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TECHNICAL NOTE

GENERAL

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Utilizing a Magnetic Locator to Search for Buried Firearms and Miscellaneous Weapons at a Controlled Research Site*,†

ABSTRACT: Forensic personnel generally use basic all-metal detectors for weapon searches because of their ease of use and cost efficiency. For ferromagnetic targets, an alternative easy to use and low-cost geophysical tool is a magnetic locator. The following study was designed to demonstrate the effectiveness of a common, commercially available magnetic locator in forensic weapon searches by determining the maximum depth of detection for 32 metallic forensic targets and testing the effects of metallic composition on detection. Maximum depth of detection was determined for 16 decommissioned street-level firearms, six pieces of assorted scrap metals, and 10 blunt or bladed weapons by burying each target at 5-cm intervals until the weapons were no longer detected. As expected, only ferromagnetic items were detected; weapons containing both ferromagnetic and nonferromagnetic components were generally detected to shallower depths. Overall, the magnetic locator can be a useful addition to weapon searches involving buried ferromagnetic weapons.

KEYWORDS: forensic science, forensic geophysics, magnetic locator, buried metallic weapons, evidence search, controlled geophysical research

Forensic evidence searches require a multidisciplinary team of investigators and various types of equipment because of the confounding issues involved with trying to locate buried bodies and evidence. Incorporating supportive geophysical technologies into forensic investigations is a growing practice as they allow for scene inspection without scene destruction (1–11). However, proper training is required to determine the capabilities of these tools for forensic searches, and operator experience is essential when including geophysical tools into the search for forensic evidence (1,5,12,13). Those limitations have created a need for controlled geophysical research in the area of forensic searches, especially for buried evidence. The majority of published controlled geophysical research has focused on archeological features and artifacts (14–16), buried human remains detection utilizing pig carcasses as proxies (2,3,10,11), buried metal drums (17,18), and unexploded ordnance (UXO) (19). Controlled geophysical forensic research involves burying specific targets and utilizing specific geophysical tools to detect the buried items. In addition to providing a unique setting for determining the limitations and capabilities of specific tools used for locating buried evidence in specific environments, controlled geophysical research offers field training for specific equipment and known variables. Parameters established during controlled research should mimic real-life search scenarios while allowing flexibility for the geophysical tools to be properly tested.

When searching for metallic evidence that has either been buried or discarded (i.e., tossed onto the ground surface, possibly under organic debris, but not buried in soil), it has been generally recommended to use a metal detector, as basic models require little operator training, are fairly inexpensive, and are among the most popular geophysical tools to use (1,4–6,8,12,17,18,20–23). However, another relatively inexpensive option that has been recommended for weapon searches involving discarded or buried metallic evidence is a magnetic locator (1,5,6,12). Magnetic locators differ from all-metal detectors in that they detect only ferromagnetic objects (material or substance that is highly magnetic such as iron), while a basic all-metal detector normally used by law enforcement personnel normally detects all types of metals (13). While magnetic locators have the potential to be valuable geophysical tools in weapon searches, there has been no controlled research that explores the effectiveness and utility of these tools for weapons detection.

Purpose

Because of the paucity of published research involving the use of geophysical tools to locate buried weapons during crime scene searches, the following study was designed to demonstrate the effectiveness of using a magnetic locator at a crime scene or a suspected weapon burial site for the detection of various types of metallic weapons at varying depths. The maximum depth of

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detection for 32 metallic forensic targets and the effects of metallic composition on detection were tested on a common, commercially available magnetic locator. Metallic targets used in the study consisted of 16 decommissioned street-level firearms, six pieces of assorted scrap metals, and 10 miscellaneous blunt or bladed weapons. By controlling the types of weapons and scrap metals, including an array of firearms, this research also allowed for the opportunity to improve standard crime scene geophysical search methods.

The purpose of controlled geophysical research is to explore the capabilities of either single or multiple methods for the detection of forensic evidence. The magnetic locator research presented here is one facet of a larger geophysical research project incorporating multiple geophysical tools for the detection of common metallic weapons (22,24). Results from the additional geophysical tools (25) and comparisons of the different tools are to be detailed in future publications.

Materials and Methods

The following section provides a summary of the materials, data collection methods, and research design specific to the magnetic locator portion of a larger controlled geophysical research project. Please refer to Rezos et al. (25) for additional project information, including a map of the research grid and specific images of the forensic targets.

Research Site and Forensic Targets

An inactive, open area of the Orange County Sheriff's Office (OCSO) Lawson Lamar Firearms and Tactical Training Center in Orlando, Florida, was selected for this research site. The firearms range provided a secure location for burying the weapons and allowed routine access for data collection. Because of the fact that the area was not utilized for target practice or other training procedures, the occurrence of site contamination by random bullet fragments, ricochets, or other metallic elements was limited. Although the soil in the research area has been classified as a Spodosol (26,27), additional fill was added to raise the ground surface when the facility was constructed. The anthropogenic soil encountered during the research project is highly representative of most urban soils, in which backyards or other search areas have been filled for leveling or building.

As real-life forensic evidence searches should utilize a grid layout, it is important for controlled geophysical research to follow the same data collection protocols. A grid containing 32 buried metallic objects and one control hole organized into seven rows and five columns was constructed on the research site (25). Two additional control holes, consisting solely of backfill, were placed outside of the grid. Each target was buried in a separate hole, with placement of the targets being somewhat random in terms of size and metallic composition. The location of each target was marked within the grid with bright orange plastic stakes owing to OCSO documentation protocols.

The metallic targets tested included 16 firearms, six pieces of assorted scrap metals, and 10 blunt or edged weapons (Tables 1–3). All protocols outlined by the OCSO's security procedures, including the decommissioning of the firearms by removing or filing firing pins and using J-B KWIK (J-B Weld Company, Sulphur Springs, TX) cold-weld liquid epoxy compound to block the firing pin channel and barrel, were followed. The firearms selected represent various metallic compositions and lengths and were selected because of their frequency in street-level crime in the Central Florida area. The weapons were provided by OCSO and included a derringer, eight pistols, four revolvers, two shotguns, and a rifle for use in this project. The firearm frame compositions consisted primarily of steel, with several other compositions including metals or materials such as zinc alloy, aluminum, or polymer (Table 1). In addition, the Glock 9 mm was included to represent a firearm comprised of a polymer frame with metal components, and the firing pin of the weapon was welded into the clip chamber to retain as much metallic content as possible.

The scrap metal sample (Table 2) consisted of copper, aluminum, and iron (including rebar) and represent types of scrap metals frequently encountered during forensic weapon searches. A total of 10 blunt (mallet, claw hammer, prybar, baton, brass knuckles) and edged (machete, sword, Buck knife, Philip's head screwdriver, scissors) weapons that were recovered from OCSO crime scenes were

TABLE 1—*Firearm sample.*

Firearm	Type	Metallic Composition	Length (mm)	Unloaded Weight (oz.)
Davis Derringer D9	Derringer/9 mm	Steel	119	12.8
Raven Arms MP25	Pistol/0.25	Zinc Alloy/Steel	123	14.4
Hi-Point Model C	Pistol/9 mm	Steel/Polymer	178	35
Smith & Wesson 5906	Pistol/9 mm	Stainless Steel	190	38.3
Glock Model 19	Pistol/9 mm	Polymer Frame/Steel Slide and Firing Pin	187	20.6
North American Arms Mini-Magnum	Revolver/0.22 Magnum	Stainless Steel	130	6.4
Jennings Bryco 59	Pistol/9 mm	Zinc Alloy/Steel Magazine	170	33.6
Smith & Wesson Model 686	Revolver/0.357 Magnum	Stainless Steel	235	37
Lorcin L380	Pistol/0.380	Aluminum Frame, Magazine, Slide/Steel	171	30.4
Colt Commander	Pistol/0.45 ACP	Steel	196	27
Smith & Wesson Model 37	Revolver/0.38 Special	Steel	167	25
RG Industries RG23	Revolver/0.22 Long rifle	Aluminum Frame/Steel Barrel, Cylinder	148	14.4
Norinco AK Hunter	Rifle/7.62	Steel/Polymer	1067	125.5 Includes Wooden Stock
Mossberg Model 500A	Shotgun/12 Gauge	Steel/Polymer	711	96
Remington 870 with Knoxx COPStock	Shotgun/12 Gauge	Steel	762	120
Ruger P89	Pistol/9 mm	Aluminum/Stainless Steel	203	32

TABLE 2—*Scrap metal sample.*

Type	Metallic Composition	Length (cm)
Aluminum edging	Aluminum	53
Solid iron pipe	Iron	48
Hollow copper tube	Copper	68.5
Rusty iron pipe	Iron	57
Solid aluminum pipe	Aluminum	47.7
Rebar	Iron	66.5

TABLE 3—*Blunt and edged miscellaneous weapon sample.*

Type	Metallic Composition	Length (cm)
Scissors	Steel	20
Buck knife	Stainless Steel	22.2
Prybar	Steel	32.2
Mallet	Steel	38.4
Machete	Steel	68.2
Baton	Steel	25.7
Philip's head screwdriver	Steel	26.2
Brass knuckles	Brass (Copper and Zinc)	11.6
Claw hammer	Steel	35
Sword	Steel	81

also provided, and the composition of these targets was primarily steel (Table 3).

Geophysical Tool—Schonstedt GA-72Cd®

The Schonstedt GA-72Cd® magnetic locator used in this project is a field sensor that is designed to detect the magnetic field of ferromagnetic objects while ignoring nonferromagnetic materials such as gold, silver, copper, brass, and aluminum (Fig. 1) (13). According to the manufacturer, materials that may be located with this tool include magnetic markers, stakes, manholes, septic tanks, well casings, barbed wire, chain link fence, valve boxes, cast-iron pipes, steel drums, weapons, projectiles, UXO, hunting knives, hand guns, and other buried weapons (13).

This model utilizes two sensors, located in the shaft and spaced roughly 14 inches apart, to respond to the difference in the magnetic field around the locator (13). The magnetic locator includes Low, Medium, High, and Maximum sensitivity settings. According to the manufacturer, the level of sensitivity required for accurate detection differs based upon background interference and depth of object. High sensitivity will allow for deeper detection, but also increases the sensitivity of the machine, producing background noise (13).

The digital display and the audible alarm operate very similar to metal detectors; as the operator moves closer to a target, the audible tone and/or digital readout will increase. Digital indications of both signal strength and polarity register in the display unit when a magnetic object is located, and audible tone changes can also be discerned with training and experience (13). Advanced operator training and experience are required for simultaneous use of both indications, helping to pinpoint a target and determine its burial orientation. Using the polarity readings, the positive and negative ends of the target can be determined, if the object is buried horizontally. If an object is buried vertically, the audio signal will only sound directly over the object and can appear either positive or negative.

Data Collection Parameters

The locator provides several sensitivity settings, and the proper setting for the research site had to be determined. The lowest sensitivity setting did not adequately detect the targets, and the maximum setting produced too much background interference. Medium setting provided the proper balance of background noise and target detection for the research site and was first utilized in detection for this reason. High setting was used to determine any increases in the depth detection capabilities of the machine. The magnetic locator was used very much like a metal detector in that it was slowly waived in front of the operator, pointing at the ground. When the audio and visual readings became stronger, an object was located by running the locator in an "X" type fashion over the area. The point of strongest readings was most likely a magnetic object.

FIG. 1—*Schonstedt GA-72Cd® magnetic locator being used for data collection in the field.*

Using Medium and High settings, target detection was successful at multiple depths. For each burial depth, data collection was first conducted over the entire grid on Medium setting, with a detection result noted for each target. Detection was categorized into "No," "Slight," and "Strong." S*light* detection readings meant that a change in the locator's hum was audible, but may not have been noticeable enough in real-world searches involving areas that are littered with trash metals and/or have a high mineral content, include large groups searching in the area, or have other background noise or distractions to qualify as a *strong*. *Slight* may also have included a noticeable change in the polarity readings on the display, enough change to determine orientation of the target. This was only recognizable after much operator experience and is not recommended for beginning operators. *Strong* readings were recorded when the volume of the hum left no doubt that a metallic or magnetic target had been located. High setting was then utilized at the same burial depth over the entire grid to determine whether High setting increased either strength of detection or actual target detection.

Although the research grid is in an area of the firearms range not utilized for target practice, the facility is a live firearms range.

As such, testing for metallic items such as bullet fragments, ricochets, and other metallic debris was conducted during data collection. Following controlled research parameters, each hole and any backfill were tested both prior to the first burial and during subsequent reburials to ensure that no foreign metallic debris was present. Testing for foreign metallic debris involved scanning the walls, floor, and backfill with the magnetic locator prior to placing a weapon in the hole. Control holes were also established, which were dug to the same level as the burials, but consisted only of debris-free backfill. Burials were first dug down to a depth of 20–25 cm, and reburials were performed at 5 cm intervals. All targets were retested individually in the grid with the magnetic locator, with two additional project members providing inter-observer confirmation.

A number of quality control procedures were also utilized for data collection: The control holes were important in determining whether the disturbed soil of the burial holes affected detection; a probe was used to determine the exact location of the target, confirming that positive hits were the result of the target and not because of a foreign metallic object in the soil. Scanning the holes and backfill for foreign metallic debris was conducted with the magnetic locator preburial and during each reburial. Also, targets were retested in the control hole outside of the grid by continually digging up and reburying the weapons 5 cm deeper until maximum depth of detection was determined.

Results

While data collection results included both *slight* and *strong* readings, the following results only detail the *strong* results, as they are more likely to represent a target in real-life search scenarios and/or be recognized by trained operators. In addition, Table 4 provides descriptive statistics regarding maximum depth of strong detection for the target groups, taking into consideration size and metallic composition.

Firearms

Data collection on Medium setting (Fig. 2) showed that all but two firearms (14 of 16; 87.5%) were detected at varying depths. Four of the six largest firearms were detected the deepest, down to 50–55 cm. When using High setting (Fig. 2), all 16 firearms were detected to greater depths than on Medium setting. The two largest firearms, the Norinco AK rifle and the Remington 870 shotgun, were detected to a maximum depth of 70–75 cm. Overall, the firearms comprised of mostly steel were detected to greater depths than those of mixed metallic composition, and generally the larger the weapon, the greater the depth of detection (Table 4).

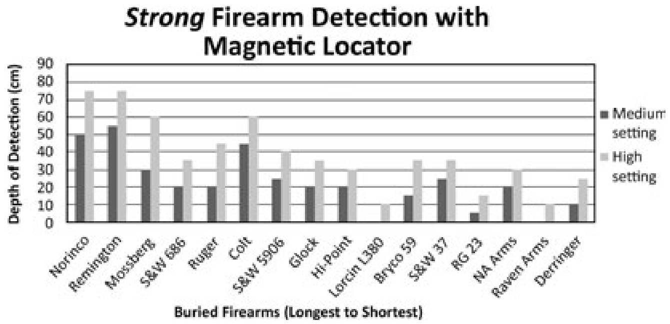

FIG. 2—*Results from firearm detection with the magnetic locator comparing maximum depth of strong detection on Normal and High settings.*

Scrap Metals

Data collection on Medium setting (Fig. 3) showed that only three of the scrap metal targets (50%) were detected; the rebar, the solid iron pipe, and the rusty iron pipe were detected, while the hollow copper tube, aluminum edging, and solid aluminum pipe were not detected. The rusty iron pipe was detected the deepest, down to 55–60 cm. When using High setting (Fig. 3), the rebar, rusty iron pipe, and the solid iron pipe were still the only targets detected; the rusty iron pipe was detected the deepest, down to 65–70 cm.

Miscellaneous Weapons

Data collection on Medium setting showed that nine of 10 miscellaneous weapons (90%) were detected; only the brass knuckles were not detected once buried (Fig. 4). The screwdriver was detected the deepest, down to 70–75 cm. When using High setting (Fig. 4), the nine targets were still detected; the brass knuckles did produce a *slight* audible response on High, down to a maximum depth of only 0–5 cm. Again, the screwdriver was detected the deepest, down to 80–85 cm. Size was generally not a factor for greater detection depths concerning the miscellaneous weapons (Table 4).

Discussion

Searches for forensic evidence generally have the greatest success when a multidisciplinary approach is employed, and when performing a buried weapon search, there will be greater success at finding the target if multiple geophysical tools are incorporated.

TABLE 4—*Descriptive statistics for maximum depth of strong detection on forensic targets.*

	Medium			High		
	Range (cm)	Mean (cm)	Median (cm)	Range (cm)	Mean (cm)	Median (cm)
Five small handguns (<17 cm)	0–25	12	10	10–35	23	25
Eight large handguns (>17 cm)	0–45	20.63	20	10–60	36.25	35
Seven steel handguns	10–45	23.57	20	25–60	36.43	35
Six mixed composition handguns	0–20	10	10	10–45	24.17	25
One rifle and two shotguns	30–55	45	50	60–75	70	75
Three detected scrap metals (iron and steel)	20–60	40	40	30–70	53.33	60
Four small misc. steel weapons (<30 cm)*	20–75	47.5	47.5	30–85	55	52.5
Five large misc. steel weapons (>30 cm)	5–65	26	20	25–65	39	30

*Brass Knuckles not included.

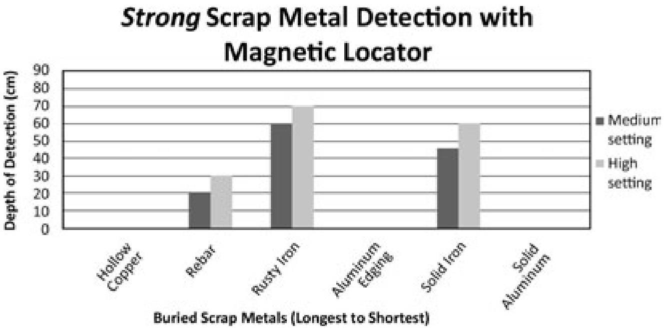

FIG. 3—*Results from scrap metal detection with the magnetic locator comparing maximum depth of strong detection on Normal and High settings.*

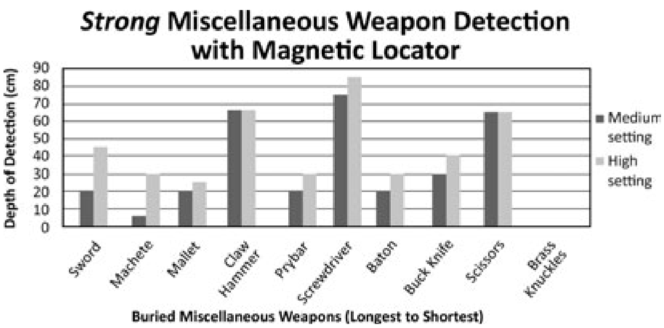

FIG. 4—*Results from miscellaneous weapon detection with the magnetic locator comparing maximum depth of strong detection on Normal and High settings.*

Controlled research of individual geophysical tools is essential for determining the capabilities of these technologies when performing forensic searches for metallic weapons. There are several options in geophysical technologies to consider when searching for buried or discarded metallic evidence.

More expensive options that require extensive training but offer greater depths of detection for larger metallic objects include ground penetrating radar and magnetometers (1,6,12,19,24). Other options that are less expensive, require less extensive or minimal training, and are more suitable for shallower target detection include metal detectors and magnetic locators (1,4,6,8,14,16,18–23,25). Prior to this study, there were no reported studies that focused on the capabilities of a magnetic locator for detecting metallic evidence either alone or in conjunction with other geophysical methods. The magnetic locator utilized in this project was easy to use, although advanced training should be considered to distinguish slight and strong responses.

When considering maximum target detection depth, it was noted that metallic composition of the targets and sensitivity settings of the detector were the two factors that affected both detection and depth of detection. As expected, the magnetic locator was able to detect ferromagnetic items (iron and steel), regardless of size, but not those of nonferromagnetic (e.g., copper and aluminum) composition (13). Once greater depths were reached, the higher setting generally proved to be more helpful in *strong* detection of the targets. As suggested by the manufacturer, the magnetic locator was able to locate firearms down to 30.48 cm, with 62% (eight of 13) being detected either *strongly* or *slightly* on Medium down to at least 30–35 cm (13). On High setting, the magnetic locator detected the larger long guns deeper than the handguns.

The most striking instances where metal composition was a factor with firearm depth of detection using the magnetic locator included the Lorcin L380 and Raven Arms MP-25. Both of these weapons were only detected down to 5–10 cm using the High setting. Although these are two of the smallest weapons, it is not surprising that there was shallow detection based on the metal composition of the weapons. While they do include some steel components, the Lorcin L380 has an aluminum frame and magazine, and the Raven Arms MP-25 is primarily zinc alloy with an aluminum clip. Zinc is classified as a diamagnetic alloy that weakly repels magnetic fields, and aluminum objects are not supposed to be detected by the magnetic locator. As a result, these weapons can only be detected at a shallow depth because of the minimal steel components. In addition, the second largest handgun, the Ruger P89, was detected at a shallow depth (15–20 cm) with the magnetic locator using the Medium setting and was not detected any deeper using the High setting. This detection limit is not surprising considering that the metallic composition of Ruger P89 is primarily aluminum, with additional stainless steel components.

Conversely, the Jennings Bryco 59, which is also comprised of a zinc alloy, was detected much deeper, to 30–35 cm, because the clip is larger and made of steel. Also, while the frame for the RG Industries RG23 is comprised of aluminum, the weapon was detected to 30–35 cm because the barrel and cylinder are both comprised of steel. The NA Arms Mini-Magnum also stands out as being detected to a deep maximum depth with the magnetic locator. While it is the third smallest handgun tested, it was detected deeper than 20 cm on the Medium setting which suggests that the steel utilized for this weapon contains a high amount of iron.

The decreased detection of items comprised of nonferromagnetic materials is further demonstrated by a number of other items that were tested. For example, the two pieces of aluminum scrap metal and the hollow copper tube were not detected with the magnetic locator on either the Medium or High settings. Furthermore, the brass knuckles were not detected with a *strong* hit using either the Medium or High settings. As brass is composed of copper and zinc, it should be expected that any detection by the magnetic locator would be at shallow depths (13). This would actually make the magnetic locator a more efficient tool in forensic weapon searches; even though items of similar metallic composition may be detected, false hits on scrap metals would be limited when searching for a potential firearm.

The screwdriver, which was one of the smallest targets, was conspicuously detected the deepest out of every target using the magnetic locator. Maximum *strong* depth of detection for the screwdriver was 70–75 cm on Medium and 80–85 cm on High. A representative from the manufacturer (personal communication, Mark Pugh, Jan. 28, 2009) confirmed that the deep detection depth could have been the result of high iron content and magnetization of the tool, which is a common feature of screwdrivers for picking up screws. Because the magnetic locator is designed to detect objects that can be magnetized, it would make sense that an object that is already magnetized would be detected deeper than any object which is not.

When the results of the magnetic locator are compared with those of the Fisher M-97 all-metal detector portion of this research project (25), there are a number of detection differences between the two tools (Tables 5–7). Because the all-metal detector detects all metals, all of the forensic targets were detected with this tool. In terms of the number of firearm targets detected, the results were the same when comparing the all-metal detector and magnetic locator regardless of instrument setting (Table 5): seven firearms were detected to greater depths with the all-metal detector, the magnetic

TABLE 5—*Maximum depth of strong detection (cm) for firearms comparing the all-metal detector and the magnetic locator.*

	Medium		High	
Firearms (Longest to Shortest)	All-Metal Detector*	Magnetic Locator	All-Metal Detector*	Magnetic Locator
Norinco (C5)	25–30	45–50	45–50	70–75
Remington (G1)	30–35	50–55	50–55	70–75
Mossberg (D5)	25–30	25–30	40–45	55–60
S&W 686 (B3)	20–25	15–20	35–40	30–35
Ruger (G2)	20–25	15–20	35–40	40–45
Colt (B5)	25–30	40–45	35–40	55–60
S&W 5906 (A4)	20–25	20–25	35–40	35–40
Glock (A5)	15–20	15–20	30–35	30–35
Hi–Point (A3)	15–20	15–20	35–40	25–30
Lorcin L380 (B4)	15–20		30–35	5–10
Bryco 59 (B2)	15–20	10–15	35–40	30–35
S&W 37 (C1)	15–20	20–25	30–35	30–35
RG 23 (C2)	15–20	0–5	30–35	10–15
NA Arms (B1)	10–15	15–20	25–30	25–30
Raven Arms (A2)	15–20		25–30	5–10
Derringer (A1)	10–15	5–10	25–30	20–25

*Data derived from Rezos et al. (25).

TABLE 6—*Maximum depth of strong detection (cm) for scrap metals comparing the all-metal detector and the magnetic locator.*

	Medium		High	
Scrap Metals (Longest to Shortest)	All-Metal Detector*	Magnetic Locator	All-Metal Detector*	Magnetic Locator
Hollow copper (D1)	10–15		25–30	
Rebar (D4)	15–20	15–20	30–35	25–30
Rusty iron (D2)	25–30	55–60	40–45	65–70
Aluminum edging (C3)	15–20		30–35	
Solid iron (C4)	25–30	40–45	40–45	55–60
Solid aluminum (D3)	10–15		20–25	

*Data derived from Rezos et al. (25).

TABLE 7—*Maximum depth of strong detection (cm) for miscellaneous weapons comparing the all-metal detector and the magnetic locator.*

	Medium		High	
Miscellaneous Weapons (Longest to Shortest)	All-Metal Detector*	Magnetic Locator	All-Metal Detector*	Magnetic Locator
Sword (F5)	20–25	15–20	35–40	40–45
Machete (E5)	20–25	0–5	35–40	25–30
Mallet (E4)	20–25	15–20	35–40	20–25
Claw hammer (F4)	25–30	60–65	40–45	60–65
Prybar (E3)	15–20	15–20	30–35	25–30
Screwdriver (F2)	5–10	70–75	15–20	80–85
Baton (F1)	20–25	15–20	30–35	25–30
Buck knife (E2)	10–15	25–30	25–30	35–40
Scissors (E1)	10–15	60–65	25–30	60–65
Brass knuckles (F3)	10–15		25–30	

*Data derived from Rezos et al. (25).

locator detected five targets to greater depths, and four targets were detected to equal depths. Overall, the greatest depths for the larger firearms were obtained with the magnetic locator. Smaller firearms, particularly those comprised of nonferromagnetic materials or a mix of nonferromagnetic materials and steel, were generally detected deeper with the all-metal detector. In terms of the ferromagnetic scrap metals that were detected by the magnetic locator, they were generally detected to greater depths (two of three) than the all-metal detector regardless of setting (Table 6). In addition, in terms of the 10 miscellaneous weapons, half were detected to greater depths with each instrument (Table 7). However, the greatest depths were obtained with the magnetic locator.

A number of conclusions can be gleaned from the comparison of the two tools with this sample. Both tools can be used to locate ferromagnetic targets, while the magnetic locator usually detects items at deeper depths, particularly larger targets, and reduces the number of scrap metals detected. Conversely, the all-metal detector is a better option when searching for items comprised of either nonferromagnetic or a mix of nonferromagnetic and ferromagnetic components.

Forensic Search Guidelines

All forensic searches should consist of a multidisciplinary protocol that employs multiple methods. When considering whether a magnetic locator should be used over an all-metal detector, metallic composition is the main target characteristic to consider. If the target is of a nonferromagnetic composition or a mix of nonferromagnetic and ferromagnetic components, an all-metal detector would be the proper choice. When searching for a ferromagnetic target, both the all-metal detector and the magnetic locator would be suitable. However, regardless of target size, a magnetic locator should provide greater depths of detection on ferromagnetic targets than an all-metal detector. As the magnetic locator only detects ferromagnetic targets, it would be beneficial in the field, as common types of scrap metals would be excluded from the search area, increasing the potential for locating the actual suspected weapon. Finally, if the metallic composition of the target is unknown, either the all-metal detector or a combination of both tools can be incorporated for a weapon search.

To ensure that a suspected weapon site is viable for geophysical survey, information regarding the area in question should be gathered to discern any areas of interest and to ensure that geophysical testing is possible at the location. Also, having buried metal pipes, electric lines, and metallic fences flagged prior to the search may reduce the number of false positives that need to be investigated. Any personnel performing the geophysical search should be properly trained on the tool(s) in question prior to the day of the search. When a weapon search is performed using a magnetic locator, a grid may be set up on the survey area, utilizing transects of 1 m spacing. During data collection, the shaft should be pointed close to the ground and swung slowly so that there is overlap with adjacent grid lines. High sensitivity setting of the magnetic locator provides overall greater detection depths, but should be utilized only when background noise is limited. An experienced operator may also utilize the polarity readings to assist with pinpointing the orientation and size of a buried metallic target (13). Observed positive target responses should be marked with nonmetallic flags for further invasive inspection.

Conclusions

Forensic personnel involved with searches for buried or discarded metallic weapons tend to rely on basic metal detectors because of ease of use and cost efficiency. As an alternative, magnetic locators provide more advanced detection methods than all-metal detectors for a minimal cost. However, as more types of geophysical tools are now being used to search for buried evidence, controlled research is essential to determine the capabilities of the tools and for operator training. The most important issue to consider when using a geophysical tool for a buried weapon search is metallic composition of the suspected target. Because the magnetic locator is designed to detect items of ferromagnetic compositions, the innate differentiation of nonferromagnetic scrap metals from the ferromagnetic targets in question reduces the amount of time, money, and manpower, which may be spent excavating false positives. This aids not only in locating an object but in clearing a suspected area so that investigations can be performed at other suspected sites (1,5,10–12,14,28,29).

Data collection in this study with Medium setting allowed for detection and readings at multiple depths; once greater depths were reached, High setting proved to be more helpful in detecting the targets. Overall, larger ferromagnetic items were generally detected to greater depths than the smaller items, while weapons comprised of both ferromagnetic and nonferromagnetic materials were generally detected to shallower depths. The majority of the targets were detected to depths no greater than the range of 30–40 cm. With the exception of the magnetized screwdriver, the two largest targets (one of the shotguns and the rifle) were detected to a maximum depth of 70–75 cm on High setting. If the target in question is determined to be a ferromagnetic weapon that is either a shallow burial or has been discarded, the magnetic locator may be the optimum geophysical tool to use for a weapon search.

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