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Bullet Residue as Distinguished from Powder Pattern

It is often necessary to determine the distance and direction from which a gun was fired at an object. This is easily accomplished by observing the position and dimensions of any powder pattern deposited. The presence of a powder pattern usually indicates a close-proximity firing. A case involving a rifle used to fire through a window and shade on a door was presented for such a routine investigation. Contrary to the initial opinions of the investigating officer at the scene, laboratory tests showed that the pattern was not a powder pattern but instead a lead residue appearing much like a powder pattern, yet having distinctive and reproducible characteristics. These lead residues can occur at long distances from the muzzle (that is, 9 m or 30 ft) and are always present on the opposite side of the target, if it is penetrated. Information regarding the case which lead to the investigation is presented. Equipment devised to reproduce the test is described, and photographs of the patterns produced are presented. Included are points of difference between conventional powder tattooing and the lead residue observed by us. Some discussion is given to the effects of varying distances, calibers, and bullet compositions.

Case History

In September 1974, St. Louis police were called to investigate a fatal shooting. A female resident of an apartment at the scene reported that she, her son, and her son's friend were present when they heard the sound of breaking glass in the kitchen door. Thinking someone was attempting to break into the apartment the woman retrieved from a nearby closet a 30-06 caliber, bolt action, J. C. Higgins rifle, loaded it with one cartridge, and fired one shot through the kitchen door while standing about 5 m (15 ft) from the door.

Upon opening the kitchen door investigators observed the lifeless body of a 50-year-old man who apparently had been shot in the neck. The victim was identified as the estranged husband of the woman suspect.

Examination of the kitchen door indicated it was wood with six panes of glass located in the top half. A window shade and sheer curtain covered the inside of the window, preventing through vision. A glass pane in the lower left side of the door by the door knob had been broken. The middle pane on the right side of the door was shattered.

The investigation developed an unusual twist when the investigator who was outside the door noticed a gray-black ring of residue surrounding the hole in the shade (Fig. 1). Most law enforcement officers are aware that powder residues are associated with close-proximity

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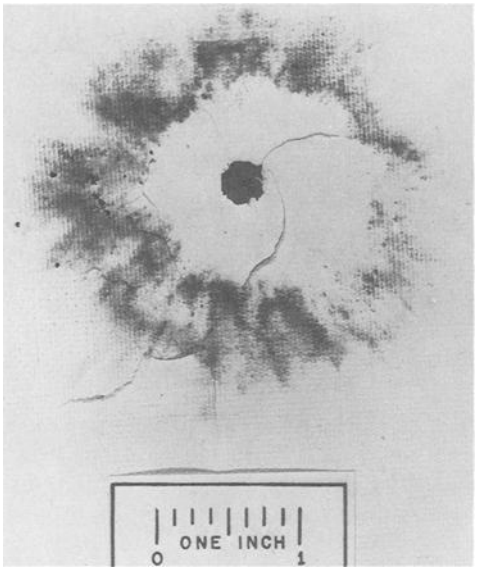

FIG. 1—*Pattern found at scene.*

shootings. These residues are composed of burned and partially burned particles of powder, lead, grease, and smoke deposits and are usually visually present when the muzzle to target distance is no greater than 380 to 455 mm (15 to 18 in.). The unusual character of the observed residue resulted from the fact that it was located on the back of the shade or that side of the shade that faced the outside.

This development caused consideration of the possibility that the suspect could have shot the victim inside the apartment, placed the body on the rear porch, and then fired a shot through the window and shade in an attempt to conceal the true facts from the police.

The evidence technician at the scene presented the problem to the criminalistics section of the laboratory and conveyed the door with the window shade and curtain intact to the laboratory.

Laboratory Examination

In the laboratory an examination indicated a hole in the shade that was approximately 6 mm (0.25 in.) in diameter. A clear area approximately 38 mm (1.5 in.) in diameter surrounding the hole was encircled by a ring of residue that varied from 12 to 25 mm (0.5 to 1 in.) wide. The residue had the visual appearance of a gunshot powder residue pattern except for the clear area surrounding the hole.

A pattern series was fired with the same weapon, the same type of ammunition (Winchester-Western, 30-06, Springfield pointed soft point) as used by the suspect, the same shade, and other unbroken panes of glass from the door in an effort to duplicate the residue pattern in question.

The first shot in the pattern series was fired from a distance of 4.5 m (15 ft) at the shade drawn over the window in an effort to duplicate the conditions described by the suspect. Inspection of the first pattern revealed a residue pattern (Fig. 2) on the exit side of the target shade which was similiar to the pattern from the scene (Fig. 1). This test indicated that the shot was fired from within and served to reinforce the suspect's story.

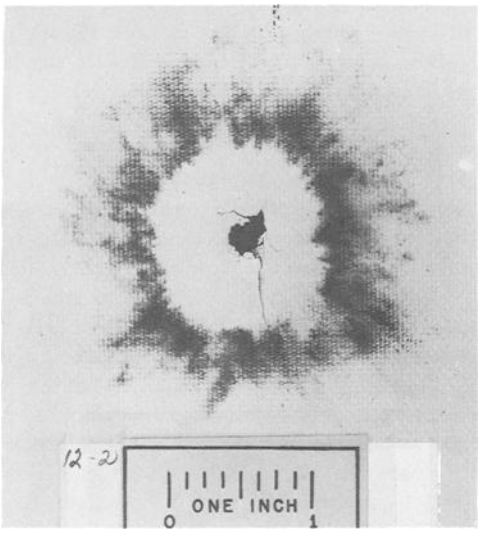

FIG. 2—*This test pattern made in the laboratory was deposited on the back of the target material. The weapon was a 30-06 fired from 4.5 m (15 ft). A pane of glass was 19 mm (3/4 in.) behind the target.*

To the criminalist, however, this solution created unanswered questions concerning the mechanism which produced the effect:

1. What was the residue?
2. What caused the deposit on the reverse side of the target?
3. At what distance do these patterns occur?
4. What influence do velocity and bullet size and types have on the pattern?
5. What effect does the material of the backup have on the residue?

Method

In an effort to investigate this phenomenon, a setup was devised so that numerous test firings could be made at various distances with various materials as targets and backups.

Two metal display stands were used. To one of the stands a piece of glass was taped with common masking tape attached to the periphery of the glass. This was the backup to the target, which was a piece of plain white paper taped lightly to the second stand. The stands were then arranged so the distance between the target paper and the backup could be adjusted easily by sliding the front stand to the proper distance. The distance was measured and the stands were then clamped into position. The target and backup were replaced after each test shot was fired.

The presence or lack of residues was determined by examining the reverse of the target sheets. Examination of the residue deposited was conducted macroscopically, microscopically, and instrumentally. X-ray fluorescence analysis was performed on the residue with a Finnigan 77-800 energy dispersive X-ray spectrometer. Scanning electron microscopy utilized an ISI Super Mini SEM II. To determine the relationship of distance between weapon and target on the size of the pattern, test shots were fired at distances of 1.5, 4.5, and 9 m (5, 15, and 30 ft) from the target with Winchester-Western, 30-06, Springfield Super-X pointed soft point ammunition.

The effects of velocity, bullet size, and bullet type were determined by firing the types of ammunition shown in Table 1 at a set distance of 4.5 m (15 ft).

The effects of the backup material on the pattern were determined by using single strength, double strength, and plate glass as backup material.

Conclusion

The residue formed on the exit side of the target material was determined to be lead, with no other elements detected by energy dispersive X-ray analysis.

A portion of the residue was examined by scanning electron microscopy and it was revealed the particles were smooth and round with the appearance of having been melted (Figs. 3 and 4). This phenomenon is observed in bullets with exposed tips of lead cores and unjacketed bullets but not with Silvertip® or copper jacketed bullets; it is observed to a lesser amount in bullets of lower velocity. It is believed that the residue is caused by the lead alloy becoming molten from a combination of heat from the cartridge explosion and the heat of friction of the bullet passing down the barrel. After penetration of the target and upon impact with the backdrop material the molten lead alloy is sprayed around the bullet in a cone shape and deposited on the back of the target. Since high-velocity bullets generate more frictional heat they become more molten and produce heavier residues.

The distance from weapon to target is not essentially material to the deposit of the residue or the size of the residue pattern at ranges under 9 m (30 ft). However, at longer ranges the bullet may be cooled, which would minimize the effect.

Varying the distance between the target and the backup has the greatest effect on the residue pattern. At very close distances, 6 mm (0.25 in.), the residue ring is small and dense. As the target is moved away from the backup the residue ring enlarges and decreases in density. Very little residue is noted at a spread of 76 mm (3 in.) or more.

A comparison of bullets, calibers, and velocities indicates the smaller caliber bullets and those of slower velocity give patterns of lighter density. Also shown is a greater amount of individual lead particles, indicating a breaking up of the smaller calibers.

The strength of the backup material is a prime factor in the density of the residue pattern. When the glass used as a backup was changed from single strength to double strength and then to plate glass, there was a noticeable increase in density (Fig. 5) as the stronger glass caused more spattering because of its greater resistance.

TABLE 1—*Types of ammunition used.* [a]

Caliber	Manufacturer	Ammunition Type	Bullet Type	Weight, grain [b]	Muzzle Velocity, ft/s [c]
30-06	Winchester	Springfield Super X	pointed soft point	110	3370
30-06	Remington	Springfield	soft point "Core Lokt"	180	2700
30-06	Winchester	Springfield Expanding	Silvertip expanding	150	2970
30-06	United States	Springfield M2	full metal case	150	2805
.45	Winchester	Auto Ball	full metal case	230	850
.38	Winchester	Special	Lubaloy	158	855
.22	Remington	Long Rifle Super X	lead	40	1285

[a]Information was compiled from Remington-Peters 1971 sporting firearms and ammunition catalog and Winchester-Western 1973 sporting arms and ammunition catalog.

[b]1 grain = 64.8 mg.

[c]1 ft/s = 0.3 m/s.

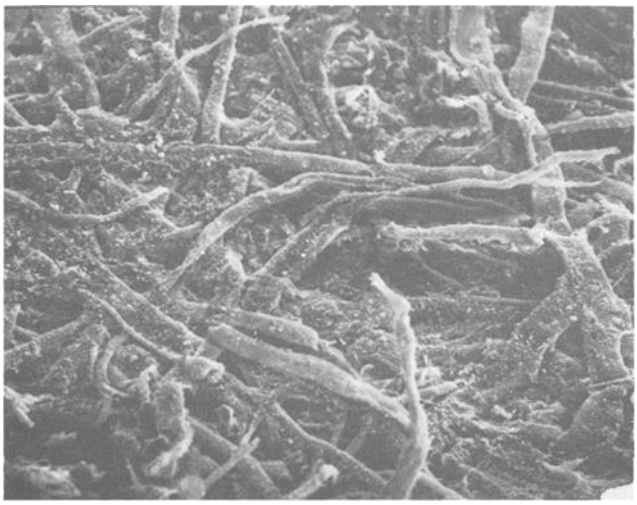

FIG. 3—*Scanning electron microscopic photograph of black residue on a paper target (magnification, about ×150).*

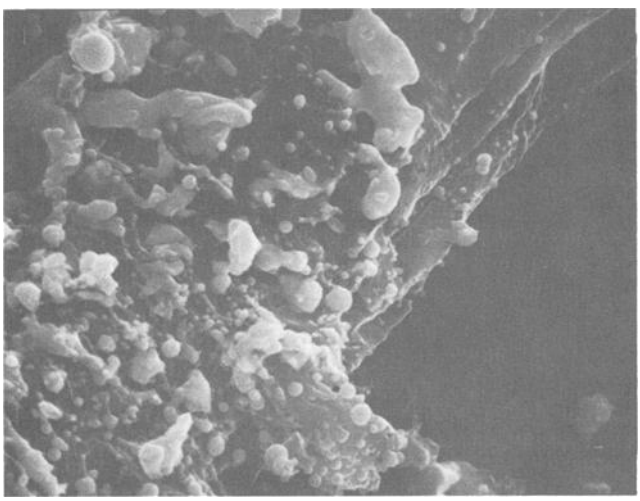

FIG. 4—*Note that the residue in this SEM photograph appears to have been molten (magnification, about ×7500).*

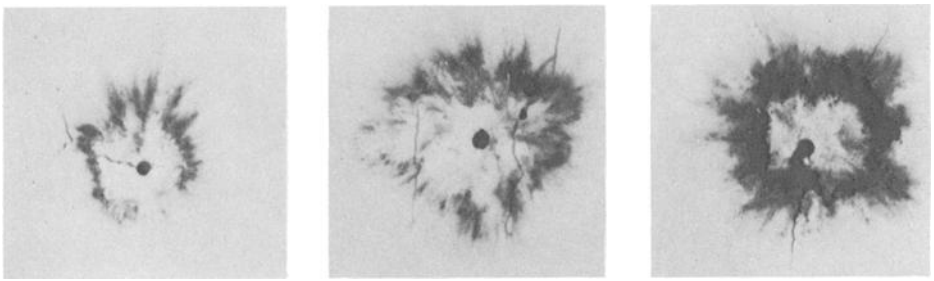

FIG. 5—*These patterns deposited on the back of the target material illustrate the increased density caused by greater resistance of the backup material;* (left) *single strength glass,* (center) *double strength glass, and* (right) *plate glass.*

Summary

Lead residues are characterized by halo-like deposits encircling a clear area adjacent to a bullet hole. They occur when open-tipped lead core jacketed or full lead bullets of medium or high velocity pass through a light target with a pattern-receiving surface and strike resistance within 76 mm (3 in.) of the target. The residue is found on the exit side of the target and could, but should not be, confused with or interpreted as a gunshot powder residue pattern, which does not exhibit the halo effect.

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