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# FORENSIC GUNSHOT RESIDUE ANALYSIS


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# Preface

Gunshot residue (GSR) examination is a specialized discipline of forensic science. Techniques for examining GSR have evolved from simple color tests to modern analytical methods. This book details current methods of GSR analysis for professionals who utilize this type of evidence in their work and introduces the subject to laypeople interested in learning about this ever-changing field.

The concept of this text was formulated with current methods of GSR in mind. A comprehensive text on the examination of GSR was compiled more than 20 years ago in a publication called the Aerospace Report No. ATR-77(7915)-3. To date, the Aerospace Report is the most comprehensive text available about GSR. Since that time, advancements have been made in the way GSR evidence is examined in laboratories worldwide, and many laboratories have modified the classification of certain particles derived from this type of evidence. This book is not meant to replace the extensive research compiled by the Aerospace Report, but rather to supplement that report and many other quality research papers that have been published over the past 20 years.

This text concentrates on certain areas that we consider most important to examiners in the law enforcement community and students of criminal justice and forensics. Chapter 1 discusses the significance of GSR evidence, collection criteria, and general topics. Chapter 2 examines particle formation and presents a current classification scheme for GSR evidence. The classification of particles is an important aspect of GSR evidence that is evolving as research in this area continues. A general overview of scanning electron microscopy energy dispersive spectroscopy (SEM/EDS) is presented in some detail in Chapter 3. This chapter will educate both bench examiners and students about this powerful method of analysis, now at the forefront of GSR examination. General theory, computer-controlled scanning electron microscopy (CCSEM), and variable pressure scanning electron microscopy are discussed.

Chapter 4 details a study of "plume" concentrations. The importance of how GSR is deposited on the hands of shooters with various types of firearms is a significant aspect of GSR interpretation. The various amounts and areas

of deposition of GSR for firearms such as revolvers, pistols, rifles, and shotguns are explained and compared. A possible mechanism to estimate particle fallout is also described.

No explanation of GSR would be complete without a general overview of commonly used firearms and ammunitions. In Chapter 5 we attempt to educate the reader on the general types of firearms used today and the components of commonly used ammunition types. Chapter 6 summarizes general guidelines for note taking, report writing, and courtroom considerations for the expert witness.

This book presents the reader with an overview of current methods of examination and interpretation used by the authors and examiners in the law enforcement community. Our hope is that the reader will combine the knowledge provided in this book with past and current literature about GSR examination, and thus continue the evolution of this valuable area of forensic science.

# The Authors

**A. J. Schwoeble** is Manager of Forensic Sciences and Special Projects, responsible for forensic analytical services and for designing, implementing, and reporting specialized testing programs for RJ Lee Group, Monroeville, PA. At RJ Lee Group, Mr. Schwoeble played a key role in developing latent fingerprint technology and the adhesive-lift technology used for sampling skin and fabric for trace evidence applications and for surface and indoor ambient air particulate sampling. He was a principal architect for computer software to perform gunshot residue (GSR) analysis. He is presently consulting with a Swiss law enforcement agency for the analysis of GSR produced from foreign manufactured ammunition, and conducting the examination of clean fire primers of U.S. manufacturers.

Mr. Schwoeble has consulted with the FBI and other law enforcement agencies on automated microscopy and sample collection techniques for the analysis of GSR and other trace evidence. He performs GSR analysis and particle analysis for over 150 law enforcement agencies and attorneys in the United States, Australia, and Switzerland. His forensic investigations incorporate the use of optical, scanning electron, and transmission electron microscopy, atomic absorption (AA), and micro-FTIR (Fourier Transform Infrared Spectroscopy). Mr. Schwoeble has qualified as an expert for GSR analysis in several states. He has been an invited speaker at meetings of the ICEM-14, ENFSI, MAFS, SAFS, CAFS, and MAAFS.

Prior to joining RJ Lee Group in 1986, Mr. Schwoeble acquired over 25 years of research and materials analysis experience at the Naval Research Laboratory, Washington, D.C., the United States Steel Research Center, Monroeville, PA, and Allegheny Ballistics Laboratory, Pinto, WV. He is the author of numerous publications. He was the 1984 recipient of the ASM Henry Marion Howe Award as the author of the published paper of highest merit in metallurgical transactions.

**David L. Exline** is a forensic scientist with RJ Lee Group, where he examines GSR, hairs, fibers, paints, and other forensically significant trace evidence. Before joining RJ Lee Group in 1998, Mr. Exline was a forensic scientist with the Anne Arundel County Police Department Crime Laboratory, Millersville,

MD, where he was responsible for the oversight and functions of the trace evidence section of the laboratory.

Mr. Exline received his B.A. in biology from Slippery Rock University, Slippery Rock, PA in 1993 and his M.S. in forensic science from the University of Alabama, Birmingham in 1995. He is a diplomate of the American Board of Criminalistics, a provisional member of the American Academy of Forensic Sciences, a member of the Mid-Atlantic Association of Forensic Scientists, and the Forensic Science Society.

Mr. Exline has instructed law enforcement agencies, attorneys, and students in the collection, preservation, and examination of trace evidence. He is a court-qualified expert in various areas of trace evidence examination. He has published in the *Journal of Forensic Sciences*, and he is the co-author of *The Forensic Animal Hair Atlas on CD-Rom*. Mr. Exline was the recipient of the 1999 American Academy of Forensic Sciences Regional Award and the 1999 International Association of Forensic Sciences Emerging Forensic Scientist Continental Award.

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*To our wives, Nancy Schwoeble and Jennifer Exline*

*Their patience and support allowed us to spend many nights and long hours compiling data, writing, and organizing the contents of this book, which took us away from family life for extended periods of time*

# Table of Contents

# Gunshot Residue as Forensic Evidence

# 1

## Introduction

Forensic science may be defined as the application of various scientific disciplines to aid the criminal justice system. Gunshot residue (GSR) evidence is an area of forensic science that is often underestimated and underappreciated by the forensic community. It is certainly one of the most underutilized types of physical evidence. The staggering increase in firearms-related offenses in the U.S. has intensified the importance of rapid and accurate GSR analysis. In a recent report, the Federal Bureau of Investigation (FBI) cites firearms as the weapons of choice in over 30% of 1.7 million incidents of violent crime.[1]

This book was written in response to the growing realization of the significance of GSR as evidence and the lack of textbooks that discuss current developments in this area of forensics. Despite advancements in analytical techniques and adjustments to the classification of GSR particles, no text that discusses these developments has been produced. In particular, this book provides a unique resource to help examiners at every level better understand current methods of analysis. The book will also aid experienced examiners by highlighting other areas that have been refined since guidelines were set forth by the Aerospace Report of 1977.[2] The Aerospace Report was a landmark study of GSR, and the information it provided to the forensic community was invaluable to GSR examiners. Since that time significant developments have occurred in the area of GSR analysis. For example, methods such as computer-controlled scanning electron microscopy (CCSEM) now offer the means to examine thousands of particles per sample in a relatively short period of time (approximately 2 hours vs. 8- to 12-hour examinations per sample using manual microscopy methods), depending on the particles present on the sample.

We hope that this book will spark interest in this ever-expanding discipline and encourage both experienced and novice scientists to revisit GSR interpretation and characterization in forensic casework.

## Value of GSR as Trace Evidence

Trace evidence is a type of physical evidence that is often not detectable to the naked eye. Often, some type of magnification or sensitive analytical technique is required to adequately characterize the evidence. GSR evidence is one of the most common and most heavily scrutinized sources of trace evidence examined in violent crime investigations. Understanding GSR and its value as significant trace evidence can aid in the investigation of violent crimes involving firearms. GSR may directly link an otherwise unknown subject to an environment of weapon discharge.

For GSR evidence to be significant, many factors must be considered. GSR is typically found on the hands or clothing of persons who have been in the environment of a discharging firearm, but it may also be found on objects in the vicinity of discharge. It is vital for law enforcement personnel to understand how GSR is created and deposited and how such evidence is collected.

Because the methods of collection and analysis are so varied, it is of utmost importance for those who collect and examine this evidence to be aware of the importance of preserving its potential value. Forensic examiners, evidence collection officers, police officers, EMS personnel, medical professionals, and anyone who comes in contact with suspects and victims following a violent crime must understand the potential existence and significance of GSR evidence. Investigators must corroborate or disprove stories, confirm or contradict suicides, and evaluate scenarios where there are no eye witnesses or other types of investigative leads. For these individuals, education about forensic evidence and training in the area of evidence collection and recognition are essential. It is important to understand the different types of sampling media used in the collection of trace evidence and which type is appropriate for particular crime scene conditions or material to be tested.

The most commonly asked question when a crime involving a firearm has occurred is "Who fired the gun?" (or in the case of a suicide, "Are we sure the victim actually fired the gun?"). These questions can often be addressed simply by taking the time to correctly collect the evidence and properly analyze the samples in the laboratory.

Another common question that arises when GSR is present is "Can you be sure who fired the weapon?" The answer is not always clear. This is why an understanding of how GSR is deposited, how it is collected, its persistence, and the means of analysis are so critical. The examiner must consider all of this information before forming any opinions.

As the reader progresses through this book, it will become apparent that the answers to questions like those asked above are not clear-cut in many cases. What can always be stated with certainty is that detection of GSR means a