TECHNICAL NOTE

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The Archaeological Water Separation Machine in Fire Investigation

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ABSTRACT: Archaeologists use water separation to improve the recovery of small items from prehistoric sites. These small items have proven to be an important part of the archaeological record. A simple experiment shows that the water separation machine might also be used to improve the recovery of small evidence at the fire scene. Four samples from three residential structure fires have been cycled through a modified Shell Mound Archaeological Project (SMAP) water separation machine and a variety of small items have been recovered.

KEYWORDS: forensic science, fires, water separation machine, archaeological technique, debris, fire investigation, physical evidence, screening

While the reference books commonly used by fire investigators are generally quite good and discuss most important aspects of fire investigation, relatively little space is devoted to the science of recovering physical evidence [*1,2*]. The typical fire investigation begins after parts of the structure and its contents have been destroyed by the fire, and the ash and debris have fallen to form a complex matrix which may contain physical evidence. Fire investigators may not be able to recover all important evidence because the complexity of the matrix and the conditions in the damaged building may combine to overpower the methods commonly taught to them.

The fire investigator is confronted by a number of occupational hazards which make it difficult for him to extract all of the physical evidence from fire debris on his initial examination. He is usually under pressure to finish the field portion of the investigation as soon as possible for a variety of reasons. Those of us who are familiar with conditions in a structure after a fire know that working conditions are often poor and lighting conditions are almost always less than ideal. These and other factors make it difficult for investigators to be sure that all small items of evidence have been recovered when using conventional techniques.

Archaeologists have devoted a great deal of effort over many years to the study of information retrieval from prehistoric sites. A variety of water separation (flotation) machines and processes have been used by archaeologists in recent years because they

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have greatly increased the recovery of small objects, and materials, such as carbonized plant remains, from prehistoric deposits [3–8]. Water separation can be used to improve the recovery of a wide range of small objects [9]. Archaeologists probably did not fully appreciate the value of small pieces of evidence until they adopted an efficient means of collecting it. Naturally, conclusions based on more complete samples are more accurate and powerful. For example, the collection and analysis of small items has sometimes changed important conclusions about prehistoric economics and subsistence [3,8,9].

Archaeological techniques have been found to be applicable to some types of criminal investigations, and archaeologists have been consulted in some cases [10–14].[2] Recovering evidence from the fire scene is much like recovering evidence from an archaeological site [15], so it is not surprising that some evidence-recovery techniques, such as water separation, would be applicable to both fields. An experiment suggests that simple water separation techniques may make it easier for fire investigators to recover small pieces of evidence from the fire scene.

Apparatus

Although many different water separation machines have been used by archaeologists, the Shell Mound Archaeological Project (SMAP) machine is widely accepted and may be the most appropriate for fire debris. Comparative tests have shown that the SMAP machine is very efficient at recovering some types of material [16]. It seems to be a practical machine for fire investigation because it is easy to build, inexpensive, simple to use, efficient, consistent, and small and light enough to be easily transportable.

The SMAP was derived from a machine designed by Bill Robertson (National Academy of Sciences, Washington, DC) in about 1974 [8]. It was first described in an article published in the *Mid-Continental Journal of Archaeology* (Ref 8, p. 82):

> . . . forces water under pressure into the barrel via a fireman's hose, the rate being regulated by a gate valve. The water emerges from a shower head directed up at the screened bottom of the insert as it rests on 2 supports welded inside the barrel. Dirt is poured onto the insert where it is agitated by water from the shower head and by a certain amount of stirring on the part of the human operator. The light fraction (predominantly charred plant remains but also occasional fish bones, fish scales, or tiny chert flakes) floats over the sluiceway and is caught in the . . . screens.

With this approach, material poured into the water separation machine is divided into two fractions depending on its specific gravity and then separated by particle size.

The material which does not float falls onto the screen in the barrel. The floating fraction washes onto the screen at the end of the sluiceway. Fine black sediment is separated from both the light and the heavy fractions and falls through one or the other of the two screens (see Fig. 1). Items of interest become cleaner and easier to identify. An appropriate screen mesh size is chosen by the investigator.

The author has conducted trials with a modified SMAP machine. The modifications to the machine consisted principally of a wider overflow and a conical bottom. The wider overflow was used because fire debris typically contains relatively large pieces of partially burned material. The cone was added to make it easier to dispose of small abrasive particles which fall through the internal screen. A metal screen with a mesh size of approximately 6.25 mm (¼ in.) was used to construct the bottom of the internal cylinder and the bottom of the overflow screen for these preliminary trials. Smaller mesh screens may also be used.

Water was supplied to the machine with a garden hose; larger hose may be used if low

[2]Tsu, D. P., National Park Service, personal communication, 4 March 1983.

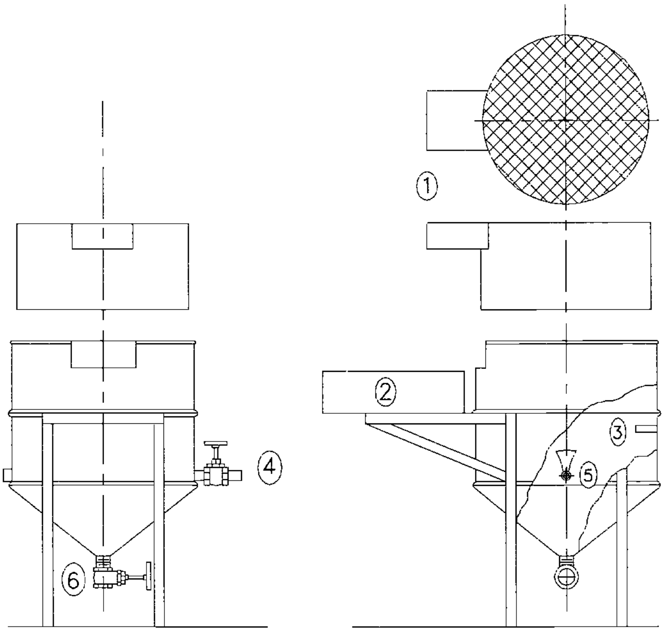

FIG. 1—*Diagram of the modified SMAP machine:* (1) *sheet metal cylinder with screened bottom to catch the heavy fraction and a sluiceway to carry the light fraction;* (2) *archaeological screen;* (3) *cylinder supported by a piece of metal welded to the side of the approximately 190-L (50 gal) steel drum;* (4) *hose and valve through which water enters;* (5) *shower head dispersing the stream and agitating the water;* (6) *3.8-cm (1½-in.) (or larger) valve through which debris passing through the screen in the bottom of the cylinder and collecting in the cone at the bottom of the barrel is periodically flushed out.*

water pressure is a problem. The water flow is typically restricted to an opening of approximately 12.5 mm (½ in.) at the shower head connection, anyway. The principles involved are simple, so good results can be obtained under a variety of conditions.

Procedures

Four samples from three structure fires have been cycled through the machine with very encouraging results. The structures were extensively damaged, older wood-frame single-family homes in each case. The samples consisted of ash and debris collected from the floor of each structure after fire suppression efforts were complete. One of the samples was collected from a living room (Sample 1), one from a kitchen (Sample 2), and two were taken from a bedroom (Samples 3*a* and 3*b*). The samples were from the most heavily damaged part of the room in each case. The samples were collected as they became available and stored in plastic garbage bags. The size of each of the samples was approximately 10 L, but smaller samples might be appropriate, depending on the composition of the debris and the mesh size of the screens.

Approximately ½ L of water was added to Samples 1 and 2 1h before they were poured into the open top of the machine to replace water which had escaped during storage. Adding water to the debris also reduced the danger that airborne particulate matter (such as asbestos) would be released during the experiment. Samples 3*a* and 3*b* were fresh and still wet from fire suppression efforts.

Each 10-L sample was poured into the water separation machine and agitated gently until the separation process was complete. The internal cylinder and screen, which held the heavy fraction of the sample, and the overflow screen, which held the light fraction, were lifted from the machine. Identifiable items found on the screens were retrieved and photographed. The screens were cleaned with a garden hose and the drain valve was activated before the next sample was processed. The machine is capable of recovering much smaller items than those shown in Fig. 2 when they are present.

Results and Discussion

A number of small items were recovered from the screens (Fig. 2). Only three of these, the swab and the two pencil fragments, were associated with the light fraction. This is not surprising because one would not expect as many small, light items to survive the fire. The thin pencil fragments found in the light fraction of Sample 2 were almost certainly broken at the fire, during sampling, or during storage and handling. The shaft still appears to be quite strong, and it is unlikely that it would be broken by the circulation of the water in the machine. The broken ends fit together nicely. The metal pencil end from the heavy fraction of Sample 2 belongs to a separate instrument. There was no visible damage to any of the other items; water separation is a gentle process which should not harm fragile evidence.

It is interesting to note that a large portion of each 10-L sample consisted of small heavy particles (with a specific gravity of approximately 1.0+), which separated from the larger items and passed through the screen in the cylinder. These were deposited in the bottom of the machine and were eventually flushed out through the drain valve. The elimination of the small sediment had two positive effects. The items of interest were clean and easily recognizable, and the sample in each screen was smaller and easier to sort.

The purpose of the experiment was to determine whether the water separation machine

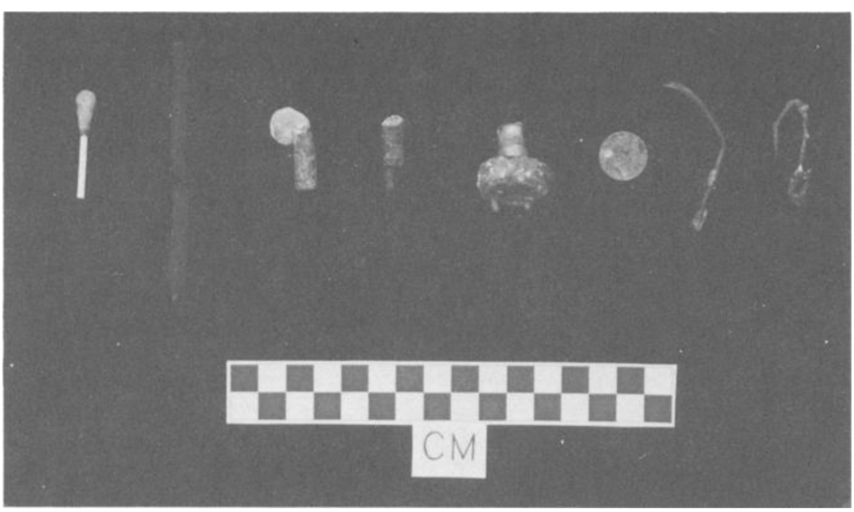

FIG. 2—*Some small items recovered from finely divided fire debris, from left: part of a small swab (Sample 3b, light fraction); charred pencil fragments (Sample 2, light fraction); copper-jacketed bullet with melted core (Sample 3a, heavy fraction); eraser end of a pencil (Sample 2, heavy fraction); vacuum tube (Sample 2, heavy fraction); dime (Sample 3a, heavy fraction); wire with fragment of insulation (Sample 3b, heavy fraction); curtain hook (Sample 3b, heavy fraction).*

would work effectively at a fire scene. Large-scale experimentation will be required to determine exactly what the improvements in evidence recovery rates are and if it would be valuable to compare the recovery rates of the various methods and machines available. Water separation might also be used by those who are interested in studying the composition of fire debris.

Either the light or the heavy fraction may be further divided on the basis of particle size. Stacked geological (ASTM) screens may be placed under the sluiceway to sort the light fraction. Stacked screens might also be used inside the barrel or under the drain valve to sort the heavy fraction. It may not be appropriate to use stacked screens to sort fire debris by particle size in every case, but the investigator should be aware of the technique for those cases in which he is looking for specific types of evidence of known size or in which he wishes to investigate the fire scene in great detail. The investigator must determine the degree of accuracy appropriate to each case.

Bullets, shell casings, most human bones and teeth [*17*], and even precious stones have a specific gravity of more than 1.0 and may be expected to sink. Lighter and more porous materials like wood or paper products can usually be expected to float if they are not completely saturated before they are introduced into the machine. It is important to note that extremely small items (such as carbonized plant remains, pollen, or other finely divided material) may be floated by surface tension even if they are heavier than water, sometimes even after the sample has been gently stirred. They can be skimmed off with a hand strainer or captured in a fine overflow screen or filter if the investigator wishes to examine them.

Water separation should be used with caution. It is a method that is well suited to the recovery of identifiable pieces of physical evidence which are *not water soluble.* Accelerants, explosives, and other delicate water-soluble evidence may be damaged or washed away by flowing water. However, laboratory samples should normally have been taken before screening or water separation is employed.

Secondary excavation techniques allow the investigator to perform a more detailed examination of material from the fire scene under more favorable lighting and working conditions. Fire debris can be examined outside of the structure under conditions where lighting, visibility, and poor working conditions are not factors. It is a relatively simple process to examine the debris in place in the usual way and them move the sample to a new location for a more thorough secondary examination. The investigator can still retain spatial control over any evidence found through the use of a grid system. Techniques routinely used by investigators to maintain control over samples sent to forensic science laboratories can be used to maintain control of samples processed by water separation machine. In general, it is safe to assume that more evidence will be recovered if secondary evidence recovery techniques are employed, and the evidence will still be meaningful, fair, and accurate.

The practice of screening material removed from a crime scene is a secondary technique which is not new or remarkable. It is standard procedure in many police and fire investigations. Screening is probably one of the simplest and most common methods available to us which will separate finely divided particles from the larger pieces. Small particles obscure the other classes of material, which usually include the physical evidence we are looking for.

Dry screening is of limited value in many cases, and is not routinely used by fire investigators, because the efforts of the suppression crews usually leave the debris on the floor of the fire building dripping with water, and the wet ash and fire debris form a soggy black mass that is difficult to screen effectively. Small wet ash particles cling to the larger pieces and will not fall through the screen, or the whole ash matrix forms a find of slush which clogs any small mesh screen. Determined efforts to screen fire debris can result in damage to fragile evidence. This is a good technique, but it probably works best with a completely dry matrix. Also, screening dry ash may expose the investigator to dangerous airborne particles.

Water separation is no substitute for a careful methodical examination of fire debris, but it is an extremely useful secondary technique which can enhance the recovery of small items (for example, timing devices, and human bone material). If effective secondary evidence recovery techniques are used, the investigator can state with confidence that no potentially important evidence has been overlooked. Conclusions that are based on all classes of evidence are more complete and powerful. The value of the investigator's analysis depends on the quality of the sample on which it is based. Any secondary search for evidence will take some extra time and effort, but small evidence can be an important class of material which can have a considerable influence on conclusions about the case. The water separation machine minimizes that time when applied to areas of special interest. The time spend could be well worth the effort.

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