CASE REPORT

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Metal Particles As Evidence in Criminal Cases

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ABSTRACT: Three cases of a link between metal particles, generated by a grinder fitted with an abrasive disc, and suspects are reported. One involves a safe breaking, another a warehouse robbery and the third is an explosive find. The persistence of these particles on clothing is also examined.

KEYWORDS: criminalistics, metal, evidence

Many different types of tools are used in the execution of criminal acts. The investigation of such crimes involves establishment of a link between suspect, tool, and scene. Knives, screwdrivers, and pliers are the most common tools encountered and many examples of physical fit between tool and scene are published [*1*].

The normal method of comparison of tool marks is the use of light microscopy. However, other techniques such as scanning electron microscopy (SEM) have been used [*2*].

The detection of iron traces on hands to establish a link between a suspect and tool or firearm frequently involves spraying the hands of the suspect with 0.1% methanolic solution of ferrozine and observing the sprayed area in daylight for magenta stains [*3*]. Another study uses a ferrozine-ascorbic acid mixture on hands and gloves and the revealed iron traces outline the shape of the metal object [*4*]. X-ray diffraction was used to compare debris from oxygen and abrasive disc cutting of safes and to examine clothing in a safe breaking operation [*5*].

A recent study [*6*] reports on a link between three suspects and a safe via the particles produced by abrasive cutting of the safe. That report also dealt with the effect of the speed of rotation of the abrasive disc on the population of particles produced. We wish to describe three cases of a link between suspects and scene through metal particles found on the suspects' clothing, where no tool was recovered for examination.

Tests were carried out to examine the persistence of these particles on clothing and to compare the population of particles produced on cutting plain steel, stainless steel and aluminum.

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Case 1

A male entered a grocery shop during normal shopping hours and made some purchases and inquiries. Later that evening the safe on the premises was broken into by cutting the side hinges. The hinges had striation marks and a burnt appearance showing the cutting implement to be a grinder. Five hours after the discovery of the incident the suspect was apprehended and his clothing was sent to the laboratory for examination.

A control sample of the debris around the safe was forwarded for comparison. The clothing of the suspect was examined and hollow metal spheres and shavings, which had striation marks, were recovered. These particles had the appearance of burnt steel exhibiting colors of blue, pink, and red.

Case 2

A warehouse containing food products was secured with steel padlocks. Inside the warehouse the food was stacked on orange-painted metal racks. A truck was parked in the warehouse and empty blue wooden pallets were stacked on the back of the truck. The premises closed at 5:30 p.m.

At 10:00 p.m. the premises was found to be open and the truck and food products missing. The locks had been cut and had a burnt appearance. Striation marks characteristic of a grinder having been used were apparent on the cut surfaces. At midnight the police discovered the stolen truck located 5 kilometers from the scene still containing the stolen goods. The truck was kept under surveillance and at 8 a.m. three males approached the truck and were apprehended by the police. Their clothing together with samples from the truck and the warehouse were sent to the laboratory for examination.

In the debris from the footwells of the truck were found metal spheres and shavings. The clothing of the three suspects was also found to contain spheres and shavings together with orange paint, matching the orange racks and blue paint matching the pallets. All these particles had the striation marks and burnt steel coloration as did the debris around the cut locks at the scene.

Case 3

A large explosive cache was found containing home-made explosive (ammonium nitrate/calcium carbonate, diesel oil, and nitrobenzene). Three aluminum beer kegs whose lids had been cut open were also discovered at the scene. The cut edge of the kegs showed striation marks and many slivers of metal were found around the top of the kegs. Beer kegs are commonly used as containers for explosives in Northern Ireland.

Two males were arrested close to the find and their clothing together with explosive swabs of their hands were sent to the laboratory for examination. No traces of explosives were found on their clothing or hands. However, small slivers of metal were recovered from both suspects' clothing and these matched the slivers from the beer kegs.

Materials and Methods

The clothing of the suspects in all cases were brushed over clean white sheets of paper and the debris then transferred to petri dishes for examination. Steel particles were removed (Case 1 and Case 2) from the petri dishes using a SIRCHIE Finger Print Labs magnet. Light microscopy was carried out using an Olympus stereomicroscope. Scanning electron microscopy/energy dispersive X-ray (SEM/EDX) was carried out using a CAM-SCAN SEM linked to a Link AN 10/555 Analyzer.

A Makita grinder with rotational speed of 6500 rpm equipped with a 9″ abrasive disc was used in tests to cut a piece of (a) plain steel (b) stainless steel (c) aluminum beer keg.

In the persistence tests, a woven acrylic sweater was held in the stream of sparks produced on cutting of the plain steel. The garment was examined after 4 hours normal wear. The process was repeated and the garment examined after 17 hours.

Results and Discussion

Figures 1, 2, and 3 show the metal spheres and shavings from Case 1. It can be seen from Fig. 3 that these spheres are hollow and contain the striation marks which are seen on the shavings also. It can also be seen from these figures that the debris left at the scene contains larger spheres than those recovered from the clothing of the suspect. In studies of the transfer and persistence of glass [7,8], the authors show that smaller glass fragments travel further and that larger fragments are lost more quickly from the surface of the garments.

In Case 1 the size of the particles on the suspect are on average smaller than those at the scene. This may be a combination of (a) the larger particles not reaching the suspect during the grinding operation and (b) the loss with time of the larger particles. However because of the mode of operation of the grinder the distance between the operator and the item being cut is less than 0.5 m making (a) less likely. In Case 2 the particles from the footwells of the truck arose by falling off the clothing of the suspects probably 0.5 to 1 hour after the cutting operation and these were larger than those on the suspects indicating that the larger ones are lost preferentially. These results are very much in line with those for glass particles.

Some indication of the persistence of metal particles on clothing may be obtained from these cases. These are shown in Table 1.

In Cases 1 and 2 the steel particles from the suspects and scenes and the surfaces of the items that had been cut displayed the colors characteristic of the oxide films formed on

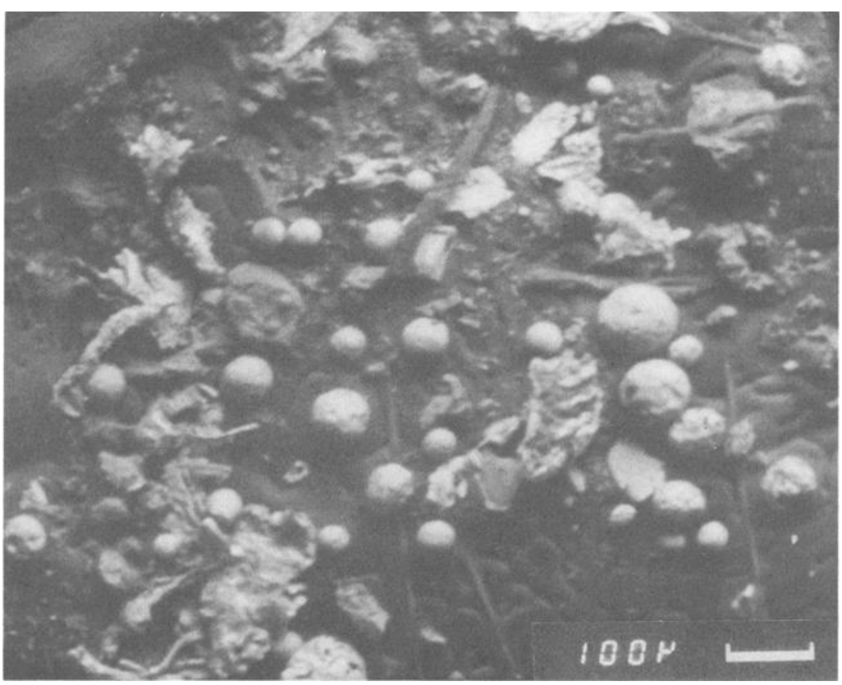

FIG. 1—*SEM micrograph of particles from suspect in Case 1.*

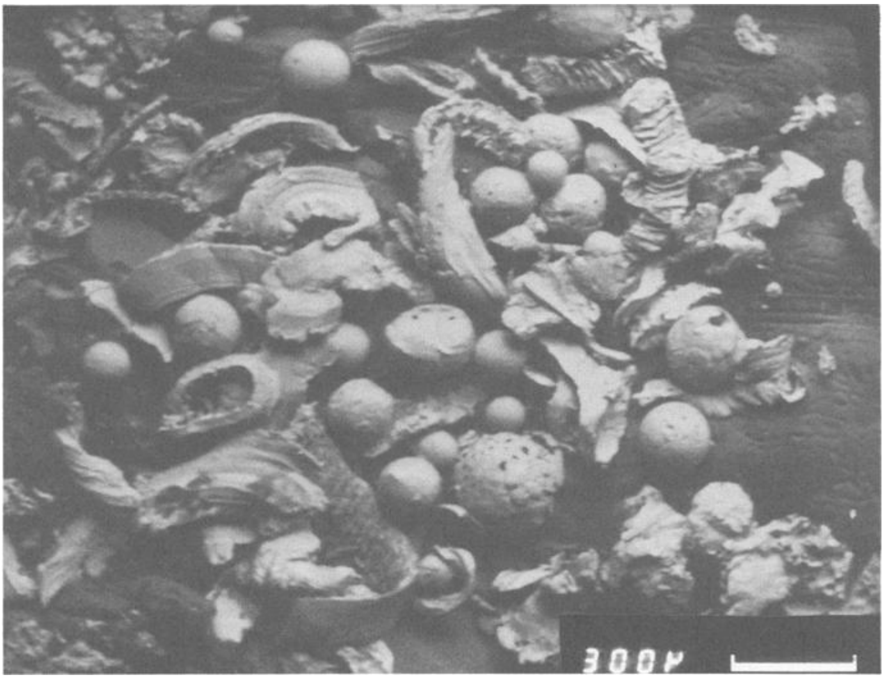

FIG. 2—*SEM micrograph of particles around safe in Case 1.*

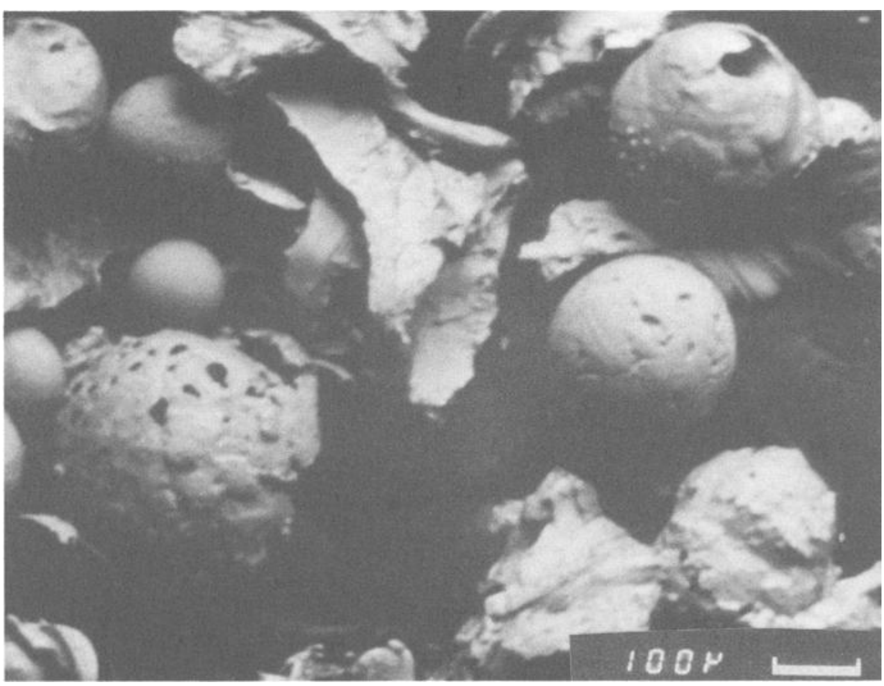

FIG. 3—*Particles from Fig. 2 on larger scale showing striation marks and hollow spheres.*

TABLE 1—*Average size of metal particles in Cases 1 and 2.*

Source	Case	Time between incident and apprehension	Avg. size of sphere
From floor near safe	1	–	150 μm
From suspect	1	>5 h	50 μm
From footwell of truck	2	0.5–1 h	150 μm
From suspect	2	>10 h	50 μm

heating steel [9]. SEM/EDX analysis of the particles in Cases 1 and 2 showed the particles on the suspects to have the same composition as the debris from the scenes and all were of plain steel with trace amounts of Si, Mn, and Ca present.

In Case 3, no spheres were recovered either from the scene or on the suspects and the particles did not display the blue/red colors seen in Case 1 and 2. The composition (SEM/EDX) of the particles from the suspects and the beer kegs again agreed in this instance.

In our test cutting, many spheres were produced with stainless steel, contrary to another report [6]. However, more spheres were produced with plain steel than with stainless steel. One report [10] suggests that these spheres are formed when the extreme heat generated during grinding causes some of the steel to actually melt and acquire spherical shapes under the influence of surface tension. During the solidification process in air that follows, the material becomes oxidized and the evolution of dissolved gases during the solidification process presumably makes the particle hollow.

A suggestion[2] for the markings on the surface of the spheres is not that they are striation marks from the cutting implement but dendrites (crystals) of oxide formed on solidification. (One would expect the striation marks to disappear if the steel melts). The lower number of spheres encountered with stainless steel may be attributed to the temperature only rising enough occasionally to melt the stainless steel.

It is suggested by another report [11] that the exothermic oxidation reaction raises the temperature until the particle melts. This report also suggests that spheres are also formed by platelets of the metal coalescing to form spheres.

The low number of spheres from stainless steel may be due to the stainless steel not oxidizing easily and hence the temperature rise due to oxidation does not occur and less spheres are formed. The true picture may be a combination of these events.

No spheres were produced in our tests on the beer keg. This is because aluminum is softer and therefore the disc cuts easily through the metal with less heat built up. Pieces of the abrasive disc were seen in the debris from the cutting of the two steel samples.

A test on the persistence of these particles was carried out using the plain steel as a source of particles. Figures 4, 5 and 6 show the size difference in the spheres from cutting-area (Fig. 4), garment shaken after 4 hours (Fig. 5) and after 17 hours (Fig. 6). These again show the loss of the larger particles initially and demonstrate that a number of particles are still retained after 17 hours.

An exhaustive study on the transfer and persistence of these particles would involve examination of the time of exposure to particle stream, nature of garments worn, distance from object being cut and other factors and is beyond the scope of this report.

Conclusion

Metal particles produced by the cutting action of an abrasive disc can be used to link suspects to scenes. These particles vary in shape and size depending on the material cut.

[2]Private communication, Prof. E. Petty, University of Limerick, 1994.

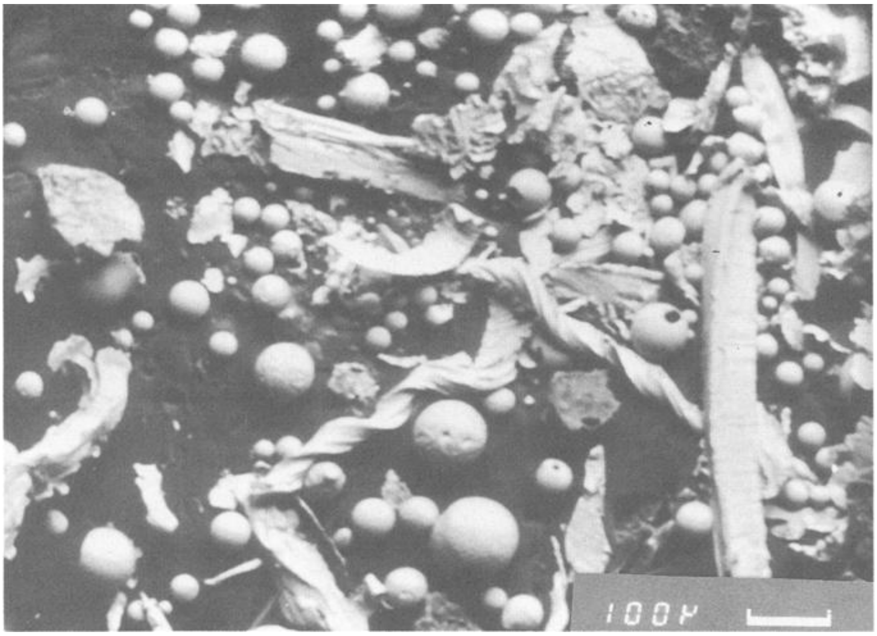

FIG. 4—*SEM micrograph of particles from plain steel around cutting area.*

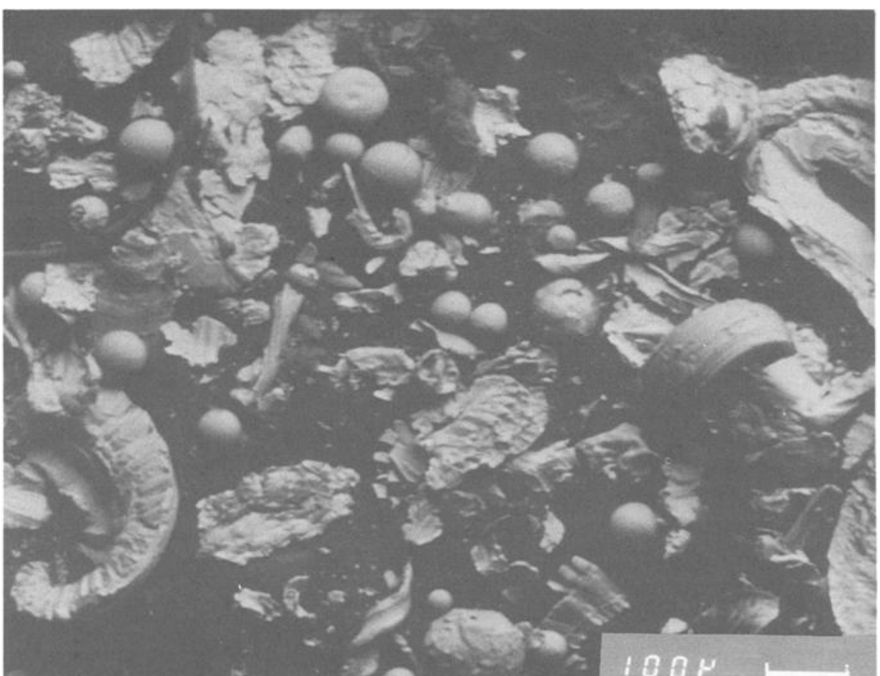

FIG. 5—*SEM micrograph of particles removed from jumper after 4 hours wear.*

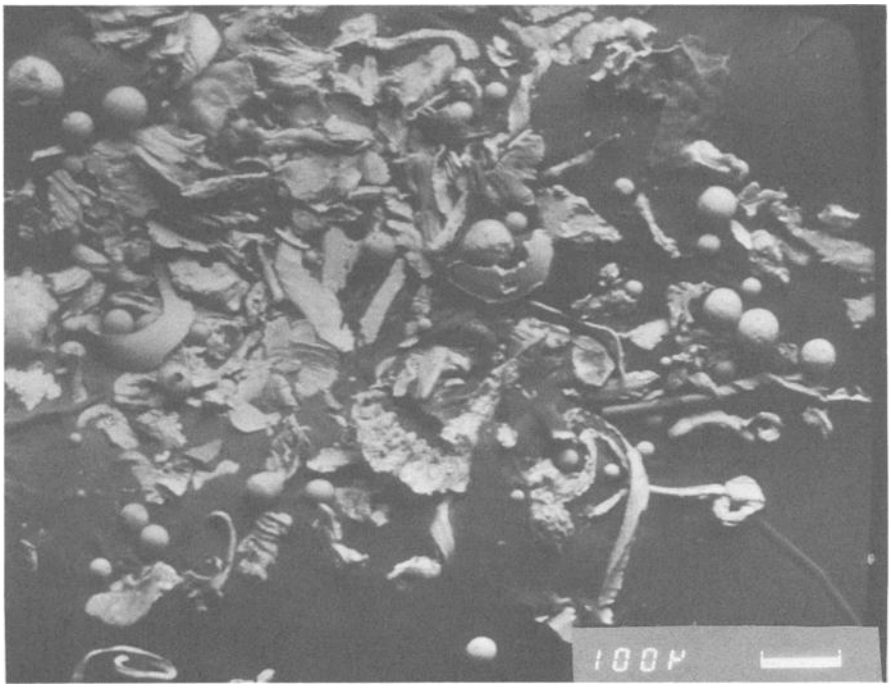

FIG. 6—*SEM micrograph of particles removed from jumper after 17 hours wear.*

Smaller particles remain on the clothing longer and these particles can remain on the clothing at least up to 17 hours.

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