CASE REPORT

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Identification of Ammunitions Used in a Lethal Robbery. Comparison Between Scanning Electron Microscopy/Energy Dispersive X-Ray Analysis (SEM-EDX) and Instrumental Neutron Activation Analysis (INAA) Measurements

REFERENCE: Moauro, A. and Falso, G., **"Identification of Ammunitions Used in a Lethal Robbery. Comparison Between Scanning Electron Microscopy/Energy Dispersive X-Ray Analysis (SEM-EDX) and Instrumental Neutron Activation Analysis (INAA) Measurements,"** *Journal of Forensic Sciences*, JFSCA, Vol. 38, No. 5, September 1993, pp. 1237–1242.

ABSTRACT: Gunshot residues (GSRs) sampled in proximity of the hole left by a bullet on the clothes of a person wounded during a homicidal robbery, have been examined by the authors, on request of the Court. These investigations have shown that gunshot residues GSRs can be considered consistent with a shot discharged by a pistol SIG SAUER, found on the crime scene, with Sellier & Bellot (S&B) ammunition. Actually, these cartridges leave residues in which tin is present together with lead and barium, as found in the examined GSRs. An evaluation of the firing distance and a comparison between scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX) and Instrumental Neutron Activation Analysis (INAA) have been also performed.

KEYWORDS: forensic science, forensic investigations, ballistics, ammunition identification, neutron activation analysis

Scanning electron microscopy coupled with energy dispersive X-ray (SEM/EDX) analysis is considered at present the most definitive procedure for the detection and identification of gunshot residues (GSR) particles, as it is based on their morphology and elemental composition [*1*]. However it has some drawbacks in evaluating quantitative aspects of GSRs deposition and in identifying ammunition brands based on their composition. In our opinion these aspects can be better fulfilled by using instrumental neutron activation analysis (INAA). In this context INAA has been used previously in our laboratory in many forensic investigations [*2–4*]. In this work we compared the elemental

Received for publication 9 Nov. 1992; revised manuscript received 25 Feb. 1993; accepted for publication 26 Feb. 1993.

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composition determined by EDX to that obtained by gamma spectrometry, after neutron activation of the same samples. Activation Analysis reveals additional trace elements that can be evaluated for a more exhaustive analytical comparison.

Case History

Two armed young robbers burst into a village jewelry store in Central Italy in which the owner, a jewel firm representative (both armed with licensed handguns) and a casual customer were present. One of the robbers seized the customer but the robber was shot dead almost immediately. During the exchange of fire, the customer was slightly wounded in the cervical region of his neck by a bullet that pierced the collar of his coat.

The other robber escaped but was captured some days later. At the crime scene the police found a SIG SAUER cal .9 mm Parabellum pistol (mod.P226), loaded with Sellier & Bellot (S&B) cartridges, having one less than a full magazine (14 of 15). An empty case of this type and a deformed cal .9 mm bullet were also recovered. After some preliminary investigations on firearms (performed by the local police station) that showed it plausible that the same bullet had hit the customer and killed the robber, the Court of Justice (Corte d'Assise), during the trial, entrusted the authors of this paper with the following tasks: a) the analysis of the GSRs near the hole found on the clothes of the customer; b) an approximate evaluation of the related firing distance, to exclude distances less than 20 cm or greater than 100 cm.

Given the trial in course, only ten days were conceded to perform these investigations.

Experimental Procedure

The sampling of GSRs was performed by exhausting with a Millipore pump a circular region 3 cm in diameter around the bullet hole in the neck area of the customer's clothes. The particles were collected at 635 mmHg on cellulose ester filters (1.2 cm in diameter and 0.45 μm in porosity). These were then coated with a very thin graphite layer and put on double layer adhesive coated stubs. The SEM/EDX measurements were performed by a CAMSCAN IV scanning electron microscope, coupled with a Si (Li) detector and a TRACOR Northern II 55/5402 automated search system, all of which is located in the National Police Headquarters, Rome, Italy.

To estimate the firing distance, seven rounds were fired in the ballistic laboratory, using the SIG SAUER pistol and the S&B Luger ammunitions, both found at the crime scene. The pistol was held fixed on a rack and targets were prepared by cutting squares of fabric of 15 cm^2 from clean areas of the coat and pinning them on cardboard backing. These were put at 20, 40, 60, 80, 100, 150 and 200 cm, respectively from the muzzle. After the shots were fired, a disk of 3 cm in diameter was cut around each bullet hole and the above mentioned sampling and protocol measurement procedure applied.

After the report was delivered to the Court, the same samples were then irradiated for 300 s in the pneumatic device of the TRIGA reactor of National Agency for New Technologies, Energy and Environment (ENEA) at Casaccia Centre (Rome), at a neutron flux of 10^{12} cm^{-2} s^{-1}. Gamma spectrometry measurements were performed using a Germanium (High Purity) detector coupled with a computerized multichannel analyser for spectrum analysis.

Results and Discussion

Figure 1 is a photograph of two particles collected by suction from the bullet hole area of the coat collar of the client. In Fig. 2, its EDX spectrum showing the X-ray peaks of tin, lead and barium is displayed.

FIG. 1—*BSE images of two particles collected from the bullet hole area.*

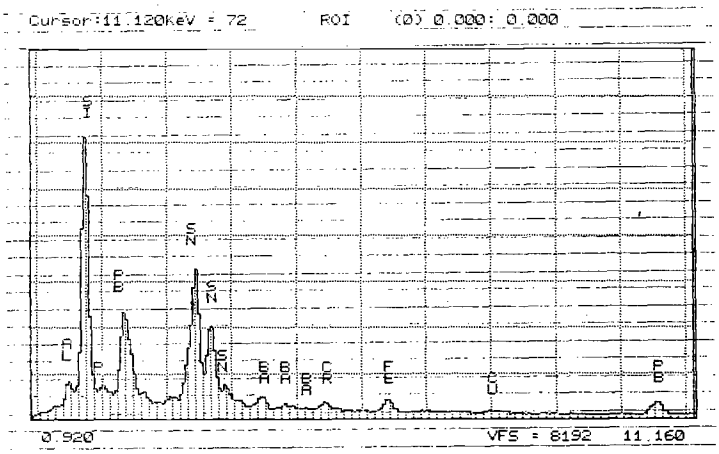

FIG. 2—*The EDX spectrum of the particles reported in Fig. 1.*

Similar spectra were obtained from GSRs extracted from the S&B Luger empty case found at the crime scene and from those of the tests (see Fig. 3). The peculiar presence of tin in GSR from S&B ammunition has been previously reported, due to a structural component of the case, that vaporizes and mixes with barium and lead from primer residues [5]. Therefore our results could be considered consistent with the residue found on the coat, originating from the S&B cartridges, contained in the SIG SAUER pistol. The other guns present at the murder scene, did not contain this type of ammunition (hardly found in Italy) and were also of different caliber.

In Fig. 4 is reported the gamma spectrum of the neutron activated GSR, from the S&B case exhibit, and in Fig. 5 that collected from the coat on the filter. In the latter,

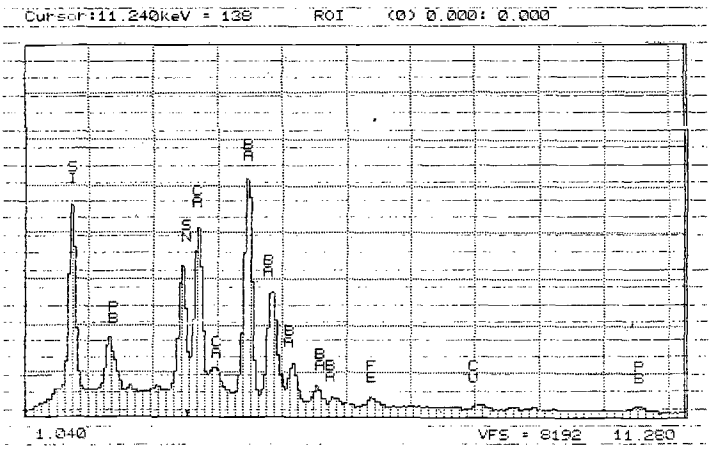

FIG. 3—*EDX spectrum of a GSR particle from an S&B empty case.*

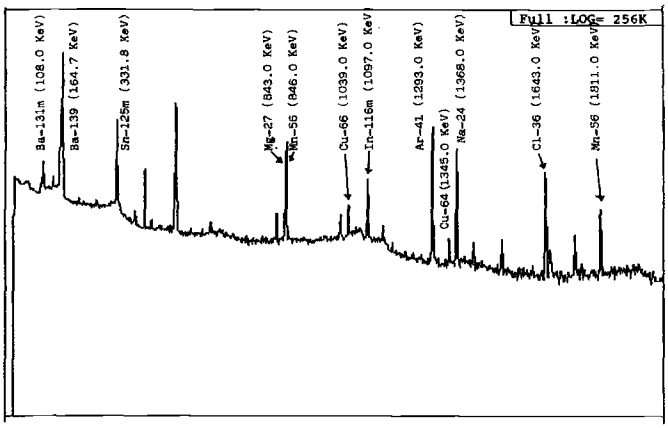

FIG. 4—*Gamma spectrum of the neutron activated GSRs from S&B case exhibit.*

there are many peaks already seen in Fig. 4, as well as those of titanium and aluminum activation isotopes. These can be explained as due to traces of these elements contained in the filter (3 ppm of Al), given the high sensitivity of INAA for them.

As regards the question of the firing distance, in Table 1 are reported the particles found in the tests performed with the found pistol and its ammunition at different distances; by comparison with the value measured in vicinity of the hole in the coat collar, an approximate firing distance of 80 to 100 cm can be estimated.

Conclusion

Based on the tin presence and antimony absence in the GSR particles from the S&B cartridges and coat collar, we were able to eliminate the customer having been hit by a bullet fired from G. Fiocchi (GF) cartridges, found in the guns of the jewelry owner and sales representative. On fact, the GF shells do not yield GSRs containing tin but on

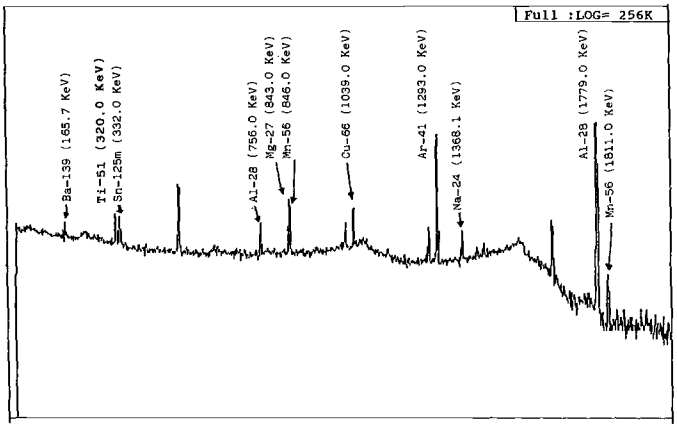

FIG. 5—*Gamma spectrum of neutron activated GSRs collected from the customer's coat.*

TABLE 1—*GSR particles detected in firing tests performed with the SIG SAUER pistol and its S&B ammunition on targets at different distances from the muzzle.*

Distance (cm)	No. of particles[a]	
	Three components (Pb-Sn-Ba)	Two components (Sn-Ba/Pb)
20	high number of particles	
40	208	80
60	41	87
80	23	12
100	32	22
150	10	11
200	—	3

[a]The small number of cartridges and the short time interval at our disposal, prevented us from performing more accurate evaluations.

the contrary, antimony is present in them. By comparing the EDX spectra to the gamma spectra of the neutron activated samples, it can be seen that the latter reveal the presence of peaks related to additional trace elements. These elements are probably connected to the brass of the cartridge but their presence could be of importance when GSRs from leadless cartridges have to be examined.

Acknowledgments

The support given by P. L. Carconi in neutron activation and gamma spectrometry measurements and by E. Garofalo, as ballistic expert, is gratefully acknowledged.

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