Tools used in Archaeological surveys

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Introduction:

Geophysical survey methods are used for locating burial bodies from a forensic point of view (Dupras T.L., Schultz J.J., Wheeler S.M., Williams L.J., 2012). These methods are performed on the soil surface, through excavations or combinations of placing sources and detectors. The method will depend on the survey that needs to be performed according to the geographical and topographical conditions. Geophysical survey methods are used to discover hidden things that remain beneath the earth's surface or the water bodies (Dupras T.L., Schultz J.J., Wheeler S.M., Williams L.J.,2012). Geophysical surveying also involves the use of equipment to measure and analyse features of the land/sea to identify anything unusual or out of place. There are some important methods and tools that are used for a variety of different purposes in the field of forensics. The use of geophysical surveys has become more common in the last few years as technological advances have made it possible to find pieces of evidence of a crime and criminal activity that were previously undetectable. Geophysical surveying is useful in several different situations, particularly in cases where there is currently no physical evidence of any crime. For example, it can be used to check for the presence of bloodstains that have been wiped away or where the evidence has been destroyed by water or fire.

It can also be used to search for traces of gunpowder following a shooting, which can otherwise be difficult to detect. Geophysical surveying can also be used to determine underground structures such as tunnels or bunkers. These techniques are also useful in locating fossils and other interesting foreign objects inside the ground. In this essay, the types of geophysical survey methods will be discussed and described along with their advantages and disadvantages.

Ground penetrating radar

It is also known as GPR and this is a survey method that uses electromagnetic energy to image the subsurface. A GPR machine usually comprises a transmitter, a receiver and a signal encoder (Warner

Survey, 2019). If a buried object is encountered when the energy signal is emitted, then the signal emitted is returned to the receiver and it will also record in a two-way travel time with a strong signal (Hunter J., Cox M., 2007, Cheetham P. 2005). To get the best result a contrast between the target and host material is needed. This is the most flexible and effective geographical method (Hunter J., Cox M., 2007, Cheetham P. 2005). To detect the changes in the electrical properties below the surface this device uses electromagnetic energy in the form of high-frequency radio waves (Tim H., softdig.com).

Advantages: It helps to directly pinpoint the objects' locations or remains without giving any disturbances. While compared to the other methods, it is less expensive. It is accurate in detecting foreign components found on the ground. With the help of this survey method, it was made possible to measure the depth, dimensions and thickness of targets (Tim H., 2020, softdig.com). A large search area can be covered with quick data. The frequencies can also be regulated to deliver the requested amount of range of resolution and penetration depths (Tim H., 2020, softdig.com). While performing this survey, no digging, excavation, or any type of disturbance to the soil is needed. So, this method can be used on private properties which are properly cemented such as pavements or front yards of a house.

Limitations: It is highly conductive, as an error occurs when this method is performed on materials such as soil that are contaminated with salt or clayey areas. It can be used in water with salinity above a few ppm. If the depth increases, it will be much more difficult to determine the resolution. The coverage speed of this device is really slow also an experienced operator is required. Besides this, the ground must be really smooth, open and relatively levelled (Dupras T. L., Schultz J.J., Wheeler S.M., Williams L.J., 2012).

Electric resistivity meter

The electric current is passed through the earth's surface then the electrical properties of the subsurface are measured (Cox M., Hunter J., 2016). The electric current's conductivity will be higher in clay-rich soil when compared to dry soil or any other solid rock. A grave is detected by using this method when there are changes in the resistance to an electric current which is caused by the remains (Cox M., Hunter J., 2016). The variations in the electrical resistivity can also indicate the contamination

level, the composition and also the layer of thickness of the soil (Electrical Resistivity, Hager-Richter Geoscience INC,2022) (Anon., n.d.).

Advantages: It detects lateral and vertical changes simultaneously in the subsurface electrical properties (Electrical Resistivity, Hager-Richter Geoscience INC) (Anon., n.d.). It has the potential of detecting unstable ground and can also assist in the analysis of the stability of a dam. The resistor used here is cheap and can be replaced easily. Lastly, it does not depend on an external voltage (Resistors, physics-and-radio-electronics.com) (Anon., n.d.)

Limitations: This method cannot be used in highly industrialized or urban areas as the power lines or the structure of the buildings may interfere with getting accurate data. The high-resistance resistors will withstand a large amount of electric current. So, in the process, a large amount of energy is wasted. In addition, this device needs a ground disturbance to proceed (Dupras T. L., SchultzJ.J., Wheeler S.M., Williams L.J.,2012). The accuracy of the data becomes lesser when it comes in contact with the bedrock or soil mixed with rocks (Platts W. R., Olinepubs.trb.org) (Anon., n.d.)

Magnetometers (MAGs)

A magnetometer can detect two magnetic objects, which are permanent and temporary magnetism. Therefore, it is a device used to measure a magnetic field and it is non-invasive. It is used to detect foreign particles or abnormalities in the ground with the help of the soil's magnetic signal. If anything is found then a different type of signal would appear rather than the normal one ((L. Gutiérrez, J.M. de la Fuente, 2017, sciencedirect.com) Based on the magnetic properties, magnetometry can also provide the quantitative and selective determination of MNPs (magnetic nanoparticles) in cells or tissues (L. Gutiérrez, J.M. de la Fuente, 2017 sciencedirect). It is also stated that MAGs do not transmit any signal to the ground therefore a transmitter is not needed. Instead, a single or paired receiver is needed to help detect the burials' magnetic field (Dupras T. L., SchultzJ.J., Wheeler S.M., Williams L.J.,2012). The Magnetometer used in the search for a possible clandestine burial is based on Faraday's law of induction (youngwonks) (Anon., n.d.). A magnetic core would be wrapped around by a copper coil and the core will be magnetized with the magnetic field lines which are produced inside

the core (youngwonks) (Anon., n.d.). Then, the magnetic field fluctuations will bring about the flow of the electric currents.

Advantages: Magnetometer is mainly used for detecting weapons as they have magnetic properties. It is quite helpful in locating a grave if the remains have been cremated (Dupras T. L., SchultzJ.J., Wheeler S.M., Williams L.J.,2012). It can be applied in marine environments. A MAG with a strong magnetic power can provide a search of a given area in a clandestine burial.

Limitations: It is also sensitive to the environment as sometimes the magnetic properties got mixed up with the objects found. The information obtained through this is not quite accurate. The low voltage and low electric current can create disturbance in acquiring an accurate result (Advantages of magnetometer sensor, rfwireless-world.com, 2012) (Anon., n.d.). A strong magnetic field will disrupt the sensor of a magnetometer. In addition, using this device for underwater searches is hard.

Electromagnetic Induction meters

It is a way of creating electromagnetic force (EMF) by way of a moving magnetic field around an electric conductor and, conversely, the creation of current by moving electrical conduct through a static magnetic field (Electromagnetic induction, techtarget.com) (Anon., n.d.). These are more commonly known as EM conductivity meters. These devices contain a transmitter and a receiver with these it is used to measure the differences in electric conductivity of the ground (Dupras T.L., Schultz J.J., Wheeler S.M., Williams L.J.,2012).

Advantages: The units of EM induction methods do not have to touch the ground surface (Davenport, 2001; Reynolds, 1997). This method can also detect all metallic substances that are in the burial sites. Therefore, this method is much more suitable for detecting deep metallic burial sites. However, this method can be used over wooden areas (Dupras T.L., Schultz J.J., Wheeler S.M., William sL.J.,2012). This method needs no power supply, is inexpensive and also tends to cling to vertical surfaces.

Limitations: The measurement that is produced by an EM induction meter are only averages of ground conductivities within the depth range. Certain geological features that have high conductivities, such as clayey soils, may quickly dissipate the EM fields and not permit signal penetrations. It has no control

over the magnetic field surface and also the magnetic particles are attached to the poles (Permanent magnet or magnetic particles, twi-global) (Anon., n.d.).

Magnetic locators

It is only used to find or detect particles that contain ferreous. It can cover a wide range of borders. In addition, this device is very sensitive. Therefore, it can only detect iron and steel. This device operates in a similar way to a magnetometer. Instead, it operates using the earth's magnetic field. The magnetic field is measured with the distortion that surrounds a buried metal target (advantages and disadvantages of metal detectors, pti-world.com) (Anon., n.d.).

Advantages: This device is easier to store. And when compared with the MAGs the magnetic locators used are less expensive. In addition, the process of using this device is very simple to handle. It is really sensitive to metals and is more functional at a very wide range. For professional work, it is the perfect device for locating metals. This device can also work in the snow and even in deep water bodies.

Limitations: It is costlier than metal detectors and less easy to store. A professionally trained person is needed to handle this said device. In addition, this device can only detect ferrous materials (engineersuplly.com) (Anon., n.d.).

Metal Detectors

These are one of the most common tools of the geophysical survey as they are less expensive and much easier to use (Dupras T.L., Schultz J.J., Wheeler S.M., William sL.J.,2012). In short, it is a device that is used to detect metallic particles that are in the soil or any water bodies. This device can commonly detect metals up to 10-20cm, however, in special cases like ideal places or more advanced detectors can detect metals up to 30-45cm or up to 2000cm/20m (Gary I., metrometaldetectors.com). This device uses a quite simple process, that is the principle of electromagnetic inductions to detect metallic objects (pti-world.com) (Anon., n.d.).

Advantages: It makes a sound when metal is detected. Batteries are used instead of electrical sources for working also it has removable and adjustable rods (Metal locators vs metal detectors,

engineersupply.com) (Anon., n.d.). This device can work in any type of soil and it is very versatile. In addition, this device can be used by anyone. Since it is easy to carry around, the search process can get much quicker with just a walk-through around the possible burials (Metal detectors, pti-world.com) (Anon., n.d.). It is really an affordable device.

Limitations: It can only locate metals so no other objects cannot be detected using this device. While conducting surveys around a search area, causes privacy concerns. As people passing through it find this process uncomfortable (Metal detectors, pti-world.com) (Anon., n.d.). Due to the electromagnetic fields created by the metal detectors, can cause tampering with any other electronic devices around them. Furthermore, a false alarm might ring if a person passes by the area where this device is working due to the ornaments or jewellery he or she is wearing.

Side-scan sonar

It is a tool used in marine and the sound waves are used to produce a detailed graphic image of the seafloor surface, riverbed or lake bottom (Dupras T.L., Schultz J.J., Wheeler S.M., Williams L.J.,2012). The system also includes a data collection control, a torpedo-shaped towfish, a power supply and a tow cable. A GPS is needed to establish the search area. This device will be planted in the bed of the water bodies and the sonar pulse will be used to detect foreign particles (Dupras T.L., Schultz J.J., Wheeler S.M., Williams L.J.,2012).

Advantages: It is an important tool in conducting the underwater search. One of the major advantages of this device is that it can be used both in freshwater as well as saltwater bodies. But then it is also not affected by the muddy water or dirty water, it will always provide the best result.

Limitations: However, this device cannot detect the objects that are buried underneath the ocean floor or sea floor. And the rocky or irregular underwater surfaces make it difficult to interpret the sonar returns (Dupras T.L., Schultz J.J., Wheeler S.M., Williams L.J.,2012).

Seismic methods or techniques

It provides the most basic geographical data with the help of some common types of equipment as well as some simple procedures. In addition, it is a perfect device for detecting the large-scale and

small-scale features of the topography (rearchgate.com) (Anon., n.d.). The most important and initial process is to collect data on the surroundings (Mondol, Nazmul & Bjørlykke, Knut.,2010). It also produces controlled seismic energy which is further used to perform both refraction and reflection surveys (Awuha W., George A. M., Kur A., Joseph L. T., 2020). On the other hand, it also detects the changes in the subsurface changes in the mechanical properties (Tim H.,2020, softdig.com).

Advantages: This method can be widely used under a water body. It helps in mapping the horizons and the layers with each slot. It can also produce a detailed image of the structure or image present on the subsurface.

Limitations: The refraction and reflection perform here are not easy tasks, so errors in the refraction can conclude that it is due to incorrect data. It has a difficulty in quantitative interpretations in most cases(archive.epa.gov) (Anon., n.d.). It is not an effective device for detecting or characterizing vertical structures (Tim H., 2020, softdig.com). Furthermore, the amount of data produced by this method might become enormous making it difficult to handle or conclude the search.

CONCLUSIONS:

In the above essay, different types of geophysical survey methods are highlighted with their advantages and disadvantages. It is also clear that different types of devices are being used in the search for clandestine burials. However, the methods or devices used depend a lot on the topographical region of the area. But then GPR is one of the famous and most commonly used devices in a search for clandestine burials. Additionally, metal detectors and metal locators are devices that are widely used as it is easy to follow and the task gets completed in a short duration.

Also, methods such as side-scan sonar are particularly used for searches in underwater bodies.

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