pay-packet envelope which bears the name or number of the employee. As more than a single staple is almost invariably used for this purpose, it has been found possible to link bank notes found in the possession of a suspect with the stolen pay-packet which, as it bears the name of the loser, is thrown away at the earliest opportunity but may be found on thorough search of the vicinity. If two wire staples have been used, then the pay-packet and the notes it once contained will all have groups

of four holes which are perfectly matched. The odds against these coinciding with the holes in other pay-packets or in other notes are exceedingly great. In the illustration Figure 3–14, three wire staples were used in which case the degree of certainty is even greater.

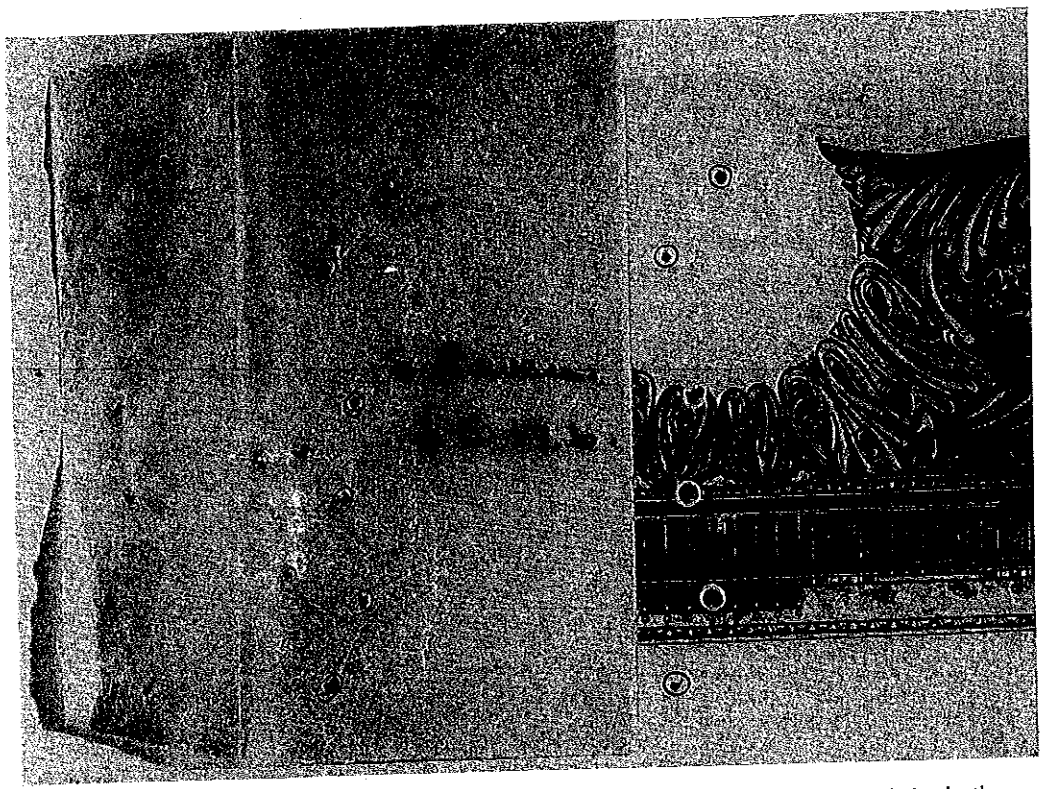

Fig. 3–14. Pin-holes in the Treasury Notes, indicated with circles, match the staple holes in the transparent envelope (one set indicated with circles). This proves that the Notes, shown on the right, had been fastened into the envelope, shown on the left.

## The Content of the Document

When the physical examination of the document has been comp'eted, attention can be paid to what has been printed, written or typed thereon.

### Secret Writing

If there is any reason to suspect the presence of secret writing, the attention should first be directed to the spacing of the visible handwriting or typescript present, generally referred to as the "overt text." It is comparatively common practice to space widely the overt text so as to accommodate the secret writing—the "covert text." If this is not done, there is the risk of the pen used for the secret writing crossing some of the overt text and producing a defect in the line which might lead to discovery of the secret writing. Apart from