APPLICATION OF ENVIRONMENTAL AND CRIMINAL GEOFORENSICS TO DETERMINE THE PRESENCE OF UNMARKED GRAVES IN A TYPICAL CEMETERY IN BENIN CITY, SOUTH SOUTH NIGERIA.

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Geoforensics is the application of geophysical techniques to criminal investigations. Forensic geologists/geophysicists may assist the police in some types of crimes to help determine what happened, where and when it occurred, or to help search for homicide graves or other objects buried in the ground.
In the cemetery under investigation, nine (9) soil samples were collected from points randomly, far away from marked graves and these points were labelled as S1, S2, S3,…S9. These soil samples were then analysed in a laboratory to observe possible presence of some heavy metals which is indicative of the presence of dead bodies in areas not marked for burial with stone walls erected. The samples when analysed using Atomic Absorption Spectrophotometer (AAS) showed increased values of heavy metals like manganese Mn, iron Fe, zinc Zn, copper Cu, chromium Cr and lead Pb. Also there was an increase in Electrical Conductivity, EC and Total Dissolved Solid (TDS).
Very Low Frequency-Electromagnetic (VLF-EM) survey was done within the nine (9) points were soil samples were collected. Specifically, sixteen (16) VLF profiles were carried out which showed very high conductivity on both real and imaginary raw/filtered values confirmatory of the presence of heavy metals in the soil samples collected at these points. The combined use of both physicochemical and VLF-EM surveys otherwise known as Environmental and Criminal Geoforensics successfully revealed the presence of indiscriminate burial activities in this cemetery located in Benin City, South South, Nigeria.

Key words: geoforensics, heavy metals, physicochemical, conductivity.

INTRODUCTION

Geoforensics involves the collection, analysis, interpretation, presentation and explanation of geological evidence. Geological trace evidence can vary considerably and may include for example; rock fragments, soils and sediments, which occur naturally in the ground, artificial (anthropogenic) man-made materials derived from geological raw materials (such as bricks, concrete, glass or plaster board), or micro-fossils. These may be transferred onto the body, person or the clothing of a victim or offender. The huge variability of rocks and soils, is helpful

in potentially placing an offender or item at a particular location (Harrison and Donnelly, 2009).
Some geological techniques may be used to help the police search for (sometimes the recovery of) objects buried in the ground, including for example, homicide graves, mass graves related to genocide, weapons, firearms, improvised devises, explosives, drugs, stolen items, money, coinage and jewelry.

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These searches may take place in urban, rural and remote locations, in both the terrestrial (land) and marine environments.
A search is the application and management of systematic procedures, combined with appropriate detection equipment to locate specified targets (or objects). It is the skill of looking for a specific object and the art of finding it.
A search may be conducted to:-
(a) Obtain evidence for prosecution. (b) Gain intelligence. (c) Deprive criminals of their resources and opportunities. (d) Locate vulnerable persons. (e) Protect potential targets. (f) Search for homicide graves and associated buried items or objects.

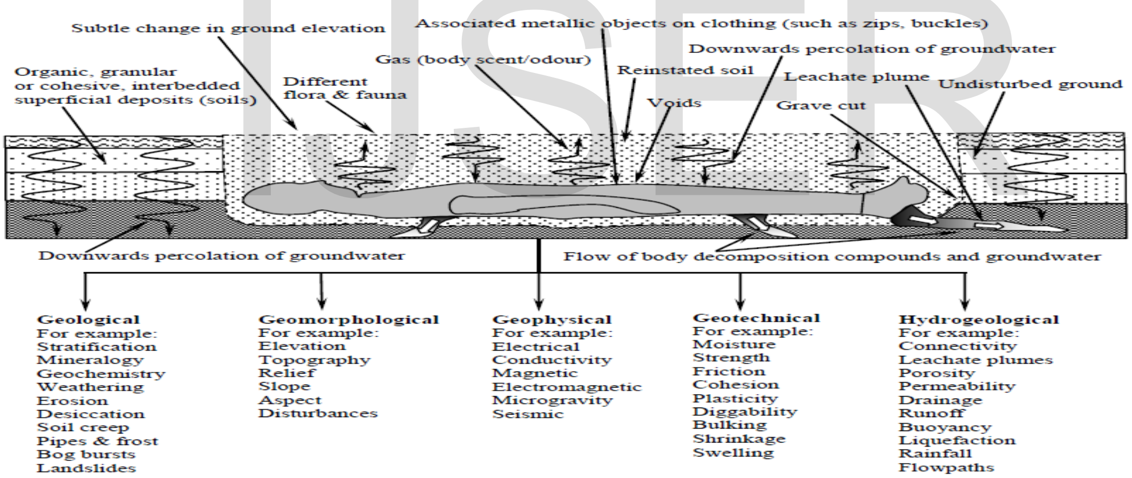

Figure 1 An idealized conceptual geological model for a shallow homicide grave. The geological, geomorphological, geophysical, geotechnical and hydrogeology properties of the body, reinstated ground and undisturbed ground may change after burial. This type of model may assist in determining the most suitable suite of assets for conducting a search. This may include for example the deployment of geophysical surveys and specially trained cadaver dogs. Harrison and Donnelly, 2009.

Many sub-disciplines within the Earth Sciences make use of either geophysical instruments to investigate the subsurface environment or use analytical methods to determine the origin, or provenance, of geological materials. These same instruments and analytical methods can be used either directly, or adapted to suit, the acquisition of data that pertain to a wide range of forensic science investigations. Such approaches are generally not new but, in recent years, there has been a significant resurgence globally in the application of geological and geophysical methods to aid forensic investigations. Traditionally, such methods were used in forensic investigations related to serious criminal cases such as terrorism, murder, abduction and serious sexual assaults, and to a lesser extent in the investigation of cases of fraud and theft. But with increasing concern into the environmental impact of human activity, with the release of contaminants into the atmosphere, hydrosphere and lithosphere, and their potential uptake into the biosphere, there has been an increased amount of environmental legislation. In turn, there has commonly been an increase in the costs associated with the legal discharge or disposal of wastes. Consequently, it is unsurprising that the illegal discharge and disposal of wastes has also increased. Identifying the distribution, impact and source of such waste materials can, in part, be addressed through the application of geological techniques, in much the same way as used traditionally, for example, in the investigation of murder cases. The diversification of the use of geological techniques into the investigation of environmental crime will, potentially, significantly increase the range of investigations in which geophysicists may be asked to assist but will also lead to a new array of research questions to be addressed.

Decomposition commences almost immediately after death and is characterized by spontaneous postmortem changes. Soft tissue that has not been naturally or artificially preserved is subject to the postmortem processes of autolysis and putrefaction (Dent, 2002).

Following putrefaction, the decomposition process continues through liquefaction and disintegration, leaving skeletonised remains articulated by ligaments. Skeletonisation proceeds until eventually only the harder resistant tissues of bone, teeth and cartilage remain. These remains are then subjected to inorganic chemical weathering.

Putrefaction is characterized by the breakdown of soft tissue and alteration of the protein, carbohydrate and fat constituents. Van Haaren (1951) indicated that the body composition is approximately 64% water, 20% protein, 10% fat, 1% carbohydrate and 5% minerals. The breakdown is due to the action of many enzymes that are already present in the tissues, or are otherwise derived from micro-organisms and fungi (Evans, 1963).

A more succinct understanding of the body's chemistry is provided by Forbes (1987) who documented the approximate elemental composition of the human. Forbes' data are for the representative lean male of 70kg mass. It needs to be borne in mind that females have a lower body mass typically 2/3 - 3/4 of that of the male. The exact water content is not quantifiable and is regarded as about 70 - 74% of body mass (Forbes, 1987). The results are summarised in Table 1.

Table 1. Summary of Elemental Composition of Representative Lean Male (70kg) (Forbes, 1987)

Element	Amount (g)	Element	Amount (g)
Oxygen	43000	Fluorine	2.6
Carbon	16000	Zinc	2.3
Hydrogen	7000	Copper	0.07
Nitrogen	1800	Manganese	0.01
Calcium	1100	Strontium	0.32
Phosphorus	500	Bromine	0.2
Sulfur	140	Lead	0.12
Potassium	140	Aluminium	0.06
Sodium	100	Cadmium	0.05
Chlorine	95	Boron	<0.05
Magnesium	19	Nickel	0.01
Silicon	18	Molybdenum	<0.01
Iron	4.2	Chromium	<0.002

The nature of the trace elements is a matter of considerable study and interest because of their role in bodily disorders. They are, however, also difficult to quantify. Moynahan (1979) pointed out that different researchers have denoted the same elements variously as trace, major, essential and/or toxic, or even as a vitamin, so that, irrespective of the ability to chemically analyse the element of interest - mainly metals, they must be simply demarcated for the relevant context. Tables 2 to 4 summarize some relevant data from various sources.

Table 2 Other Elements in Human Composition (1, 2. Keeley et al, 1977; 3, 4. Waldron, 1987)

Iodine	0.011 g in adult (1)
Cobalt	0.0015 g in adult (1)
Selenium	ca 125 µg/L in blood (2)
Manganese	13.4-13.9 ppm in bone (3)
Copper	20 - 26.0 ppm in bone (3)
Cadmium, Mercury, Arsenic	<1µg/g of bone (4)

Table 3 Typical Components of fresh Bone (Goffer, 1980)

Component	Weight %	Component	Weight %
Calcium	20 - 22	Nitrogen	6
Phosphorus	10	Iron	traces
Fat	10	Fluorine	traces
Water	10	Lead	traces *

* Lead is a bone-seeking element; about 90% of the body's total lead burden is found in the skeleton (Waldron, 1987)

Table 4 Indicative Trace Compounds of Some Human Fluids

A. Median Reference and European Values (Minoia et al, 1990)

Concentration in µg/L

Element	Urine	Blood	Serum
As	16.7-20	5-7.9	3.5
Cd	0.8-0.86	0.6-1	~0.1-0.2
Cr	0.4-0.61	0.23-2.8	0.17-0.19
Co	0.57(1)	0.39-20	0.21-0.29
Cu	23-38	960-1225	987-1100
Pb	11-17	123-157.7	0.3-<1
Mn	0.6-1.2	8.8-13.6	0.6-0.63
Hg	3.5-4.3	5.3-9.5	2.1-5.8
Ni	0.9-2.5	2.3	1.2-7.5
Se	22.1-40	105-107.5	81-96
Zn	449-456	6340-6400	922-930

(1) where there is only one value comparative data were not available.

B. Data for selenium in similar tissues (Aaseth and Thomassen, 1988)

Selenium - Concentration in µg/L

Group studied	Blood	Serum
All except China (2)	60-200	50-150
China	20-3200	10+
Australia	150	85
New Zealand	60	50

(2) different population groups in China have been treated with Selenium enhanced diets (Moynahan, 1979)

C. Representation compositions of faeces and urine (Polprasert, 1989)

	Faeces	Urine
Quantity (wet) per person per day	100 – 400 g	1.0 – 1.31 kg
Quantity (dry solids) per person per day	30 – 60 g	50 – 70 g
Moisture content	70 – 85 %	93 – 96 %
Approx. composition (dry weight percent)	**%**	**%**
organic matter	88 – 97	65 – 85
Nitrogen (as N)	5.0 – 7.0	15 - 19
Phosphorus (as P_2O_5)	3.0 – 5.4	2.5 – 5.0
Potassium (as K_2O)	1.0 – 2.5	3.0 – 4.5
Carbon (C)	44 - 55	11 - 17
Calcium (as CaO)	4.5	4.5 – 6.0
C/N ratio	~6 - 10	1
BOD5 content per person per day	15 – 20 g	10 g

* adapted from 1956 and 1983 studies of some European and USA cities.

Whilst the data in Tables 2 to 4 are all very useful for understanding the nature of the chemistry of interred remains, and can certainly be used for broad scale work in terms of elemental loadings of a cemetery, it must be remembered that it would be incorrect to slavishly apply any of the data to any one investigation or site. The nature of the human, their environmental associations and lifetime exposures to various chemicals will influence their composition, as will also gender, genetic and cultural matters. For example, the general anatomical or fluid-metabolic models basically relied upon here are not commonly used in human composition research (Heymsfield and Waki, 1991; Heymsfield and Yasumura, 1993).

Furthermore, in any attempt to explain cemetery loadings for any element, the ratio of females to males, children to adults, and typical body weights of remains for cultural groupings also need to be considered. The data of Tables 2 to 4 also suggest that the averages for some elements may be attended by wide variances.

EXPERIMENT

The investigation commenced by collecting samples from drilled holes using an auger to a depth of 5 feet (1.524m) at nine (9) randomly selected points and the soil samples placed in well labeled polythene bags and the coordinates of the points from where the soil samples were collected (denoted as S1, S2, S3,…S9) recorded using a Global Positioning System (GPS) device. Also recorded with the GPS are the boundaries of the cemeteries represented by A, B, C and D. the samples were taken to the laboratory to check the values of heavy metals and other analytes.

The values obtained from the physicochemical analysis were indicative of the presence of buried corpses as most of the heavy metals and also Electrical conductivity had high values compared to control values. To confirm positions of unmarked burial, including presence of mass graves, VLF-EM, using ABEM WADI with other accessories was done. At positions were soil samples were collected and analyzed, real and imaginary values gave very high peaks indicative of the presence of dead bodies. Specifically at S2, the peaks were very high and also broad which signifies point of mass burial.

THEORY

Electromagnetic methods use the response of the ground for the propagation of incident alternating electromagnetic waves which are made up of two orthogonal vector components, an electric intensity (E) and a magnetising force (H) (Figure 2), in a plane perpendicular to the direction of travel. An electromagnetic field can be generated by passing an alternating current through either a small coil comprising many turns of wire or a large loop of wire.

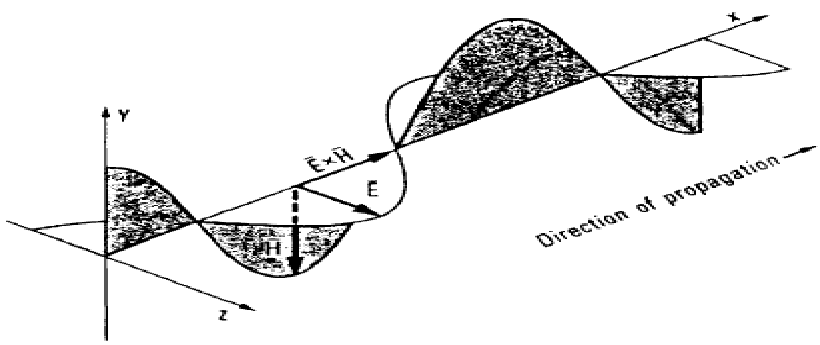

Figure 2 Basic elements of an electromagnetic wave, showing the two principal electric (E) and magnetic (H) components (Beck, 1981).

For geophysical applications, frequencies of the primary alternating field are usually less than a few thousand hertz. The wavelength of the primary wave is of the order of 10-100 km while the typical source-receiver separation is much smaller ($\approx 4 - 100\, m$). Consequently, the propagation of the primary wave and associated wave attenuation can be disregarded (Figure 3)

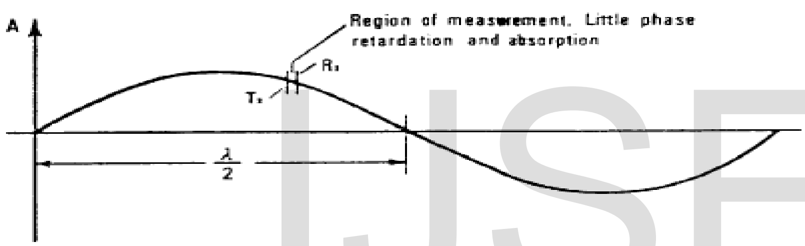

Figure 3 The physical separation of a transmitter (T_x) and receiver (R_x) is very small in relation to the wavelength of EM waves with frequencies greater than 3 kHz. Consequently, attenuation due to wave propagation can be ignored (Beck, 1981).

In general, a transmitter coil is used to generate the primary electromagnetic field which propagates above and below ground. When the EM radiation travels through subsurface media it is modified slightly relative to that which travels through air. If a conductive medium is present within the ground, the magnetic component of the incident EM wave induces eddy currents (alternating currents) within the conductor. These eddy currents then generate their own secondary EM field which is detected by a receiver (Figure 4). The receiver also detects the primary field which travels through the air, so the overall response of the receiver is the combined (resultant) effect of both the primary and secondary fields. Consequently, the measured response will differ in both phase and amplitude relative to the unmodulated primary field. The degree to which these components differ reveals important information about the geometry, size and electrical properties of any sub-surface conductor.

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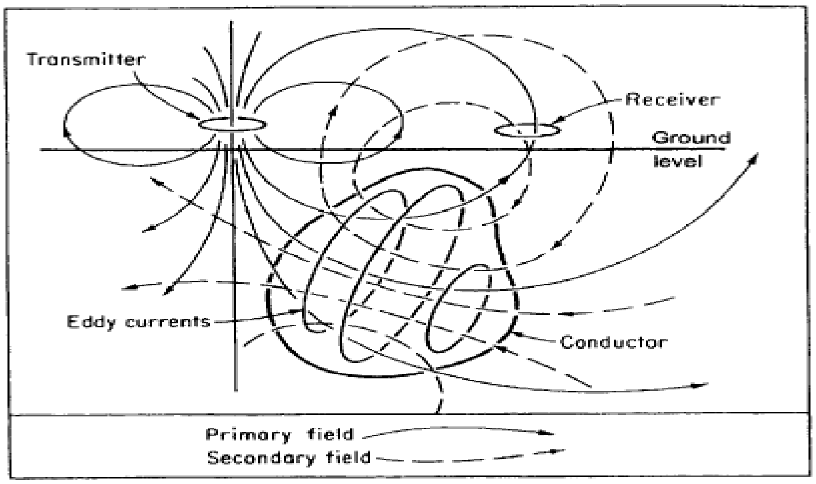

Figure 4 Generalized schematic of the EM surveying method (Grant and West, 1965)

It is useful to regard the ground under investigation as comprising three components; inductive (L), resistive (R) and capacitive (C) with the electrical circuit equivalent shown in Figure 5.

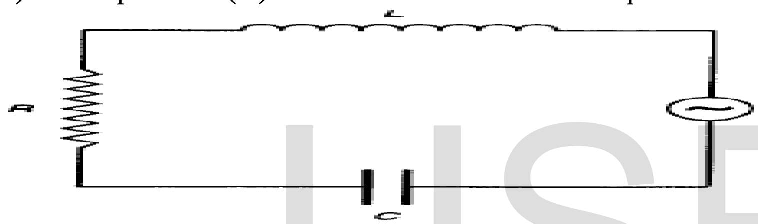

Figure 5 Basic electrical circuit containing capacitance (C), inductance (L) and resistance (R), the three electrical components that describe the equivalent behaviour of the ground.

The amplitude (E) of an alternating voltage is given by

$$E = E_O \, Sin \, \omega t \quad (1)$$

The current (I) within the equivalent circuit (Figure 1.8) is described by

$$I = E_o \, \{[\, \omega L - (1/\omega C)]^2 \, + \, R^2\}^{\,-1/2} \, Sin \, (\omega t - \alpha) \quad (2)$$

Where $\alpha = tan^{-1} \, [\omega L - (1/\omega C)]/R$ (3)

L is the inductance, C the capacitance and R the resistance.

Of prime importance in EM surveying is the consideration of the depth of penetration of the EM radiation and the resolution as a function of depth. In an isotropic resistive medium, EM waves would travel virtually indefinitely. However, in the real world, where surface conductivities are significant, the depth of penetration is often very limited. The depth of penetration is largely a function of frequency and the conductivity of the media present through which the EM radiation is to travel. At the frequencies ($< 5kHz$) used in EM exploration (excluding ground penetrating radar) attenuation effects are virtually negligible, but signal losses occur by diffusion.

A common guide to the depth of penetration is known as the skin depth, which is defined (Sheriff, 1991) as the depth at which the amplitude of a plane wave has decreased to $1/e$ or 37% relative to its initial amplitude A_0. The amplitude of EM radiation as a function of depth (z) relative to its original amplitude A_0 is given by

$$A_z = A_0 e^{-1} \quad (4)$$

The skin depth δ (in metres) is given by

$$\delta = (2/\omega\sigma\mu)^{1/2} = 503((f\sigma)^{1/2} \quad (5)$$

where $\omega = 2\pi f, and\ f$ is the frequency in Hz, σ is the conductivity in S/m, and μ is the magnetic permeability (usually ≈ 1). A realistic estimate of the depth to which a conductor would give rise to a detectable EM anomaly is ≈ $\delta/5$.

Given a known frequency for a particular equipment system, the unknown is the vertical variation of conductivity with depth. Different instrument manufacturers commonly cite effective depths of penetration for their instruments. For example, Geonics Ltd give the depth of penetration of their FEM systems (EM38/EM31/EM34) as a function of the inter-soil separation.

RESULTS AND DISCUSSION

Soil samples were analyzed and the results presented in Table 5. A total of twenty-two analytes were investigated with the pH in the cemetery showing mainly acidity while control for the nine (9) cases were slightly alkaline. It is noted that the following parameters-EC, TDS Calcium, Magnesium, Ammonium-Nitrogen, Chloride, Iron, Chromium, Manganese, Lead, Cadmium, Nickel, Phosphate, Nitrate and Sulphate had high values which can be traced to the migration of metals to a depth below 4 feet (depth of burial). Other parameters showed varying amount.

Table 5 Analysis of soil sample inside the cemetery in Benin City and comparison with a control outside the Cemetery

Analyte	Standard Method	Cemetery under investigation									
		Control	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
pH	ASTM D 1293B-95	**6.4**	3.7	3.5	4.1	3.2	3.6	5.5	5.4	3.6	4.0
Temp (^{0}C)	EPA 79	**28.3**	27.5	27.4	26.1	28.8	47.4	17.6	28.0	25.5	26.2
EC (µS/cm)	ASTM D1125-95	**25**	10	165	87	54	98	187	43	51	112
TDS (mg/l)	ASTM D1868	**11.5**	5.0	82.5	10.2	23.5	6.6	99.8	24.0	20.7	53.1
Ca (mg/l)	ASTM D1126-96B	**641.2**	208.4	1494	1054	342	695	390.8	481.9	720.5	1088
Mg (mg/l)	ASTM D1126-96B	**175**	1035	1023	947	602	280	768	1160	1263	806
Na (mg/l)	ASTM D2791-92A	**450**	20	330	310	257	36	93	60	81	270
k (mg/l)	ASTM D2791-93	**585**	26.0	429	29.0	50.8	92	87	300.7	420	260
NH_4-N (mg/l)	ASTM D1426-93	**3.17**	34.03	27.41	7.52	21.95	10.53	29.42	30.15	31.94	43.60
Alkalinity (mg/l)	ASTM D1067-92	**336**	91.5	122	291	95.5	97	105	99.6	105.7	121.5
Chloride (mg/l)	ASTM D1067-92	**183.6**	207.1	118.3	349.8	120.8	250.5	120	189	122.7	157.3
Iron (mg/l)	ASTM D1068-96	**13.4**	31.8	15.2	20.6	21.5	22.4	16.7	29.6	27.2	33.5
Zinc (mg/l)	ASTM D1691-95	**6.2**	10.2	8.7	12.9	9.6	9.4	9.2	8.5	8.3	9.1
Copper (mg/l)	ASTM D1688-95	**1.5**	9.5	7.7	9.8	10.5	9.9	11.6	3.7	8.1	12.3
Chromium (mg/l)	ASTM D1687-92	**0.41**	0.74	0.28	0.29	0.55	0.82	0.65	0.79	0.38	0.73
Manganese (mg/l)	ASTM D858-95	**1.9**	3.52	12.66	4.34	6.22	3.08	8.51	16.64	2.88	10.21
Lead (mg/l)	ASTM D3559-96	**1.37**	3.99	2.95	2.13	5.09	1.52	4.11	0.87	2.05	2.68
Cadmium (mg/l)	ASTM D3557-95	**0.23**	0.23	0.68	0.22	0.50	0.41	0.46	0.72	0.35	0.64
Nickel (mg/l)	ASTM D95	**<0.05**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phosphate (mg/l)	ASTM D515-88	**17.8**	32.8	24.2	43.7	14.9	28.3	15.5	20.4	33.0	31.1
Nitrate (mg/l)	ASTM D3889-90	**<0.001**	0.5	7.68							

					4.4	3.96	0.8	0.72	2.6	6.72	5.09
Sulphate (mg/l)	ASTM D1688-95	**0.72**	15.71	2.6	3.53	15.21	10.05	4.25	11.37	12.65	8.14

The result of soil test showed increased values of heavy metals and also an increase in the conductivity of areas described as free of burial activities by those in charge of watching over the place to prevent indiscriminate disposal of corpse. For further confirmation of this suspicion of indiscriminate burial and mass graves, VLF-EM was carried out.

Geoforensic evaluation for this research work was done using Very Low Frequency (VLF) EM method to locate buried conductive materials.

The survey profiles for VLF-EM are enclosed in an area which lies between longitude 5.60825^{o}E to 5.60960^{o}E and latitude 6.34154^{o}N to 6.34019^{o}N. The study area covers 150m by 150m which is 22.5 square kilometers.

At the start of the survey, measuring reference station location was decided. The compass was used to determine the geographic East -West direction, and survey profiles were tagged and oriented in that direction. For each profile, the operator stood at the predetermined measuring station starting from number zero and the displayed raw real value measured was noted while the filtered real, raw imaginary and filtered imaginary values were stored in the memory of the instrument. After completing the first profile, measurement then proceeded East-West for the other profiles. Having measured the 16 profiles, 4 profiles were selected as highly conductive and only these values displayed (see tables 6 to 9).

Table 6 VLF Measurement for Line 2

Frequency (KHz)	**20.9**	**Station Interval (m)**	**5**	
Signal Strength	**16**			
Profile Number	**0002/000**	**LGA/State**	**Oredo/Edo**	
Survey Date	**13/06/2014**			
Measuring Station	**Raw Real**	**Filtered Real**	**Raw Imaginary**	**Filtered Imaginary**
0	**0.0**	**-1.6**	**-90.1**	**-7.6**
1	**-3.0**	**3.2**	**-72.6**	**-6.2**
2	**5.5**	**1.5**	**-82.1**	**-5.8**
3	**0.6**	**-13.0**	**-60.1**	**-14.0**
4	**-15.9**	**-2.0**	**-34.5**	**-1.8**
5	**10.0**	**10.1**	**-63.6**	**7.9**
6	**0.4**	**0.1**	**-67.6**	**2.9**
7	**2.4**	**0.9**	**-72.6**	**1.5**
8	**-2.3**	**0.8**	**-64.1**	**0.7**
9	**3.0**	**-0.8**	**-77.8**	**-1.1**
10	**-1.5**	**-9.8**	**-64.0**	**-8.9**
11	**-82**	**-0.6**	**-55.2**	**-14.1**
12	**-1.9**	**-3.2**	**-23.6**	**-15.4**
13	**-4.0**	**3.5**	**-14.4**	**-9.3**
14	**6.0**	**8.9**	**-3.3**	**-5.7**
15	**5.1**	**0.7**	**-4.1**	**-1.7**
16	**-3.3**	**-1.3**	**-3.6**	**-2.5**
17	**3.0**	**0.2**	**2.8**	**-1.4**
18	**-2.3**	**-3.9**	**-0.9**	**-0.8**
19	**-2.3**	**0.9**	**6.1**	**1.3**
20	**2.3**	**2.3**	**-5.2**	**3.3**

Table 7 VLF Measurement for Line 5

Frequency (KHz)	**20.9**	**Station Interval (m)**	**5**	
Signal Strength	16			
Profile Number	0005/000	LGA/State	Oredo/Edo	
Survey Date	13/06/2014			
Measuring Station	**Raw Real**	**Filtered Real**	**Raw Imaginary**	**Filtered Imaginary**
0	**0.0**	**-11.7**	**-83.6**	**4.6**
1	**-10.8**	**-16.8**	**-97.6**	**5.2**
2	**-6.5**	**-9.3**	**-99.9**	**1.7**
3	**-11.4**	**11.6**	**-99.9**	**0.8**

4	**23.8**	**7.5**	**-99.9**	**0.1**
5	**-10.6**	**-10.1**	**-99.9**	**-1.4**
6	**-4.5**	**-13.3**	**-99.9**	**-4.8**
7	**-13.7**	**-7.8**	**-80.9**	**0.8**
8	**2.7**	**1.7**	**-99.9**	**2.9**
9	**-0.2**	**-5.7**	**-99.9**	**-7.6**
10	**-4.1**	**-5.7**	**-74.3**	**-5.4**
11	**-3.4**	**-1.0**	**-78.5**	**0.3**
12	**1.7**	**-1.2**	**-86.6**	**-5.6**
13	**-2.3**	**-2.8**	**-62.7**	**-3.9**
14	**-1.2**	**1.2**	**-70.1**	**3.3**
15	**2.0**	**0.3**	**-78.9**	**-1.4**
16	**-0.6**	**-3.3**	**-71.1**	**-6.0**
17	**-0.3**	**-0.7**	**-57.1**	**-5.0**
18	**1.2**	**1.7**	**-58.6**	**-3.6**
19	**0.5**	**0.0**	**-47.2**	**-0.3**
20	**-0.2**	**-0.1**	**-61.5**	**3.8**

Table 8 VLF Measurement for Line 7

Frequency (KHz)	**20.9**	**Station Interval (m)**	**5**	
Signal Strength	**16**			
Profile Number	**0007/000**	**LGA/State**	**Oredo/Edo**	
Survey Date	**13/06/2014**			
Measuring Station	**Raw Real**	**Filtered Real**	**Raw Imaginary**	**Filtered Imaginary**
0	**0.0**	**-19.8**	**-75.5**	**7.8**
1	**-17.6**	**-27.7**	**-99.9**	**7.3**
2	**-12.7**	**-15.0**	**-99.9**	**-0.1**
3	**-9.9**	**-0.3**	**-92.8**	**0.8**
4	**10.1**	**-2.5**	**-99.9**	**0.3**
5	12.0	**-8.7**	**-94.0**	**-1.8**
6	4.6	**-5.2**	**-99.9**	**-5.4**
7	-12.6	**-4.8**	**-73.0**	**-2.3**
8	6.1	**4.5**	**-99.4**	**1.3**
9	0.0	**-8.1**	**-90.0**	**-10.2**
10	-6.4	**-8.2**	**-55.4**	**-2.9**
11	-4.3	**-1.7**	**-83.2**	**-0.7**
12	1.5	**-1.0**	**-62.7**	**-6.9**
13	-3.0	**0.8**	**-57.5**	**3.2**
14	2.9	**1.9**	**-74.9**	**0.6**
15	-0.7	**1.5**	**-66.9**	**-6.0**
16	-0.7	**0.3**	**-53.2**	**-4.4**
17	0.3	**1.5**	**-54.2**	**-3.4**
18	1.3	**0.6**	**-47.1**	**-1.4**
19	-0.5	**-1.0**	**-46.8**	**6.8**
20	-0.8	**-0.8**	**-69.8**	**7.0**

Table 9 VLF Measurement for Line 14

Frequency (KHz)	**20.9**	**Station Interval (m)**	**5**	
Signal Strength	**16**			
Profile Number	**00014/000**	**LGA/State**	**Oredo/Edo**	
Survey Date	**15/06/2014**			
Measuring Station	**Raw Real**	**Filtered Real**	**Raw Imaginary**	**Filtered Imaginary**
0	**0.0**	**-2.9**	**-1.6**	**1.6**
1	**-3.9**	**0.4**	**-7.1**	**0.8**
2	**3.7**	**1.6**	**-5.0**	**-1.5**
3	**-1.1**	**-3.2**	**-1.8**	**-1.5**
4	**-2.3**	**-0.2**	**0.7**	**-0.4**
5	**1.6**	**1.8**	**-2.7**	**-0.9**
6	**-2.1**	**8.2**	**0.9**	**-2.9**
7	**10.5**	**9.5**	**7.2**	**-1.0**
8	**1.0**	**1.1**	**4.2**	**0.8**
9	**1.3**	**1.7**	**2.0**	**0.9**
10	**0.5**	**-1.0**	**4.3**	**0.3**
11	**-1.4**	**-1.3**	**1.3**	**0.2**
12	**-0.2**	**-0.3**	**3.7**	**0.3**
13	**-0.4**	**-0.6**	**0.9**	**1.4**
14	**-0.4**	**-0.1**	**-1.1**	**0.4**
15	**-0.2**	**0.8**	**-0.2**	**-0.2**

16	**0.6**	**0.3**	**0.2**	**0.8**
17	**0.2**	**-0.8**	**-0.1**	**0.6**
18	**-1.3**	**0.2**	**-0.2**	**0.1**
19	**1.6**	**-0.3**	**-0.6**	**-0.1**
20	**-1.8**	**-1.8**	**0.1**	**-0.2**

For the cemetery under investigation, filtered real and filtered imaginary components were plotted together in one figure using VLF Curves Plotting Program developed in Matlab Graphical User Interface (MGUI) to facilitate geological interpretation.

The VLF-EM sections were plotted as Karous-Hjelt filtered real component (Karous and Hjelt, 1983) for the selected profiles on which conductive sections were noticed indicative of dead bodies underground using KHFFILT program. This process yields pseudosection of relative current density variation with depth.

The pseudo images (Figures 6 to 9) revealed a number of subsurface zones with positive filtered real component which signified potential subsurface features-geologic and artificial conductors. Some of the curves have very close filtered real positive peaks, suggesting that the tops of the anomalies are of close proximity, revealed as nearly combined peaks**.** Depth of dead bodies is shallower than bedrock structures; hence anomaly characterizing them could be narrow and sharp positive peaks (high amplitudes) in the filtered real and imaginary curves. These anomalous points were then identified and indicated by the symbol **ϕ** on the curves and in the Pseudo images (Figures 6 to 9) which were then used to estimate the anomalous depths and also to visualize the orientation and lateral extensions. Profile 2 showed the presence of anomaly that begins from a depth of 5 m to 15 m and is extended laterally from 20 m to about 33 m. Profile 5 showed the presence of anomaly that begins from a depth of 5 m to 15 m and is extended laterally from 35 m to about 53 m. Profile 7 showed the presence of anomaly that begins from a depth of 5 m to 15 m and is extended laterally from 38 m to about 53 m. Profile 14 showed the presence of anomaly that begins from a depth of 5 m to 7 m and is extended laterally from 45 m to about 46 m.

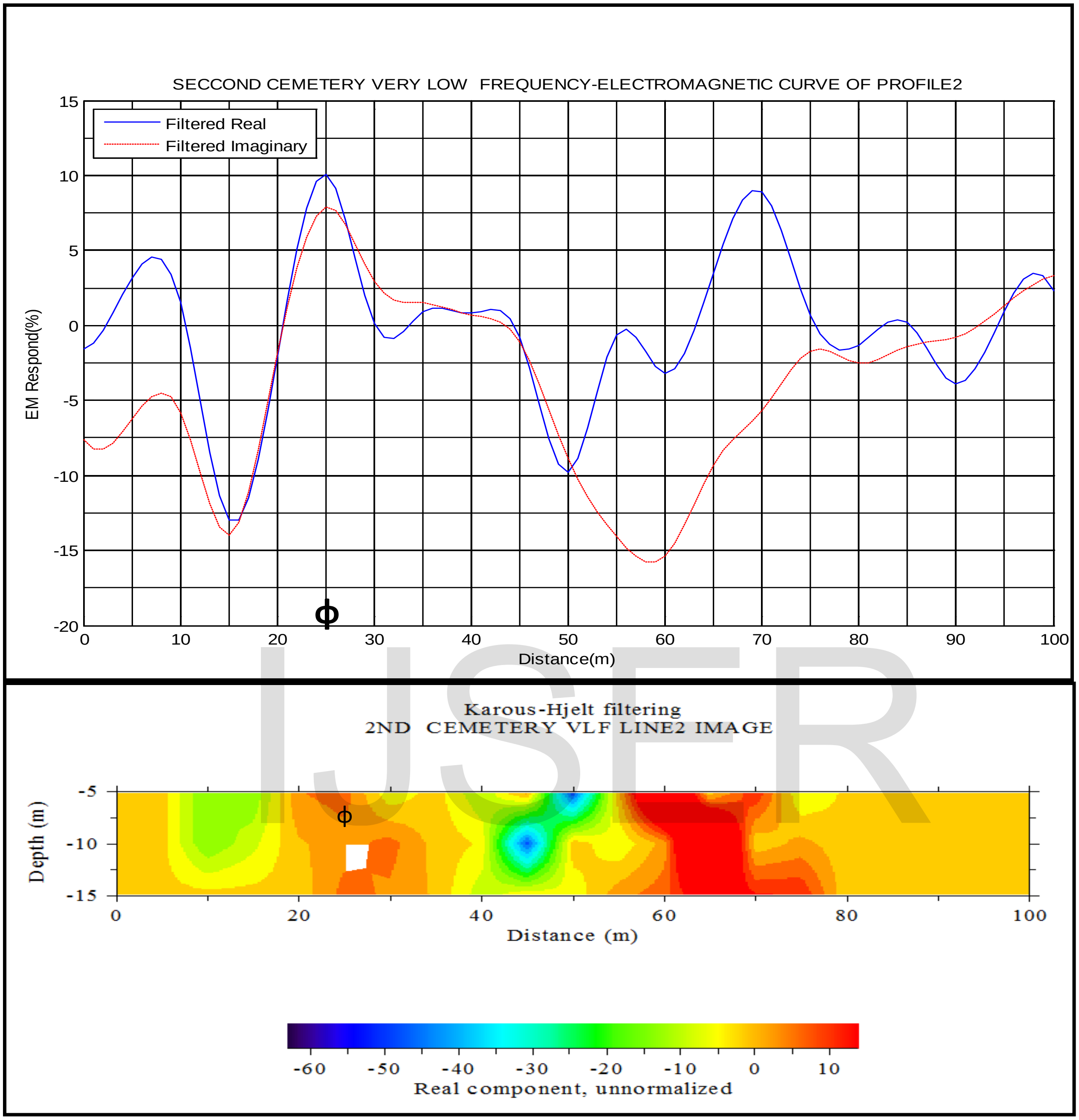

Figure 6 VLF Curve Interpretations for Profile 2

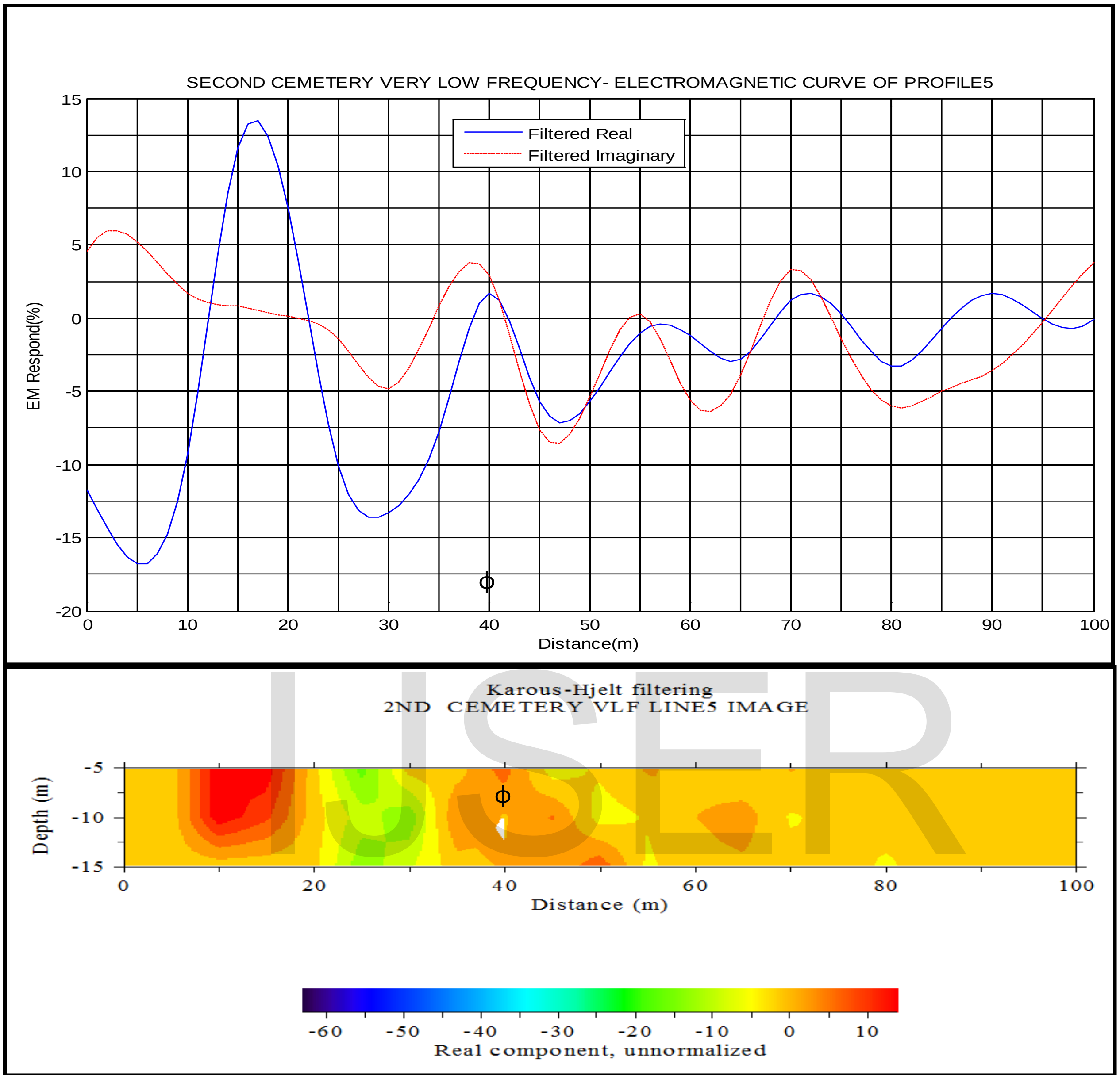

Figure 7 VLF Curve Interpretations for Profile 5

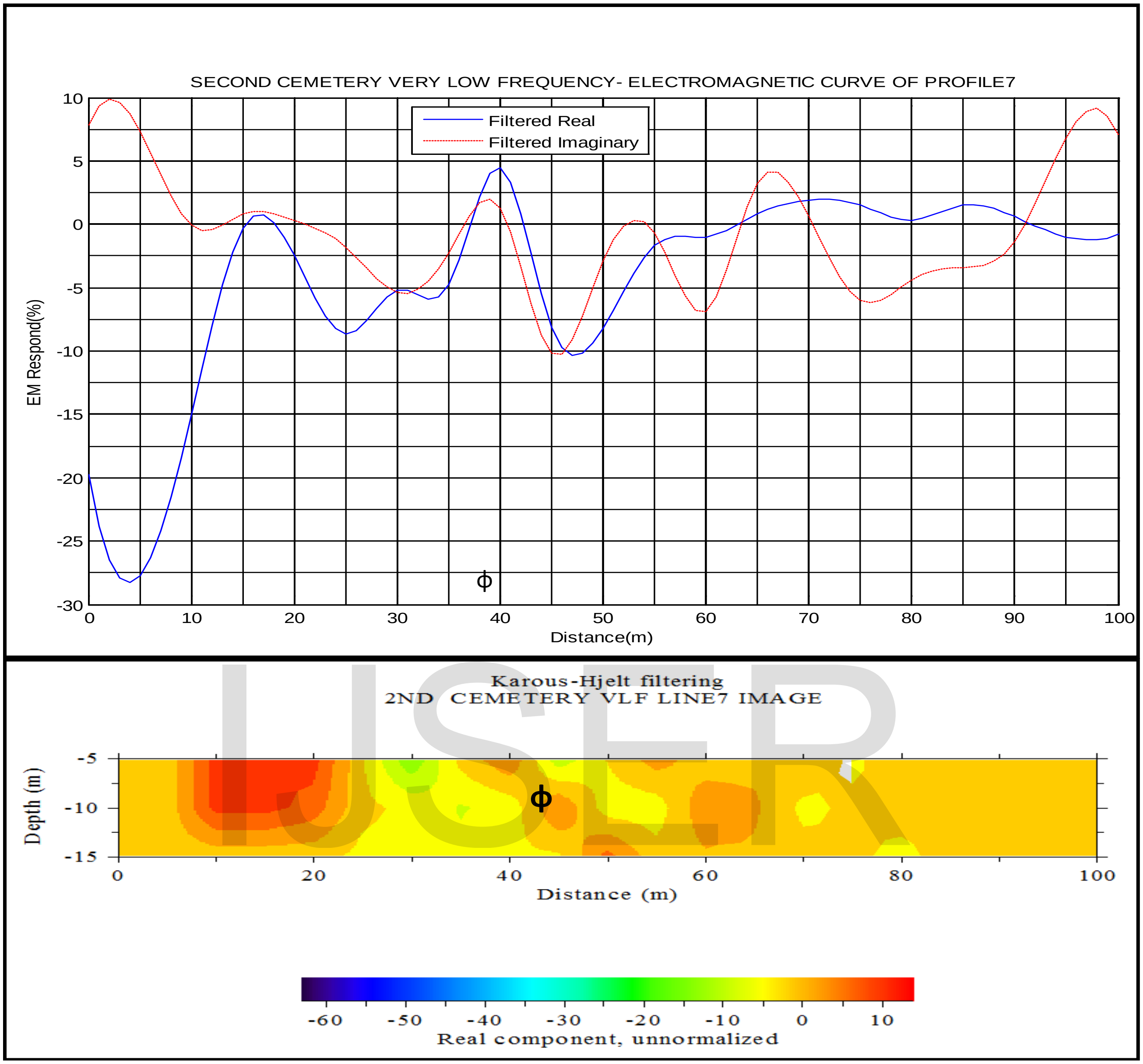

Figure 8 VLF Curve Interpretations for Profile 7

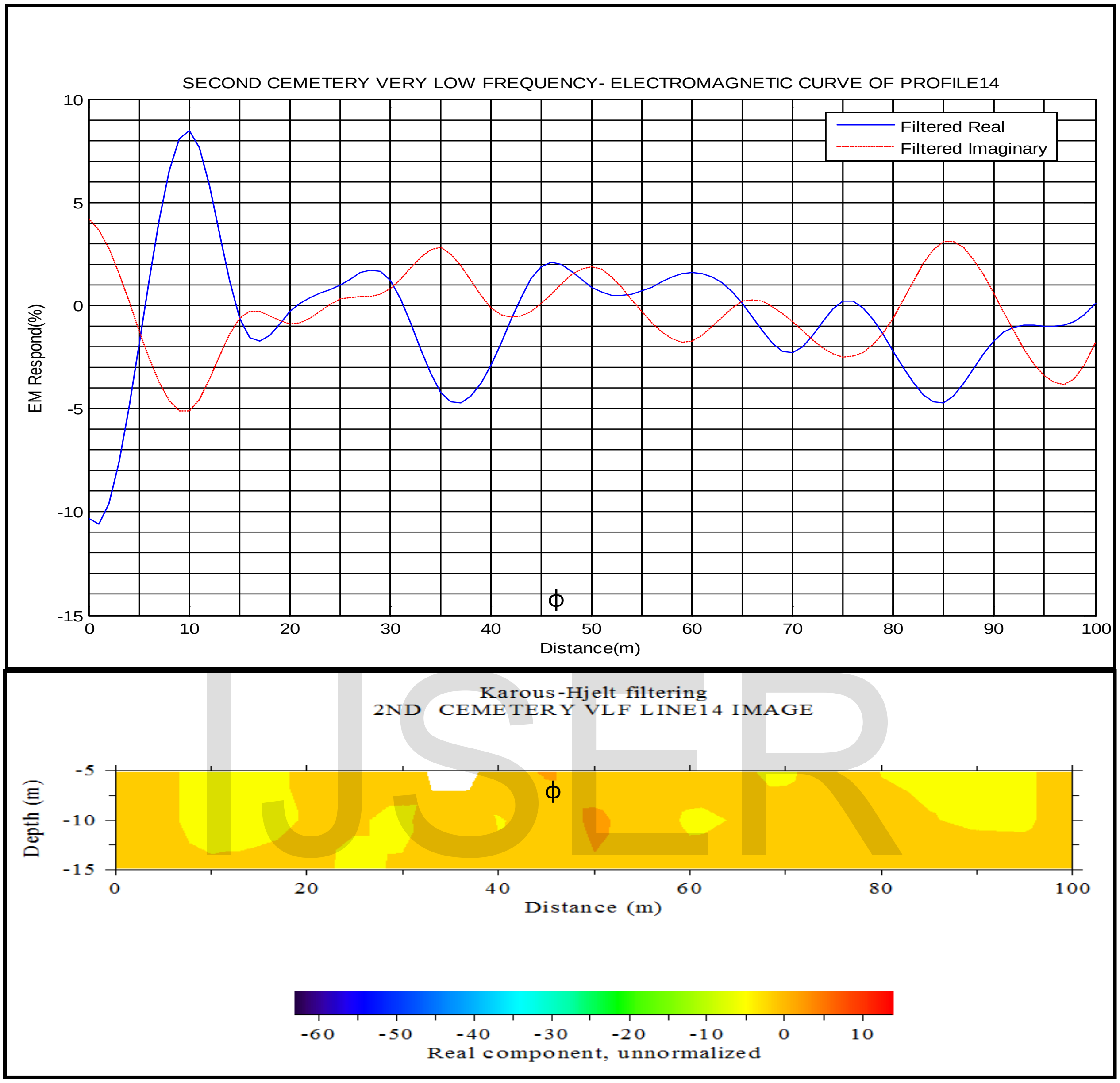

Figure 9 VLF Curve Interpretations for Profile 14

CONCLUSION

Environmental and criminal geoforensics has successfully revealed the activities of some government officials that work in cemetery as they indiscriminately burial corpses in the cemetery. The combination of physicochemical and electromagnetic methods carefully performed in this manner can be extended to other cemeteries in cities all over the world as this will prevent risk of environmental pollution as cemetery can become major source of environmental pollution.
Other methods for geophysical exploration like Ground Penetrating Radar (GPR) and Electrical Resistivity Tomography (ERT) can also be used in combination with soil test and Very Low Frequency-Electromagnetic Method as a Joint geophysical method to validate the results obtained in this research.

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