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Exploration of A Cemetery Using Ground Penetration Radar

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Abstract
Ground penetrating radar (GPR) technology is used to determine the extent to which this technique can detect with a high-frequency range from 10 MHz to 1000 MHz into the ground by a transmitting antenna and A graveyard was found beneath the depth of the three meters under Surface of the earth in the shrine of the Prophet Houd and Saleh in Al-Najaf Governorate surveyed by through 4 tracks. Ground Penetrating Radar (GPR) is a device that transmits short pulses of electromagnetic energy with pulse duration about 1 ns to 20 ns. applying the filter Time- Zero to the same profile at a depth (3m) , Two types of antennas were used in this study, with two different frequencies antennas (250, 500)MHz Three tracks (23,25,26) were surveyed using an antenna (250 MHz) and one (96) track using an antenna (500MHz) . The data were collected and extracted from the device memory and the radar segments were then treated using the special program of processing RadExplorer software which contains many filters that are used to process the received signal.

Keywords: cemetery, GPR, shrine of the Prophet Houd and Saleh , Al-Najaf.

الكشف عن مقبرة بأستخدام رادار الاختراق الارضي

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الخلاصة
تم استخدام تقنية الرادار المخترق للأرض (GPR) لتحديد مدى إمكانية اكتشاف هذه التقنية من خلال مدى التردد العالي من 10 ميغاهرتز إلى 1000 ميجاهرتز في الأرض بواسطة هوائي الإرسال وتم العثور على مقبرة على عمق ثلاثة أمتار تحت سطح الأرض في مرقد النبي هود وصالح في محافظة النجف وقد تم المسح من خلال 4 مسارات. الرادار المخترق الأرضي (GPR) هو جهاز ينقل نبضات قصيرة من الطاقة الكهرمغناطيسية مع مدة نبضة تتراوح من 1 إلى 20 ثانية. تطبيق المرشح Time-Zero على جميع المسارات على عمق 3متر، تم استخدام نوعين من الهوائيات في هذه الدراسة لترددات مختلفة (250 ، 500) ميغاهيرتز تم مسح ثلاثة مسارات (23،26،25) باستخدام هوائي 250ميغاهيرتز ومسار واحد (96) باستخدام هوائي 500 ميغاهيرتز,وقدتم جمع البيانات واستخراجها من ذاكرة الجهاز وباستخدام برنامج خاص لمعالجة برنامج RadExplorer الذي يحتوي على العديد من المرشحات التي يتم استخدامها لمعالجة الإشارة المستلمة.

1. Introduction

The ground breaking high-speed ground penetrating radar has seen tremendous progress over the past ten years, and is the best alternative to all other geophysical methods used for near-surface explorations, providing accurate estimates of the depth of many objects beneath the surface. Providing

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accurate information on the nature of the buried objects when the electromagnetic waves are sent by the transmitting antenna and are reflected by heterogeneous materials Under layers, these waves will be received by the receiving antenna to be recorded as a function of time Called Path. These waves indicate the type of object that reflected this set of recorded lines with the same pathways as the profile, [1]. Produce the greatest amount of data and provide three-dimensional images of the underlying subsurface, and the development of the technique covered geophysical, technological and a wide range of scientific and engineering applications [2]. Ground Penetrating Radar has been utilized in fields as different such as environmental management, architecture, and mineral prospecting [3]. It has aided examination of internal glacial structures [4]. It is used to detect the nature of the fault and contaminants within the groundwater [5], and the location and size of plastic or metal pipes [6] and other objects, especially in archaeology [7]. In this study, a commercial GPR system MALA ProEx System from MALA Geoscience is used. It consists of the radar control unit with 12 v. Battery. The Control Unit features a 32-bit processor, linked to a storage display device on one side and with an antenna on the other side. A special monitor is mounted to the control unit. Side of this monitor is a computer for data acquisition and preliminary analysis and filtering. Figure-1 GPR main equipment MALÅ ProEx System, [8].

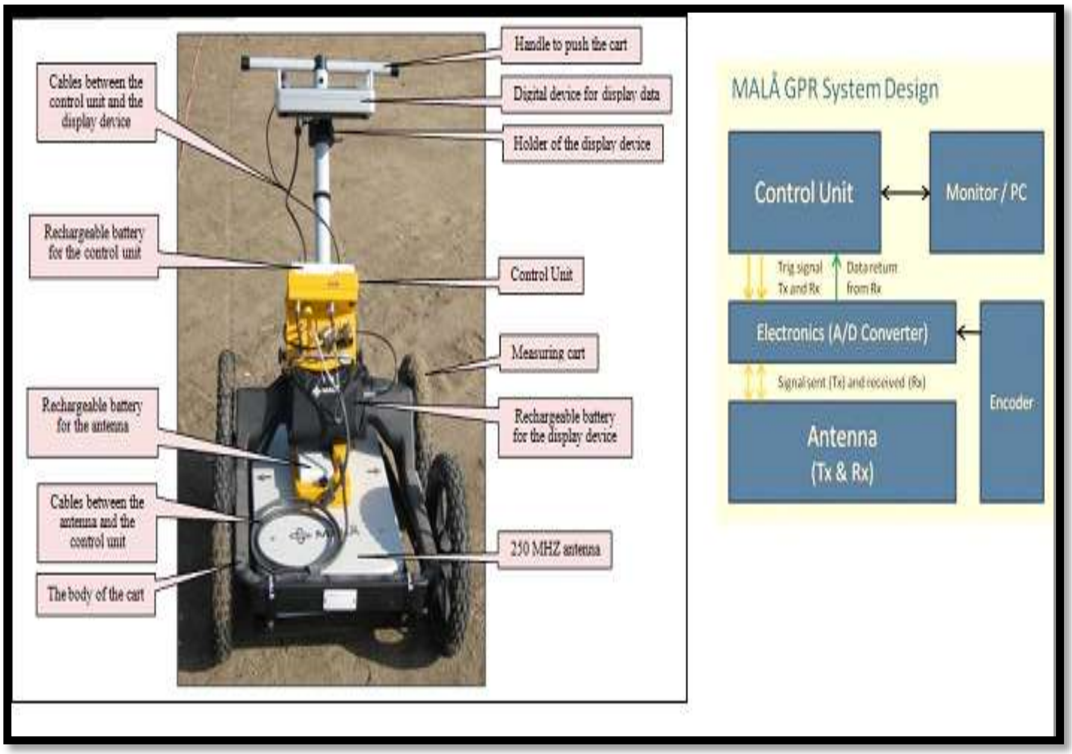


Figure 1-GPR main equipment MALÅ ProEx System

2. Study Area

AL- Najaf is located in the center of Iraq in the south-west of the capital Baghdad at a distance of one hundred and sixty kilometers. The land of Najaf governorate consists of ten different layers on a high plateau with a height of about 176 meters above sea level and about 40 meters from the level of the river Euphrates [9], the shrine of the prophets Houd and Saleh in the cemetery of Najaf, about 300m from the wall of the old, It is 446.64 meters from the shrine of Imam Ali The area coordinates (N32º.00082, E 44º.316462) Figure-2.

Figure 2-explains the study area

3. Materials and Methods

GPR Principle is radar instruments used electromagnetic waves (EM) instead of acoustic waves. EM-waves will not penetrate as deep as acoustic waves will result in much higher resolution maps. Objectives with contrast in electrical impedance to the surrounding media will be recorded and detected. Therefore surface radar device is firstly used for the detection and localization of metallic and non-metallic targets down to an approximate depth of 30 m. GPR instruments emit EM energy into the ground by transmitter (Tx), receive reflected signal (Rx), digitize the received, signal store the digital data, and display the output Radargrams. Some of the systems, supplied with computers, allow for basic processing and the printing of hard copies. in Figure-3 Basically GPR, GPR instrumentation includes: antennas providing for the emission and receiving of EM energy; a control unit governing all the parameters of radiated signal, timing, amplifier, and filter settings, and digitization rate; a laptop computer for handling the parameters of control unit, data storage, and visualization. Usually, the transmitter, amplifier and digitizer electronics are combined with the antennas in separate blocks to reduce the noise generated in connecting cables [10].

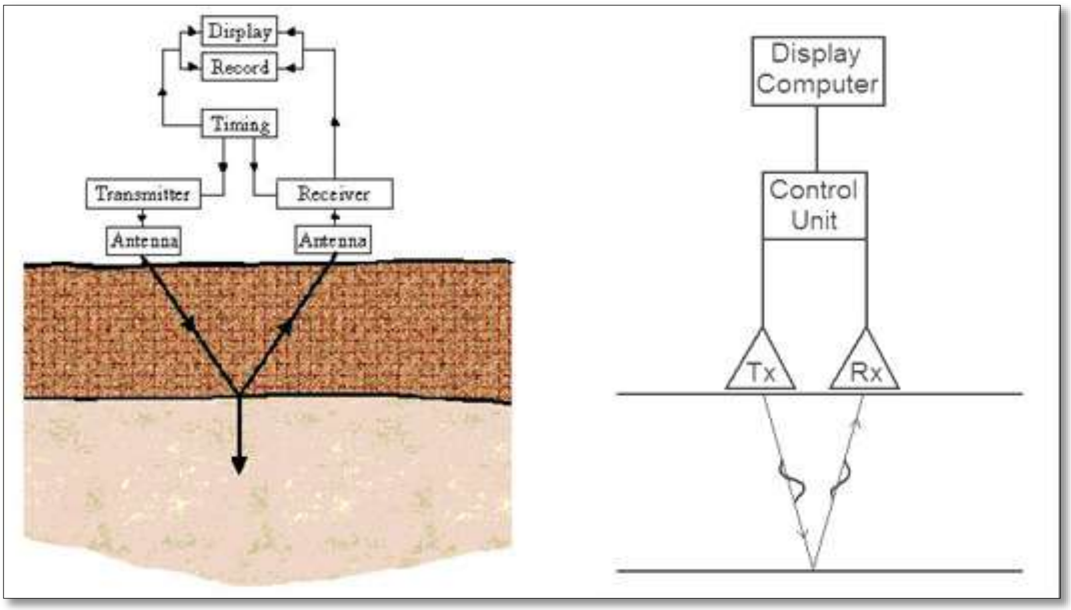


Figure -3 General scheme of GPR system [11].

With various refraction indices, some of the transmitted wave energy is reflected back to the surface. A receiver picks up these reflections as analogue signals. The input analogue signals are digitized and quantified using an analogue-to-digital converter in order to be ready for processing in the computer to create an image called the radargram [12-13]. Electrical conductivity, Electromagnetic wave speed, attenuation coefficient of the signal [14, 15].

Table 1-values of radar parameters for some materials [16]

Material	Typical Relative Permittivity	Electrical Conductivity, mS/m	Velocity, m/ns	Attenuation, dB/m
Air	1	0	0,30	0
Distilled Water	80	0,01	0,033	0,002
Fresh Water	80	0,5	0,033	0,1
Sea Water	80	3000	0,01	1000
Dry Sand	3 – 5	0,01	0,15	0,001
Saturated Sand	20 – 30	0,1 - 1,0	0,06	0,03 - 0,3
Limestone	4 – 8	0,5 – 2	0,112	0,4 – 1
Shales	5 – 15	1 – 100	0,09	1 – 100
Silts	5 – 30	1 – 100	0,07	1 – 100
Clays	5 – 40	2 – 1000	0,06	1 – 300
Granite	4 – 6	0,01 – 1	0,13	0,01 – 1
Dry Salt	5 – 6	0,01 – 1	0,13	0,01 – 1
Ice	3 - 4	0,01	0,16	0,01

4. Processing data

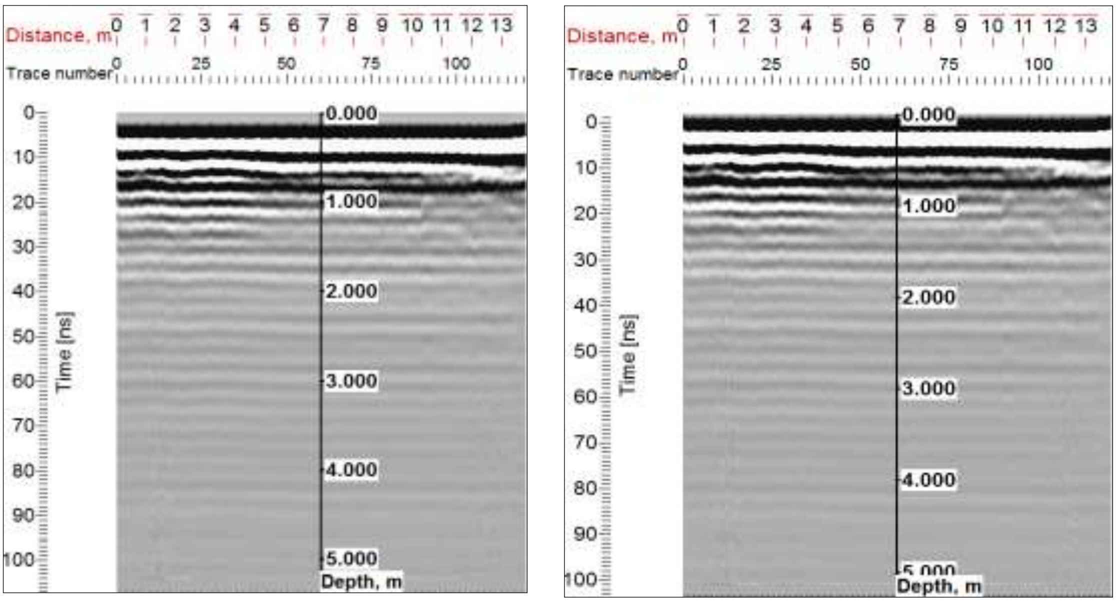
The geophysical survey identifies the target of the survey, whether to look for traces, minerals, oil, gas or other, and then to collect all the geological, topographic and geophysical data available from the region to be used to give a picture of the previous studies in the region and its main results. Physical property and geophysical methods are suitable for the study of the target, and therefore the type of equipment required to conduct the survey and the certificate of accuracy and sensitivity and determine the type of survey. Is it land, sea or air? This is done in accordance with the region's area, topography, and the purpose of the survey. It is then collected, corrected, and plotted in the maps of the Kanturian region, representing the variability of the properties of the sub-surface rocks [17]. The first processing step which was applied on the collected profiles. The editing involves reorganization and renaming the recoded files. For example DAT_26 to profile which was achieved for the selected straight line in the shrine of the prophets Houd and Saleh in the cemetery of Najaf and registering the operation setting parameters of GPR such as Because the floor is tiled and antennae250 MHz, we use it: time windows 107ns, point interval 0.05 m, sampling frequency 544MHz and velocity 81 m/ns.

GPR works best in sandy soils which do not contain boulders, stones or tree roots. A grave is a relatively well defined target, the size is typically (0.5m x 2m) and it is typically within 2m or more below the surface. GPR may detect a number of features to help identify a grave, including (a strong signal may return to a wood of the coffin, metal, or vacuum indicates the presence of tomb etc.) Here we are based on a vacuum to signify the tomb. value Disturbed ground structure and excavation features Movement or voids caused by collapse of the coffin This applies to all the selected sites and to varying degrees The field raw data of the first stage measurements (Simulation model) were conducted with antenna frequencies; registering the operation setting parameters demonstrate the cemetery under the depth of three meters below the surface of the earth in the shrine of the Prophet Hood in Al-Najaf Al-Ashraf . In the following sections, the raw data will be shown with the processed data side by side.

Processing and interpreting the data of the Houd and Saleh

5. Time- Zero Adjustment Filter

The “Time Adjustment” filter is used for adjusting the zero-point of the vertical time scale to the time-zero, the moment when the wave has actually left the emitting antenna. Applying this filter can set the direct wave arrival time. At the same time in the visualization window, the white horizontal dotted line that defines the first-arrival time position is moving.This filter was applied for all the profiles and the antenna frequency of(250) as shown in Figure-4.then apply a filter (Background Removal), as the use of this filter is necessary to remove the noise sections and access to the signal required, Figure-5.Also, we notice cemetery in the (23) profile while processing with the Background Removal filter and that cemetery is in the middle of the path with depth of (3.08m) When putting the curve on this hyperbola we notice appearance of the profile features with Figure-6 (29cm/ns) velocity and isolation constant of (1.0) comparing velocity with Table-1 represents air.When applying the Background Removal filter on the (23) profile, we notice there a distort and revealing of hyperbola with a distance of (3.49m) from the path beginning with a depth of (5.33m). When putting the curve on this we notice there a distort of hyperbola with Figure-7 (20.9cm/ns) velocity and isolation constant of (2.1).The depth of penetration in this profile was about (5m) several abnormalities were observed in the form of caverns and at different depths. One of these tracks is at a depth of (5.33m). The second track is located at a depth of (3.08m) Figures-(6 and 7), as these hyperbola are likely to be tombs.



(a)Before apply the time-zero (b) after apply the time-zero

Figure- 4 Profile No. 23

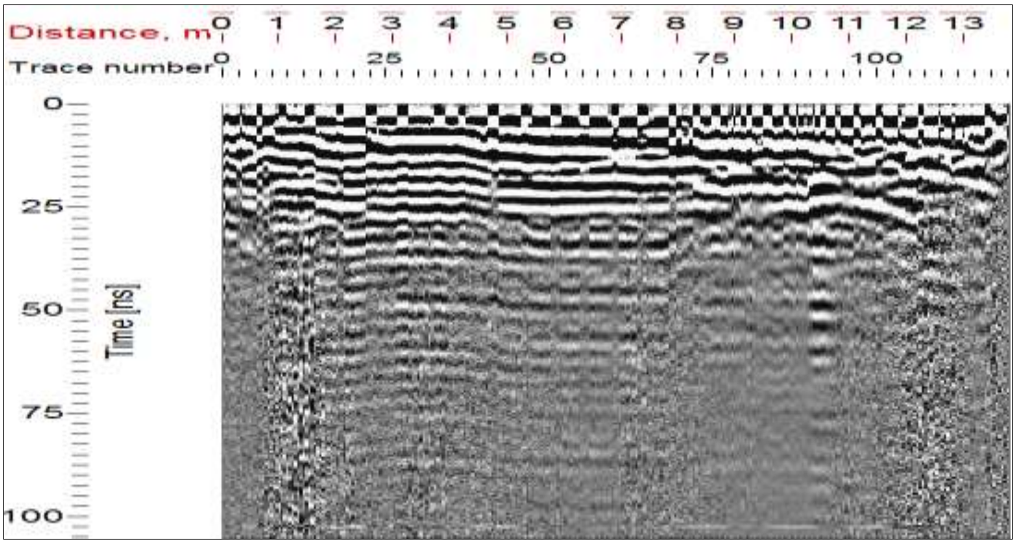


Figure 5-Profiles No. 23 after the apply background removal

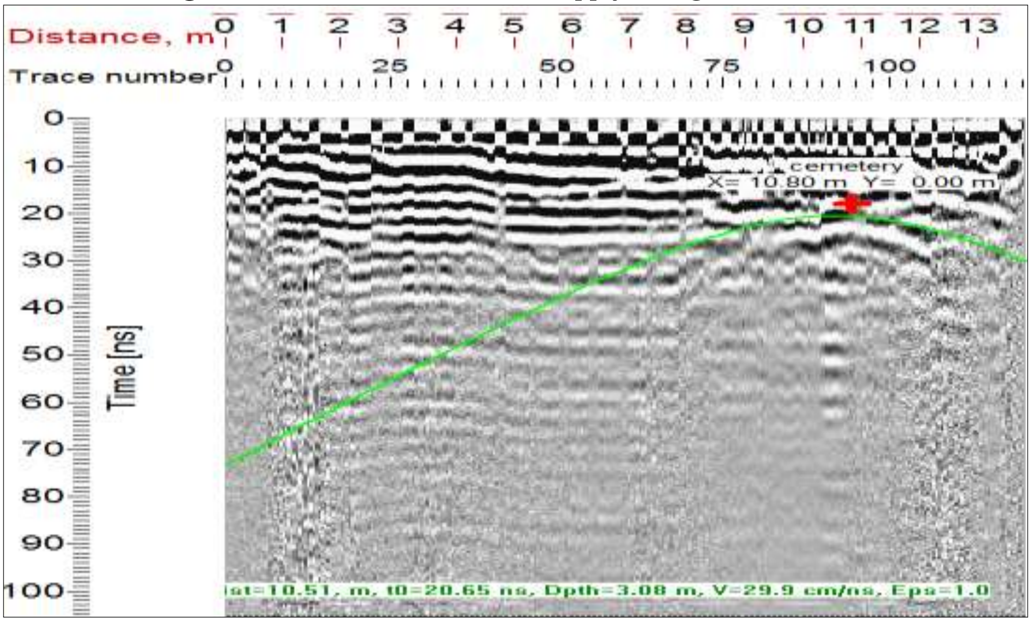


Figure 6-Profile No.23 after the Apply Background Removal

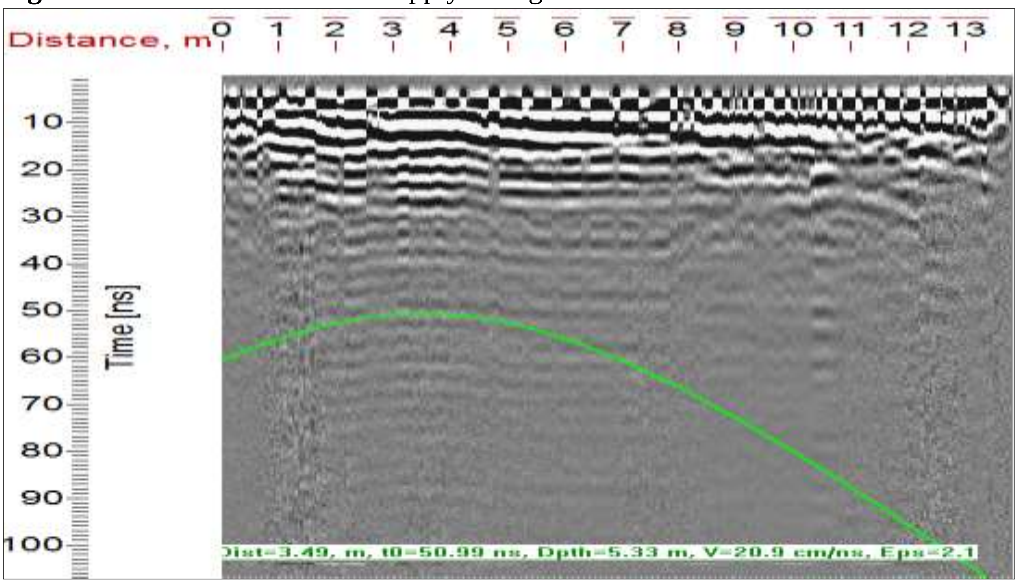


Figure 7-profile No.23 after the apply background removal

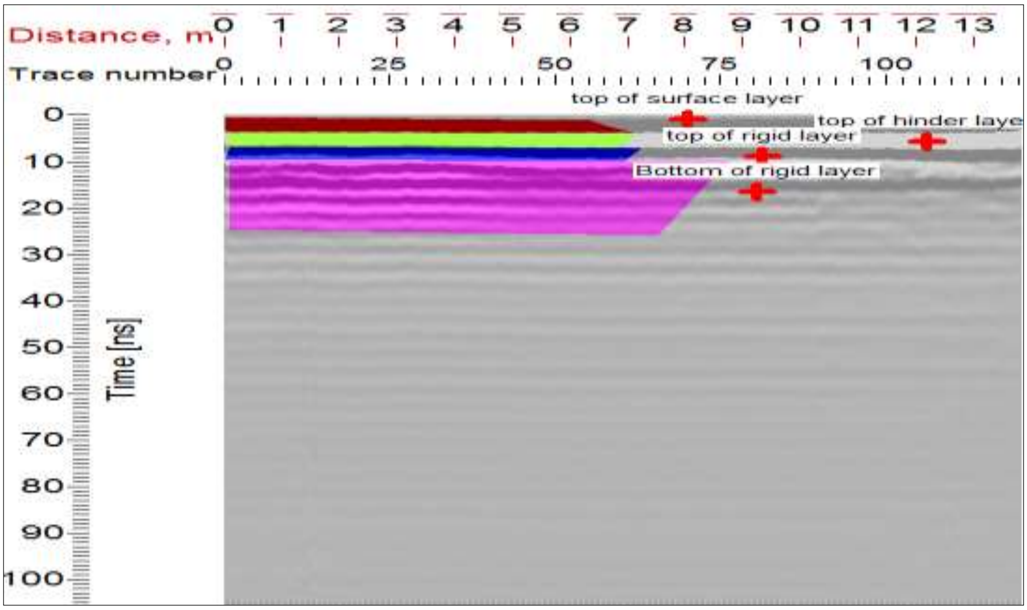
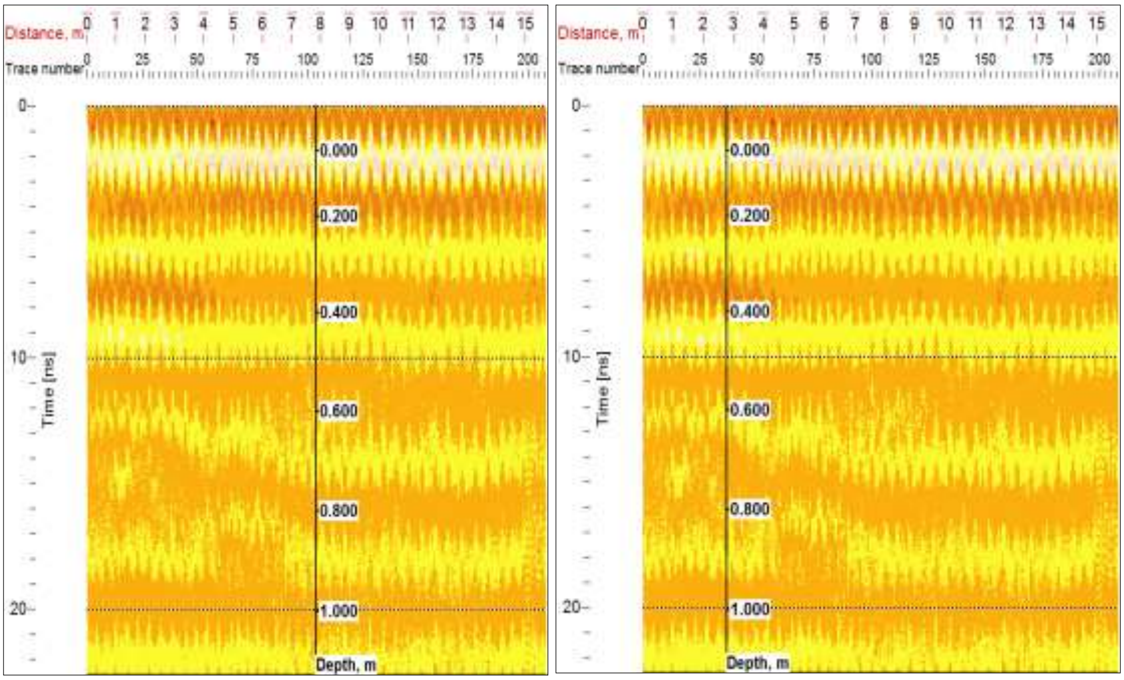


Figure 8- Profiles No. 23identifies the boundary of layers using pick and fill the layer using the model option.

Profile number (96)

When the filter zero- time is selected we note the depth of the penetration was before (1.2m) and became after (1.1m) Figure-9,10 used the antenna frequency of (500).



(a)Before applying the Time-Zero (b) after applying the time-zero

Figure 9-Profile No. 96

When applying a filter Background Removal and Edit model used The antenna frequency of (500) appear the first layer of the surface represents the asphalt layers of the blue color depth of the layer (35cm), and the second layer of the green color concrete depth of the layer(75cm) These two layers differ in electrical properties.

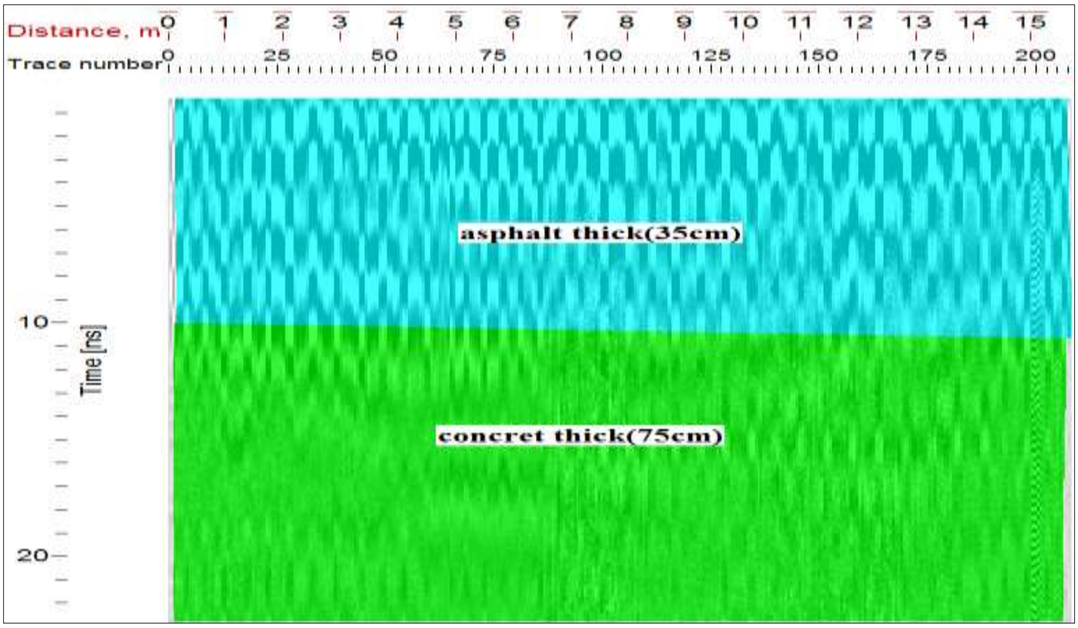
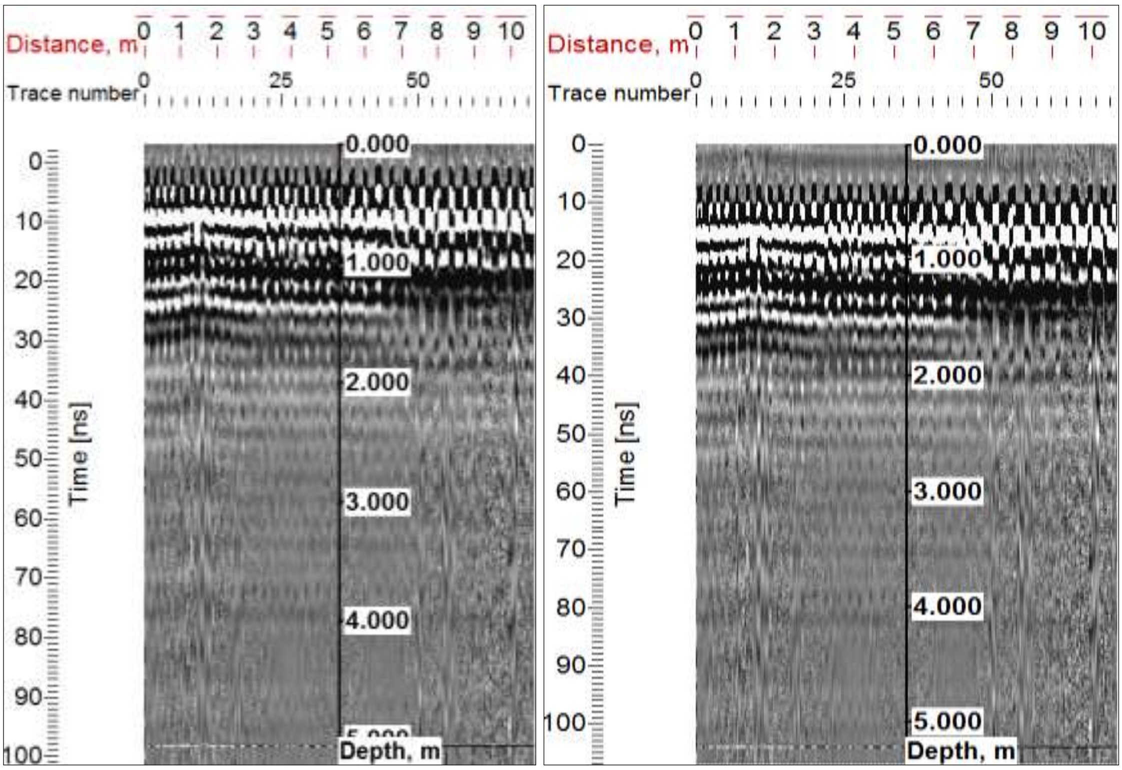


Figure 10-Profile No.96 after the Apply Background Removal and Edit model

Profile number (25)

When Profile number (25)is processed by the filter Time–Zero we notice the penetration depth with depth of (5.5m) before processing to be of (5.1m) after processing as it explained in the Figure 11 .When the 25 profile is processed DC-Removal Filter we notice there a distort and revealing of hyperbola with a distance of 1.5m from the path beginning with a depth of (4.64m). When the features of the path with velocity (30.7cm/ns) and isolation constant of (1), are compared with the Table-1 we find hyperbola that is an air gap (cemetery) as it is explained in Figure-12.



(a) After apply the Time-Zero (b) before apply the Time-Zero

Figure-11 - Profile No. 25.

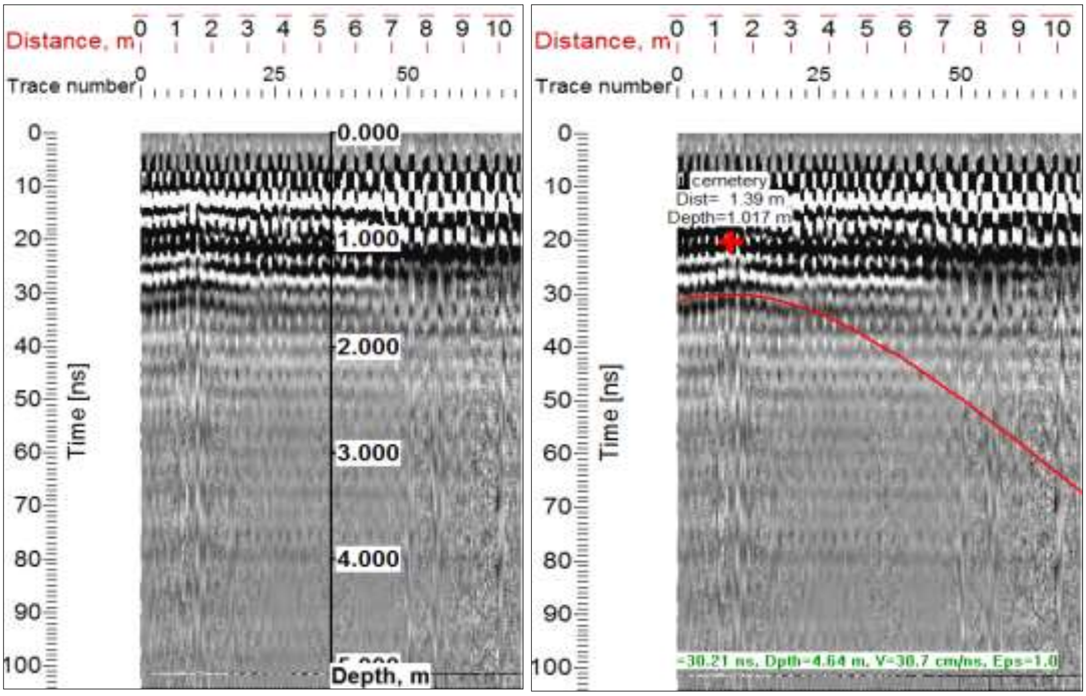


Figure 12-Profile No.25 After the apply DC-Removal.

The implementation of this filter is shown in Figure-13 and the MigrationVelocity is (11cm/ns). When applying the Stolt F-K Migration filter on the 25 profile, we notice there a distort and revealing of hyperbola with a distance of 5m from the path beginning with a depth of (4.37m). Hyperbola we notice the appearance of the profile features with (30.7cm/ns) velocity and isolation constant of Table-1as it is explained in the Figure-14.

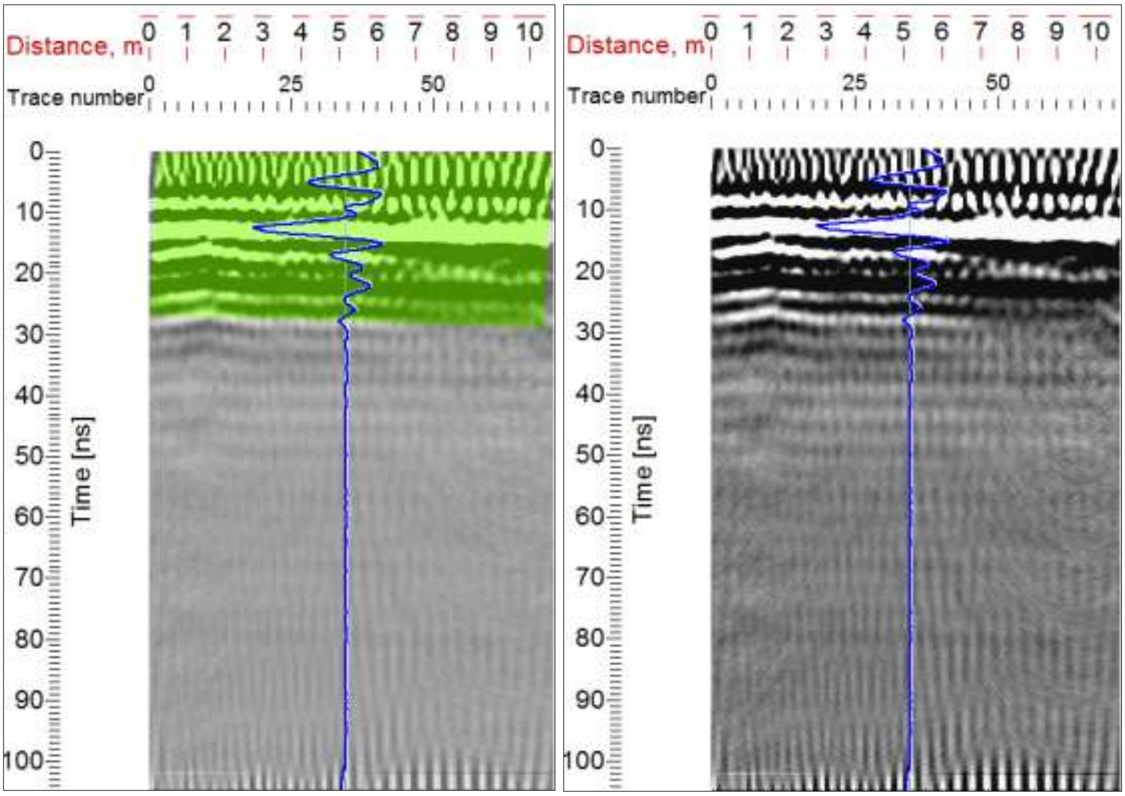


Figure 13- Profile No.25 After the applyStolt F-K Migration

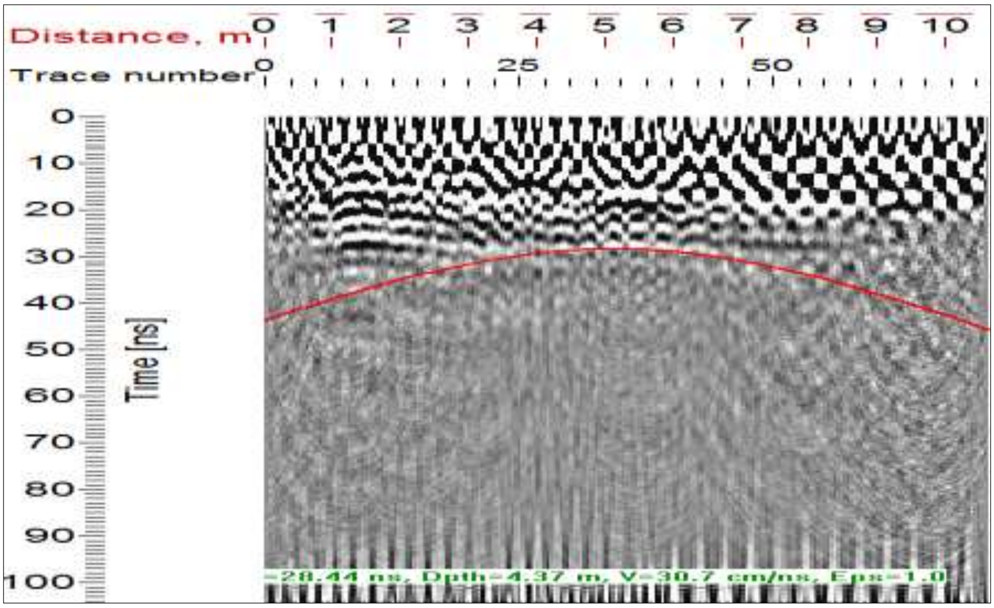
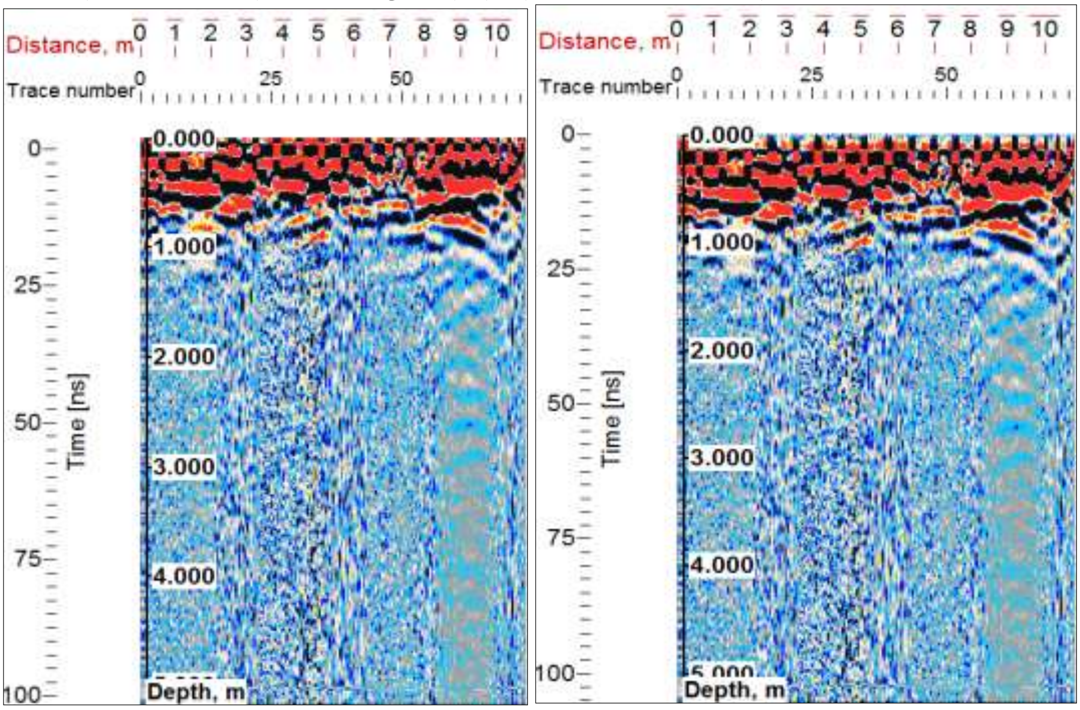


Figure 14 - Profile NO.25 After the applyStolt F-K Migration

Profile number (26)

When processing profile (No.26) filter (Removed background) being clearly the impact of industrialization applied abnormality of distance (5.4 m), because of An air gap (cemetery) velocity (40.5 cm/ns) as it is explained in the Figure-15,16.Apply a filter reflection strength for the same profile this filter does not have any parameters, e.g. of application of this routine is presented on Figure-17.a (the initial data) and on Figure-(17)b (after transformation).



(a) After apply the Time-Zero (b) before apply the Time-Zero

Figure 15 - Profile No. 26.

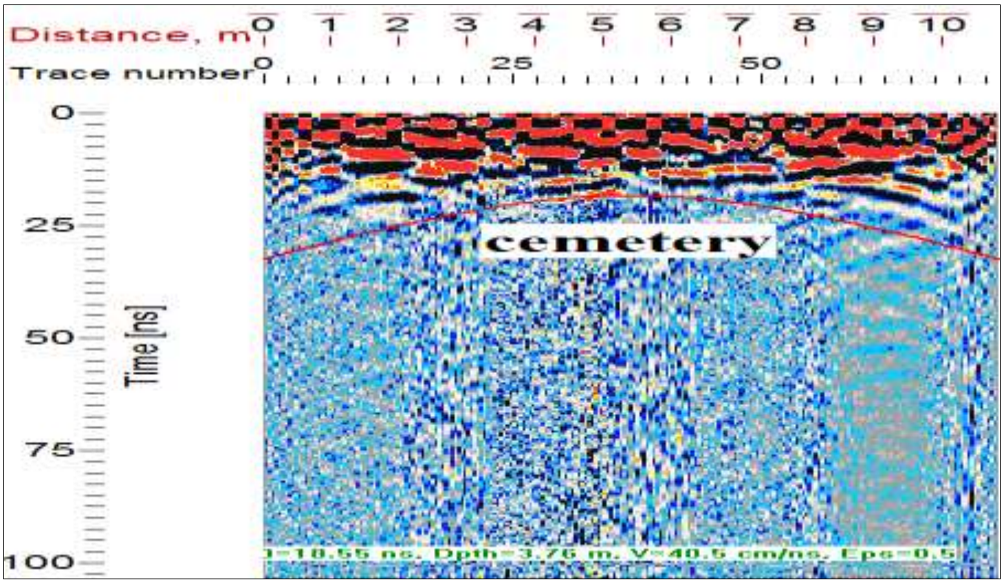
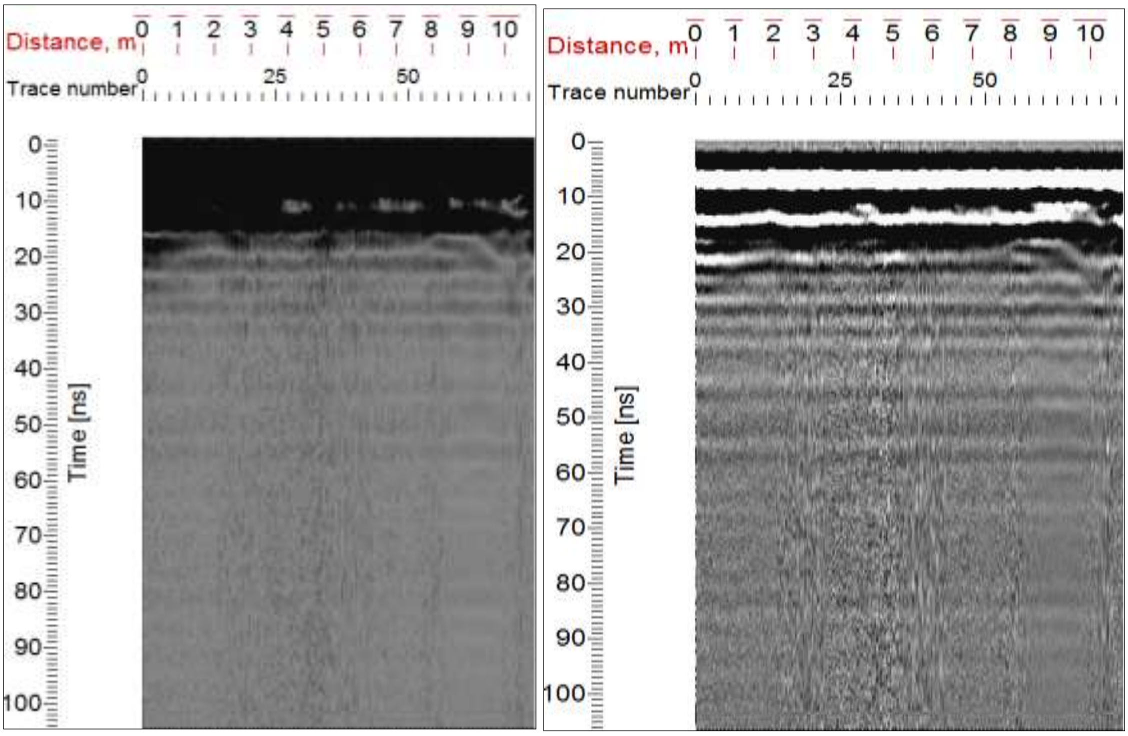


Figure 16-Profile No.26 after the Apply Background Removal



b-after the Apply a filter reflection strength a-before the Apply a filter reflection strength

Figure 17-Profile N0.26

Conclusions

GPR technique offers a number of advantages over other geophysical methods. There is a great need to evaluate subsurface parameters without disturbing the ground. It is essential that any technology used to detect, identify and locate such buried material is capable of scanning large surface areas rapidly and efficiently in the presence of disturbances. It is concluded that applying the filter (Stolt F-K Migration) for profile GPR(25) cemetery is detected at a depth of(4.37m) and filter Background Removal for profile GPR(13) cemetery is detected at a depth of(5.33m) By collecting survey data for the work area, RAD Explorer has demonstrated its ability to:

1. The application of filters (Background Removal, the Time-Zero, DC-Removal) was successful in data analysis and as shown in the paper.

2. Identification of areas showing the presence of the cemetery in the profile (23, 25and 26) by having

air blanks and knowledge by comparing the results of the speed of hyperbola with the Table-1.
3. Identify surface layers with high accuracy as shown in Figure-8 Profile 23 and Profile 96

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