

# Chapter 3

## Geophysics and Archaeology at Crime Scenes



**Pier Matteo Barone**

**Abstract** Irrespective of the type of crime and the modalities of intervention on a crime scene, the approach to the crime scene has recently evolved by virtue of the assistance of forensic geosciences. Studying, knowing, and interpreting the environment and the territory in which the crime took place are essential for providing proper direction to criminal investigations. This is because the forensic geoscientist must be able to search for and collect adequate information from the environment, place it in its specific criminal context, and characterize its actual or presumed narrative.

At first glance, such an approach specifically involves the use of various tools of analysis of various scales, which are completely noninvasive. Geophysics, on a local scale, undoubtedly allows the location and precise mapping of objects (e.g., metal drums or weapons), bodies (e.g., burials), and cavities (e.g., bunkers) of various natures and dimensions, both underground and underwater (generally, in forensic geophysics, the use of electromagnetic instruments, such as GPR or metal detector, is involved). Together with these tools, cadaver dogs are essential to complete the preliminary investigative picture, providing useful information in order to have a further confirmation of the aforementioned geophysical investigation.

The field of forensic archaeology is part of this multivariate approach. The most popular and most requested service involves the use of reading and interpretation techniques of material traces and contexts of the archaeological discipline in the forensic field. In particular, this is the analysis of the crime, recognition and classification of finds, identification of their origin and time, reconstruction of the spatial arrangement of people or objects in a given place and moment, and the temporal sequence of anthropogenic and natural actions which occurred at the scene of a crime.

**Keywords** Forensic geophysics · Forensic archaeology · CSI · Non-destructive techniques · GPR · Forensic geoscience

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Geophysical surveys are based on measurement techniques typical of classical and modern experimental physics, which, in forensic science, can primarily be used for the research of objects and bodies buried in the subsoil or in artifacts. They can also be used for the study of pollutants dispersed in the ground, illegal landfills, hidden rooms, armored shelters, and so on. The correct use of such methods requires, above all, a clarity in terminology that avoids any ambiguity in the definition of the investigative technique. In Italian and international literature dedicated to the application of physical methods to investigative and judicial investigations, there is, in fact, a certain confusion in the use of the terms remote sensing and geophysical exploration. In a broad sense, the term remote sensing refers to measurement methods that acquire information, on a small or large scale, relative to an object or a phenomenon, using appropriate devices that are not in physical contact with the object under study.

With the advent of new disciplines such as forensic anthropology, which deal with the recovery and study of human remains, the multidisciplinary nature of this field is increasingly clear. This multidisciplinary feature emerges mostly when it comes to “finding” and recovering the victim. As already mentioned above, one of the tools for carrying out the search is a cadaver dog. The role of a cadaver dog, until recently nonexistent in Italy, has for decades been a very important component of the human remains’ research teams in the Anglo-Saxon countries and Northern Europe.

Archaeology has application in this multidisciplinary forensic field when there is not only a need to search for and locate clandestine burials and recover their remains, but also in the event of concealment of evidence, pollutants, and any other material underground. The sequence of operations leading to the location and recovery of buried remains is divided into three main stages: a preliminary survey of the alleged place of burial in order to determine the location of where exactly the investigation needs to be conducted, the actual excavation phase, and the documentation and recovery of the remains as these are excavated.

The tasks of the archeologist comprise carrying out an excavation, accurately documenting each passage, and ideally recovering the objects found, whether they are human or material remains of another nature. In a forensic context, it may be important to know how to properly remove any human remains. Although, often, in the excavation sites, it is very easy to uncover just scattered bones or teeth that have been picked up and moved by carrion predators. The recovery of remains using forensic archaeology techniques can provide information about the deposition-concealment methods of the corpse and permit the finding of useful clues for the investigative forces.

Archaeological excavation is a destructive operation; consequently, the need to fully document every single advancement has always been a factor of extreme importance. Over the years, more and more accurate methodologies have been developed and perfected with the principal aim of maximizing the amount of information obtainable from the survey site. This approach turns out to be especially reported and useful in the forensic context, where the site of discovery constitutes the scene of a crime and the information stored in it can prove to be of fundamental

importance for the reconstruction of the events and the successful outcome of the investigations. Good excavation documentation can be drawn up by suitably trained judicial police officers; however, the analysis of the excavation and the remains, the interpretation of the data, and the coordination of the subsequent recovery operations remain the exclusive prerogative of the specialists in forensic archaeology.

### 3.1 Forensic Geophysics

Forensic geophysics is the localization and mapping of objects, bodies, or cavities, of various types and sizes, hidden underground or underwater, using specific geophysics tools, for legal purposes. In forensic investigations, a wide range of geophysical techniques are applied that have the potential to verify a contrast in physical properties between a target and the material in which it is buried. Generally, in forensic geophysics, the use of electromagnetic equipment, such as ground-penetrating radar (GPR) and metal detector, is involved, which means it is possible to obtain an approximate image of the variation of physical properties in the first few meters under the surface. Generally, abnormalities in the variations of the physical parameters can be potentially interpreted as coming from buried “foreign” materials. With the help of these techniques, it is therefore possible to identify and precisely define the place of concealment of the target in question, even to the extent of recognizing evidence of human occupation, anthropogenic disturbance of the soil, or soil excavation, both recent and after many years. The geophysical methods have the potential to swiftly and noninvasively investigate extensive areas, where someone has tried to obliterate an underground clandestine burial or, in general, a forensic target.

Forensic geophysics is not only effective for the research and localization of metal weapons or drums, burials, and bunkers, elements that are particularly “visible” and distinguishable from a more or less homogeneous burial or concealment context, but also very useful for identifying areas with high rates of chemical pollution, where the contaminants introduced into the ground alter their physical properties in accordance with their concentration and geometric distribution. A similar discourse can also be made for human burials because the decomposing bodies release slurry, easily identifiable by geophysical techniques as they alter the chemical-physical properties of the surrounding soil. Obviously, as for any discipline in the field of forensic geosciences, surveys of forensic geophysics must be conducted by expert personnel, who are not only aware of the physical principles, but also mindful of the notions suitable for the type of investigation to be performed.

The geophysical approach, therefore, requires specialization and experience. In fact, the development of the instruments, knowledge, and understanding of the subsoils of the area to be investigated and the ability to process and interpret the collected data are fundamental elements for the success of a geophysical campaign. Geophysical methods are very sensitive to small changes in the properties of the earth’s material, while maintaining a high resolution for the result.

Field data are acquired through a series of measurements carried out according to regular and parallel profiles, following a very tight mesh previously established, which is linked to the size of the target to be identified.

Once the measurements have been completed, the geophysicist processes the information through specific software. From their analyses, they will be able to produce a map of the detected geophysical anomalies.

The main anomaly that geophysicists must search during their investigations is the so-called “cut” that is present in any material at the time a clandestine excavation is carried out.

These cuts (whether in the ground or in rocky or artificial materials such as rocks or cement) persist for centuries from the moment they are made. This cut is very clear geophysically, due to the difference in chemical-physical properties and compactness between the surrounding material, the cut, and the filling (whether it is carried out with the same type of material or with a different one).

This anomaly, therefore, is the anomaly par excellence. It is always present in cases of clandestine burials, whether they are related to burying bodies, weapons, drums, or any other material. Every good geophysicist should know how to distinguish it in his own prospects.

Naturally, every investigation has its peculiarities, so that sometimes together with the cut, it is possible to recognize anomalies in a geophysical analysis, which are related to the dispersion of slurry or of metal objects such as shell casings and cartridges in the soil.

Understanding the context in which we are operating is therefore extremely important in not only optimizing the choice of methods to be used but also, and above all, focusing on the integrated study of the techniques mentioned above.

While the metal detector is limited solely to the search for metallic objects buried in shallow depths, the GPR—the best geophysical method in the field of forensic investigation—allows detection of anomalies of different types, such as buried bodies, decomposing sludge, pollutants, bunkers, weapons, and any buried object that has a clear variance with the natural geological background. In addition, GPR produces excellent results when used “indoors,” i.e., inside homes or huts—built or under construction—to search for secret entrances, bunkers, interspaces, or storage rooms hidden under the floor or behind walls of any material (concrete-armed and not plasterboard, bricks, and so on) (Fig. 3.1).

### ***3.1.1 The GPR: Theory and Methods***

GPR, known in the international field by the Anglo-Saxon term of ground-penetrating or probing radar, operatively, involves sending high-frequency electromagnetic pulses (10–3000 MHz) into the ground and measuring the time taken by the emitted signal from the transmitting antenna to return to the receiving one, after being reflected and/or diffracted by possible discontinuities present in the investigated material. The round-trip time (TWT), expressed in nanoseconds (ns), allows



**Fig. 3.1** The use of both electromagnetic instruments—GPR and metal detector—in a crime scene

in measuring the distance in time between the antennas and the “target.” This distance can be transformed into depth (meters) in the subsoil, if the velocity of propagation of the pulses in the investigated medium can be measured.

The attenuation of these pulses in the subsoil is related to two elements: the presence of moisture in the ground and the chosen frequency. With regard to the presence of humidity, a high level of groundwater runs the risk of not penetrating (or penetrating only partially) the electromagnetic signal, making the ground very conductive.

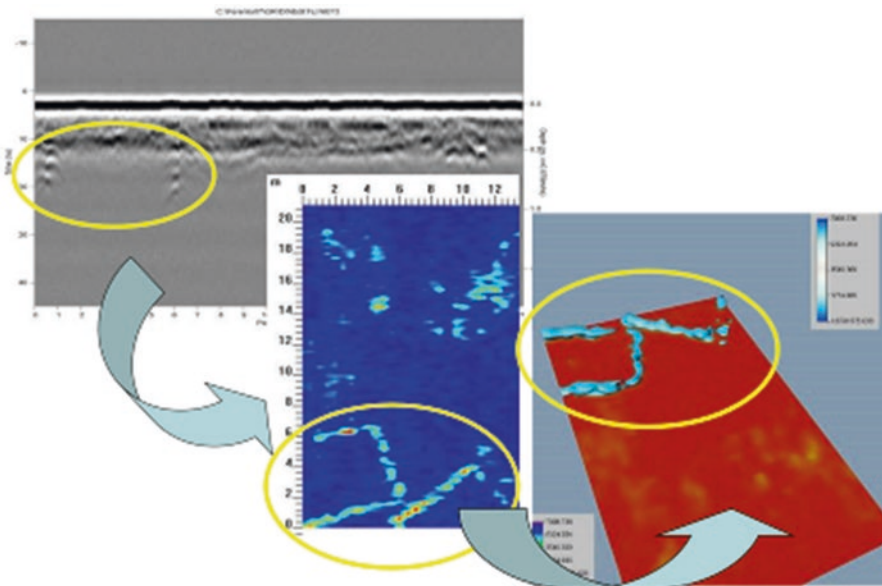
The choice of what frequency to use depends on the fact that the transmitter is connected to an antenna (Tx), which produces a very short electromagnetic pulse (around 1–10 ns). The duration of the chosen pulse is, in turn, linked to the frequency of the antenna used and to the vertical resolution required, i.e., the ability to distinguish between two layers or objects close to each other. In other words, the higher the antenna frequency, the shorter the pulse, which translates into a low signal penetration (because the attenuation also depends on the frequency) but in a higher vertical resolution.

The GPR instrumentation has two possible configurations: the so-called bistatic configuration, in which the transmitting antenna is physically separated from the receiving one, and the monostatic configuration, in which the transmitting and receiving antenna coincide.

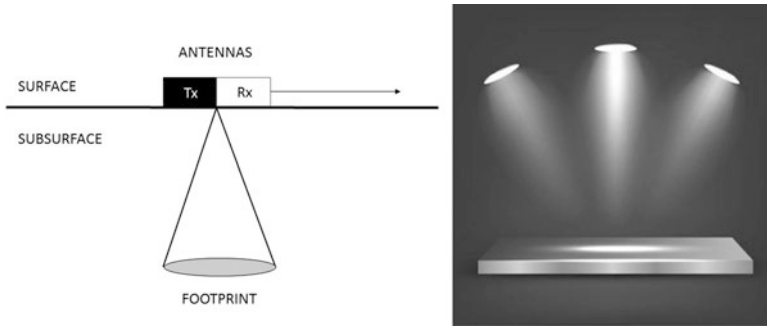
The graphical representation of GPR data is a fundamental step for understanding and interpreting results. These results report grayscale radiations (or stratigraphy), and modern software allows a very high visual resolution and definition. Moreover, if the acquisitions have provided parallel profiles inside a grid, it is possible to obtain and therefore display maps (i.e., floor plans) of the investigated area, which not only represent the geometries of buried objects at various depths, but also the dimensions, normally using an average envelope algorithm, also known as the average envelope amplitude (Fig. 3.2).

To correctly interpret a radargram, it is necessary to know how the section was acquired. The pulse transmitted by the radar antenna does not propagate in the ground or in the material in a precise manner like a laser but behaves like a so-called radiation cone, “illuminating” the buried target even before being perpendicularly above the target itself (like a lamp lit in the darkness of a room). The diameter of this cone increases with the increasing depth of the GPR signal. Moreover, its dimensions also depend on the conditions of the acquisition surface and the frequency of the antennas used (e.g., high frequencies restrict the diameter of the cone) (Fig. 3.3).

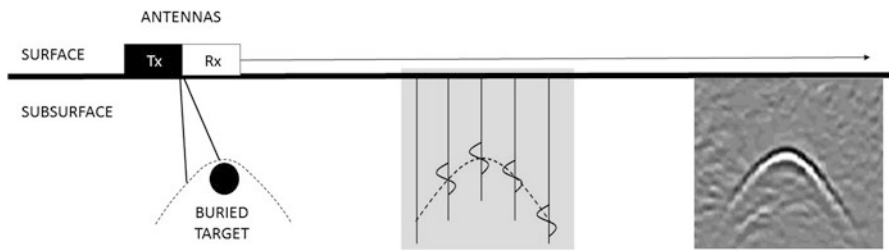
The presence of a void in the subsoil or of any specific object more or less produces a characteristic electromagnetic response: the diffraction hyperbola. The hyperbolic anomaly results from the reflection of the source point (buried target) and occurs, as we have seen, because the energy is emitted in the form of a cone, which “illuminates” a larger portion of the target itself. Consequently, the signal



**Fig. 3.2** Exemplification of how the same anomaly (in this case, a wall structure) can be visualized in three different ways: a radargram or stratigraphy of the subsoil (top, left), a map (or planimetry) at different depths in the subsoil (in the center), and a 3D reconstruction (below, on the right) acquired with GPR



**Fig. 3.3** The transmitting antenna (Tx) emits a signal that does not travel vertically in depth like a laser but creates a cone of radiation that “illuminates” the target and is reflected in the receiving antenna (Rx). On the right is the analogy with a lighting cone, for the purpose of providing an example



**Fig. 3.4** The diffraction hyperbola, visible in this figure, derives from the reflection of the intercepted target. It should be noted that only the apex of the hyperbola identifies the correct position of the buried object

is reflected not only from the target directly perpendicular to below the antennas, but also shortly before and shortly thereafter, due to the transmission of oblique waves. Only the apex of the hyperbola corresponds to the actual position of the source (Fig. 3.4).

The maximum horizontal resolution is roughly the impression of the radiation cone (or illumination area). TWT of the signal, and consequently the estimate of the depth, can be calculated by what is known as the calibration of hyperbolic queues derived from an anomaly. Important to emphasize, however, is that it is possible to determine the depth of a target as long as the speed of the signal penetration in the material or materials is known.

With the exception of buried conductive materials (e.g., metal, which has a high conductivity and magnetic permittivity), electromagnetic waves pass through the buried target, continuing their penetration and producing different reflections at different depths. In some cases, this effect allows the estimation of not only the depth of the upper part (top) of the object but also its vertical dimensions (e.g., in the presence of an underground tunnel, it is possible to identify not only the top of the tunnel but also the bottom of the same).

## 3.2 Cadaver Dogs

Cadaver dogs (or the international term K9)<sup>1</sup> have the primary task of locating the remains of missing persons. Despite extensive research in the field of technology, it has not been possible to find a worthy substitute for the dog, who has been used in these operations since 1974. In fact, on this day, the first dog, which was used for searching corpses, was trained by the New York Police Department. After ascertaining that dogs could prove to be a useful tool, the FBI, too, began breeding dogs for this type of work, including some volunteers from the National Search and Rescue Association.

The use of cadaver dogs is based on the extraordinary sense of smell of such animals. In a medium-sized dog, the total surface of the olfactory mucosa is 150 cm<sup>2</sup> compared to just 5 cm<sup>2</sup> in an adult man, and it is a tenth of a millimeter thick against 5 thousandths of a millimeter of man. There are about 225 million canine olfactory cells compared to 15 million in a human being; consequently, the dog has a 500/700 times greater capacity to perceive odors. The dog can perceive the smell of 2 mg of blood serum or even 5 mg of urine and can sense acetic acid in aqueous solution in a ratio of 1 part in 1 million.

In practice, these animals, by virtue of their particularly developed nose and a specific training program, can recognize the chemical substances (about a 100) characteristically released by a cadaver.

To ensure that the smell can be detected and therefore communicated, it is necessary that it exceeds a certain threshold and also remains in the dog's presence for a sufficient period of time. In other words, it is necessary that the odor exceeds the stimulus threshold, has an elevated period of exposure or is sufficiently intense to trigger recognition, and remains for a sufficient period of time for the dog to pick up and communicate. The training of dogs is based on these concepts, which involve the use of "baits" of odorous material. These materials may consist of pork, blood-soaked pieces, human teeth, or chemical substitutes such as cadaverine and putrescine.

The search for a corpse is configured as a hunt for the dog, where the dog behaves as a follower and the operator is the leader; locating the corpse is therefore understood as the capture of the prey, whose division is reproduced using a game preferred by the operator. It is clear that this activity requires a well-established relationship between man and animal, which is developed over the course of many years. From the time they are puppies, the operator can begin an initial research training by hiding the toys of the dog or accustoming the dog to look for things or objects. In Italy, the basic training is based on the activity involving buried pork first and then human organic material, wherein small holes are made in the ground about 3 cm in diameter, at a depth of about 10 m, at a distance of about 30 cm from each other, in a straight line for 10 m, and on more rows 15 cm of each other.

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<sup>1</sup>Symbol linked to the assonance between the Anglo-Saxon pronunciation of the letter "K" and the number "nine" and the English pronunciation of the word "canine".



This type of signaling also requires a special type of training. Most Italian dogs are trained to report by stopping and sitting in front of the source of smell and waiting for gratification; this behavior constitutes the wait for the “jump of the rabbit” or for the localized prey to exit the lair. The operator, without being seen by the dog, places it at the point established by the dog, creating the effect of gratification. Alternatively, the dog can scratch at the ground, which is behavior aimed at checking if the smell increases with the removal of the soil. Among more communicative dogs, a behavior is established, which is aimed at alerting the operator by traveling between the signaled location and the position of the operator. In some cases, it is possible to conduct surveys via T-bar<sup>2</sup> in the ground in order to allow a greater outflow of the smell and increased likelihood of identification.

From this, it is clear that the dog alone cannot resolve all problems, as it requires great collaboration and communication between the investigation departments and a specialized preparation by the operator.

When conducting research, for example, it must be taken into account that the concentration time of the dog in a targeted exercise is reduced to 10/15 min. Therefore, the research area should be limited to the real possibilities that the dog meets the source of the smell, so that it can be minutely inspected by the animal. On open ground, the area is divided into corridors of about 500 m<sup>2</sup>, arranged perpendicular to the wind direction. Each of these corridors will be considered as sectors and classified with numbers or letters.

In some very rare and particular cases, the cadaver dog is so well-trained and has reached such a level of sophistication that it senses the difference between human and animal organic matter. With the help of the conditioning method used during the training of dogs, they are able to recognize any chemical substance that is fixed in their olfactory memory by their trainer (this is the case, e.g., of dogs trained by the Cynthia Unit of the State Police of Milan Malpensa).

Finally, it should be noted that these dogs are also able to detect the presence of a body submerged in water. The dogs do not dive as contact with the water surface is enough to indicate nearness to the source. From the boat, they are already able to pick up on these volatile particles released by the decomposing human body. Maybe they are on standby all the time, or they doze off, but when they enter the field of the odor and perceive the possibility of identifying the chemicals they are trained to recognize, they immediately give the signal that something is there at that point.

On most occasions, a dog is the most effective and efficient resource. In combination with other technical resources, a dog can provide an exact indication of where to begin the excavations, thus safeguarding the integrity of the finds to be recovered.

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<sup>2</sup>The T-bars are T-shaped rods with a length of about 100 cm, with a diameter of 2.5 cm, inside cavities with an opening of 40 cm on the side, also used in archaeology to verify the consistency of the ground in depth for the search for anomalies.

### 3.3 Forensic Archaeology

Archaeology is the study of the human past, ancient, and recent, through material remains. From the fossil remains of millions of years ago, which belonged to our first human ancestors in Africa, up to today's twentieth century buildings, archaeology analyzes the physical remains of the past in search of a broad and global vision of human culture.

Forensic archaeology is the application of archaeological principles and methodologies to identify and recover evidence within the confines of the criminal justice system or for use in civil cases, operating as a discipline in its own right.

People authorized to conduct forensic archaeological investigations are mostly trained in traditional archaeological techniques but are flexible enough in their approach to adapt these methods to the different forensic contexts that may arise in criminal or civil proceedings. Integrated skills and considerations outside the parameters of traditional archaeology are the possession of a basic knowledge of law enforcement and legal procedures (as well as the ability to cooperate productively with law enforcement personnel), ability to efficiently and effectively conduct investigations under tight deadlines and under the attention of the media, as well as the ability to navigate skillfully in situations that deviate from traditional archaeological experience, such as in the presence of a burial that includes conservation of the remains of soft tissues.

The sequence of operations leading to the location and recovery of buried remains is divided into the following three main stages: a preliminary survey of the alleged place of burial in order to determine the exact location where the investigation is to be performed, the actual excavation phase, and the documentation and recovery of the remains as they are excavated.

The survey, contextualization, and localization provide for the interpretation of the territory in order to search for a presumable burial site. They are carried out with the help of various instruments, both large- and small scale. For example, aerial photographs can easily provide important information about the area to be investigated (abnormal changes in vegetation cover over large areas or changes in soil morphology), and their use in the preliminary stages of a survey can be effective, leading to a significant saving of time and energy. As seen in the previous paragraphs, on a local scale, geophysical techniques and K9 units are applied, which allow a more precise localization of the buried target.

The tasks of the archaeologist consist of carrying out an excavation, accurately documenting each passage, and ideally recovering the objects found, whether they are human or material remains of another nature. In a forensic context, it may be important to know how to properly remove any human remains. Although, often, at excavation sites it is very easy to just uncover scattered bones or teeth that have been picked up and moved by carrion predators.

The recovery of remains using forensic archaeology techniques can provide information about the deposition-concealment methods of the corpse and permit the gathering of useful clues for the investigative forces. Analysis of the context, excavation and remains, interpretation of the environmental data, and the coordination

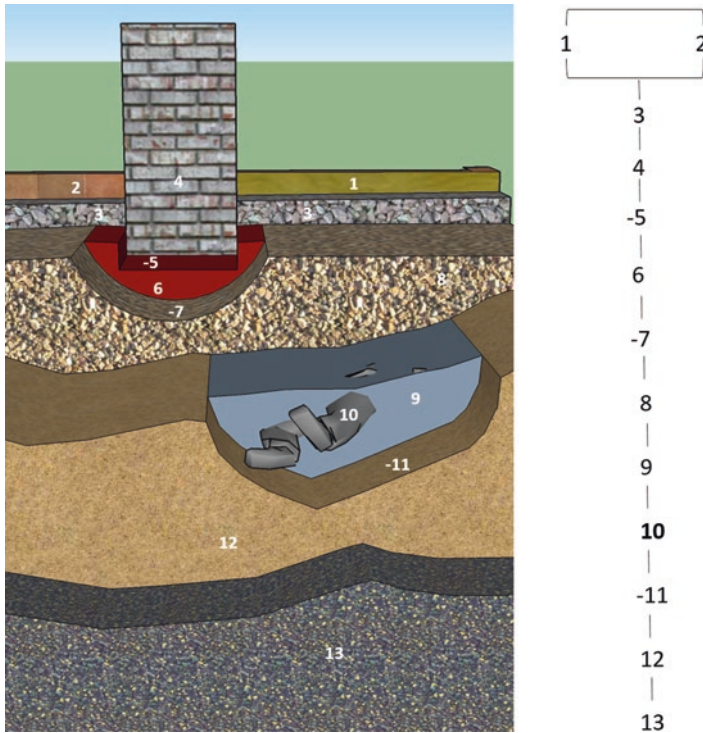
of the subsequent recovery operations remain the exclusive prerogative of specialists in archaeology. Archaeology is a destructive process. For this reason, it is preferred to integrate it with other methods in order to pass from a nondestructive analysis to a more invasive one. This minimizes the loss of information.

For this reason, three basic objectives can be summarized in an archaeological forensic investigation. The first is the understanding and interpretation of taphonomic events—the history of a site after it has been created through the deposition of remains. Taphonomic events are both natural (N-transformations) and cultural (C-transformations) processes that occur at a site and alter or transform it over time. These processes include N-transformations, such as seasonal water runoff, high levels of animal or insect activity, and tree root activity and growth, and C-transformations, such as informal excavation (due to the lack of awareness that the position is a location of criminal activity or action of a civilian), deposit of waste or other objects unrelated to the deposition event, and high levels of human traffic that can disturb the original deposition contexts. Understanding and being able to interpret the transformations that these processes cause at a site are essential for an accurate archaeological investigation (Fig. 3.5).

The second main objective is the reconstruction of the events that have caused and occurred with the creation of the site and the body deposition. This is accomplished through the collection of surface disturbance elements, excavation methods, and detailed and photographic documentation at all stages of the survey. It must be remembered that the archaeological forensic investigation of a site is inherently destructive and forensic archaeologists must therefore take all precautions to preserve the maximum amount of evidence and potential contextual information (Fig. 3.6).



**Fig. 3.5** Some phases of archaeological excavation during a forensic investigation



**Fig. 3.6** Section expanded in 3D format of a forensic archaeological stratigraphy and related Harris matrix. Note how the cuts made in the ground are indicated with the sign “-,” while the US 10 is in bold because it indicates the buried body

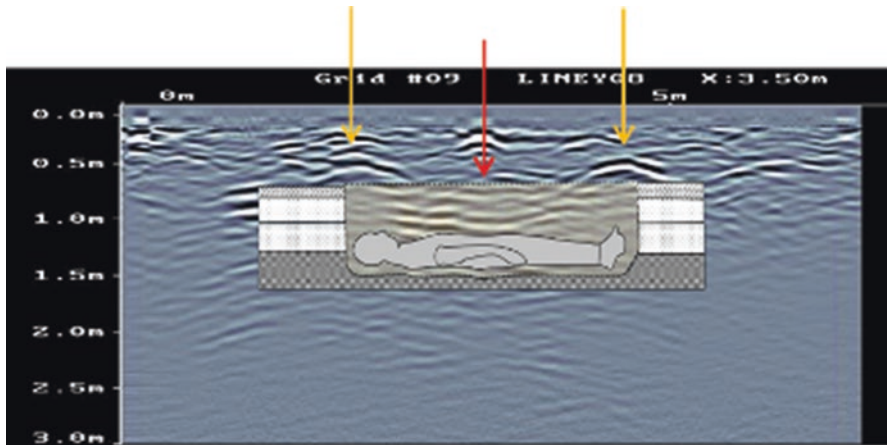
Finally, based on the evidence that the recording of this material provides for the reconstruction and the taphonomic history of the site, an investigator is able to achieve the third objective, which is a conscious interpretation of the events surrounding the deposition of the deceased person, which will help in resolving the case.

It is therefore evident that archaeologists specialized in forensic investigations provide the police with the complete reconstruction of a crime scene, with the possibility of investigating cases that are often very distant from each other and crime scenes that are still “warm” and very recent but maintaining the same high standards of evidence and resolution recovery.

### 3.4 Case Reports

#### 3.4.1 “A More Efficient Search”

“It’s about creating a more efficient search,” so Jon Dittmar (ERA Technology) commented on one of the recent investigations that witnessed a close collaboration between geophysics (specifically GPR) and forensic geo-archaeology.



**Fig. 3.7** In the radargram, yellow arrows indicate hyperboles linked to the cut made in the ground to obtain the burial, while the red arrow indicates the horizontal reflector—the filling after the cut and what remains of the body, with chemical-physical characteristics different from the surrounding soil

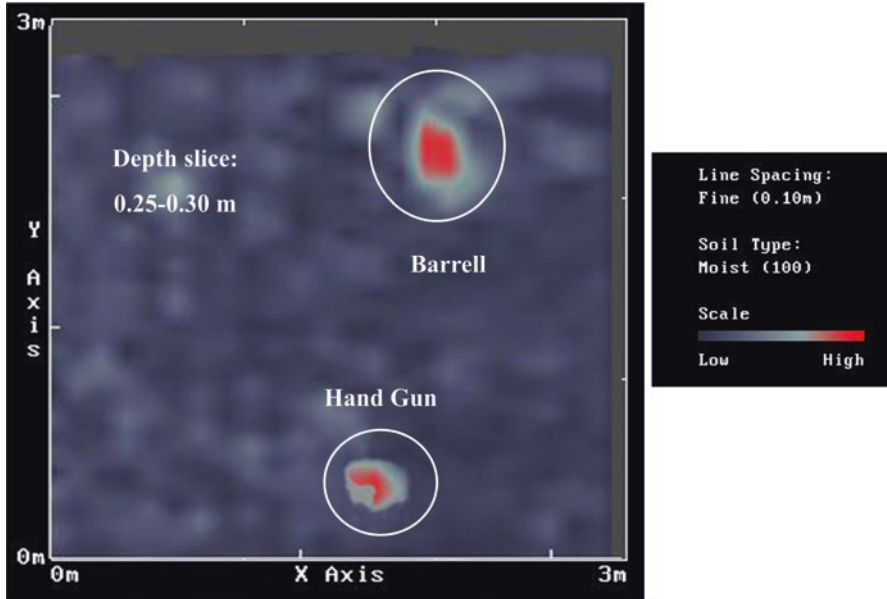
In November 2007, in the garden of a house on Irvine Drive in Margate, Kent, England, a long investigation seemed to have come to an end. Fundamental to the research was a GPR system that uncovered the bodies of two teenagers, Vicky Hamilton and Dinah McNicol, who disappeared in 1991. The geophysical system, in fact, helped the forensic investigators and the police in identifying the bodies of the two girls.

Jon Dittmar is an engineer at ERA Technology, the company that, for the first time in 1994, helped forensic investigators and police in finding bodies in Fred and Rose West's home on Cromwell Road, Gloucester. Dittmar is not only aware of the potential and ductility of GPR, but also, specifically, recognizes the absolute effectiveness of the close collaboration between geophysics and other forensic geosciences.

But how can a geophysical expert understand, analyze, and interpret an anomaly as a possible underground burial? In this case, GPR in real time obtains an electromagnetic response that is configured, as shown in Fig. 3.7. Clearly, every case and every terrain have their characteristics, but generally the presence of a hyperbolic event, a horizontal reflector, and another hyperbolic event is an index of a break, a “cut” made in the ground and subsequently filled, leaving an indelible and lasting mark in time for centuries to come (as taught in archaeology).

### 3.4.2 Weapons and Caches

The scientific investigations on the crime scene have brought to the fore the geophysical skills (particularly GPR) that are required for determining the locations and identifying missing persons, who are buried in the ground and beyond. Recently,



**Fig. 3.8** GPR map to the depth of about 30 cm in which the presence of a gun and a barrel is clearly indicated

in fact, this method has been tested to understand how accurately it can determine an object, even of small dimensions, buried in the subsoil.

Figure 3.8 displays the results following a scientific investigation in search of a gun illegally disposed of at a shallow depth in the ground and a plastic barrel with drugs and money. It illustrates how the GPR map not only indicates the clear location of the object, but also its geometry, although the gun was buried by itself, of a small size, and rolled up in a plastic bag. As for the barrel, given its size and the partial presence of air inside (an element that stands out very much in an electromagnetic response), its position and dimensions are very clear.

### 3.4.3 GPR, K9, and Archaeology

There are many cases in Italy and abroad in which cadaver dogs accompanied forensic investigations using GPR. Well-known among them is the British case of Madeleine McCann and the Italian case of Marina Arduini. Yet such concerted actions could be greater if the experts involved in these investigations put in excellent and undisputed groundwork.

A couple of years ago, the Geoscienze Forensi Italia team<sup>3</sup> was involved in the reopening of a cold case in Marcianise (CE), which involved the disappearance of

<sup>3</sup>Geoscienze Forensi Italia is an Italian platform of various experts in the various fields of forensic geosciences (geology, pedology, mineralogy, archaeology, geophysics, geochemistry, remote



**Fig. 3.9** A photograph of the joint investigation of GPR/K9 operations

Pasqualino Porfidia. This case caused quite a stir at the time (1990) and was aired on television programs such as “Chi l’ha visto” (“Has anyone seen them”). The reopening of the case, based on new indications, required the joint use of GPR and cadaver dogs in the preliminary phase to look for nondestructive and precise anomalies related to burials or corpse occultations, which then allowed a more detailed research through an eventual archaeological excavation. This integrated survey assisted in locating a specific area in which both GPR and the cadaver dog, independently, provided a positive response (Fig. 3.9). The subsequent archaeological excavation then only partially confirmed this positive identification.

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sensing, geotechnics) that provides services to scientific investigations in the forensic field with commitment, professionalism, and experience ([www.geoscienzefforensiitalia.com](http://www.geoscienzefforensiitalia.com)).

### 3.5 Criticality of the Investigation

The geophysical approach of archaeology requires specialization and experience. Indeed, the development of the instruments, knowledge and understanding of the subsoils in the area, as well as the ability to process and interpret the collected data are fundamental elements for the success of a geophysical endeavor. If the acquisition of the given GPR may seem trivial (in reality, it is both complex and delicate), its interpretation requires years of experience and innumerable studies.

Furthermore, those who commission this geophysical survey (whether it is a judge, police official, public prosecutor, or lawyer) must not only be aware about the potential of the instrument but also its limits. This is not a magic wand, but a scientific instrument that has uncertainties in measurement that must be considered when the data is acquired and interpreted.

Likewise, cadaver dogs, although a valuable resource, are living beings and as such are sometimes inclined to err when used in an erroneous manner. Moreover, their full potential is yet to be explored. Nevertheless, it should be recognized that the success of the search operations also depends on the organization of activities, which must take into account fatigue and potential distractions for the dog.

Finally, we must consider that every human operation is selective, both voluntary and involuntary, and for this reason, the moments of excavation and, more importantly, documentation are the phases involving maximum loss of information, no matter how extensive the data recovery equipment might be (Fig. 3.10). In this respect, we need to have a very precise strategy and pay meticulous attention to the

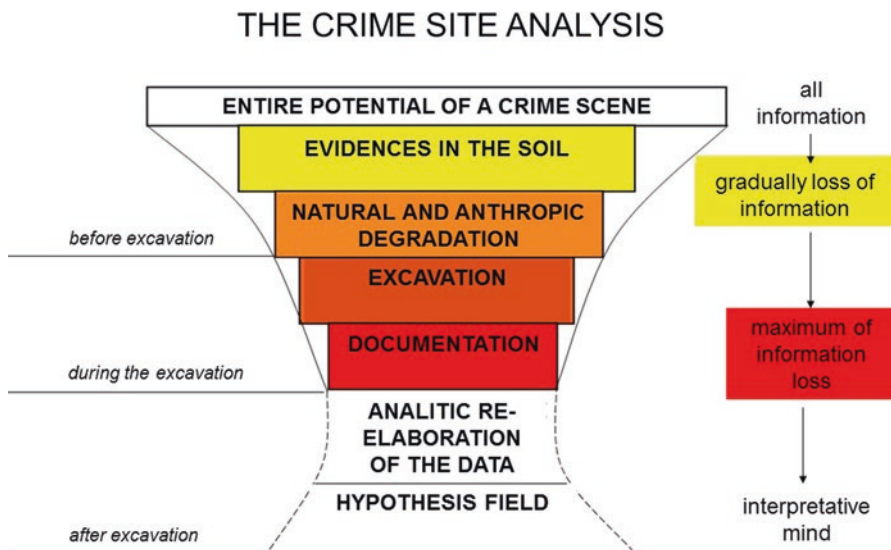


Fig. 3.10 Graph of the forensic archaeological crime site analysis



field to reach the maximum expansion of the data in our possession. This happens through re-elaboration and the formulation of reconstructive hypotheses in order to transform the sediment into history.

The origin and the context are extremely important, without which no evidence can be compiled for arriving at a clear and complete representation of the act of deposition, the events surrounding it, and the identification of people involved. Once all the evidence from a site has been recovered and treated according to the correct chain of command, a site is typically covered (filled with the soil that was originally excavated by the investigators). However, despite the filling, a slight scar is often visible at the excavation site in the form of a depression in the earth. This is because not all of the soil and material removed is replaced nor is it replaced with the same orientation or compaction that originally characterized it.

The coordination between different dogs and activity planning among other figures present onsite, such as the geophysicist, geologist, forensic archaeologist, or the medical examiner, are issues of fundamental importance.