DETECTION OF EXTERNAL EFFECTS ON GROUND PENETRATING RADAR SURVEY

Samir R. Hijab[1] and Abbas M. Yass[2]

Received: 22/ 9/ 2011, Accepted: 5/ 4/ 2012
Key words: Buried Graves, GPR Associated anomalies, Iraq

ABSTRACT

The ground-penetrating radar survey (GPR) has been conducted to detect some grave markers in a cemetery location. This was done through measuring seven profiles that range in length from (30 – 100) m. The results of only three profiles were found to deserve analysis. It was revealed that external effects were associated with the GPR anomalies in the studied area. Precautions were taken into consideration before the measurements and during the interpretation process. Reflex software was used to distinguish and process the GPR anomalies.

It was found during the excavation process that those anomalies are not related to buried bodies. It is most probably due to the soil condition of the studied area. However, it was a good chance to identify those anomalies, especially; that the excavation was performed instantly in the area.

الكشف عن التأثيرات الخارجية للمسح الراداري بالاختراق الأرضي

سمير رشدي حجاب و عباس محمد ياس

المستخلص

اجري المسح الراداري بالاختراق الأرضي للتحري عن وجود مقبرة في موقع مقترح، والذي قد يكون مقبرة مفقودة. أنجز المسح الراداري بالاختراق الأرضي لسبعة مسارات تتراوح أطوالها من (30 – 100) متر. بينت النتائج بأن عملية المسح لثلاثة مسارات فقط تستحق التحليل. اتضح من خلال عملية المسح الراداري وجود تأثيرات خارجية مترافقة مع شواذ رادارية في منطقة الدراسة. طبقت الإجراءات اللازمة لطريقة الـ GPR للحصول على النتائج قبل البدء بعملية القياس وأثناء عملية التفسير. استعمل برنامج Reflex لتمييز ومعالجة الشواذ الرادارية.

لقد وجد أثناء عملية الحفر بأن هذه الشواذ لا تعود لأجسام مدفونة، وإنما على الأرجح تعود إلى وضع التربة في منطقة الدراسة. كان هذا المسح فرصة جيدة للتعرف على هذه الشواذ، لاسيما إن عملية القلع كانت تجرى في نفس الوقت في المنطقة.

INTRODUCTION

Ground-penetrating radar (commonly called GPR) is a geophysical method that has been developed for shallow, high resolution, subsurface structure investigations by using high frequency electromagnetic waves to acquire subsurface information (Jol, 2009). GPR survey has been conducted to detect grave markers, which are located in the west of Iraq to the south of Al-Tharthar Lake (Fig.1). The distribution, orientation and the number of the graves were unknown. Yet, the depth of the graves estimated to be between (3 – 5) m under the surface.

[1] Chief Senior Geophysicist, Iraq Geological Survey, P.O. Box 986, Baghdad, Iraq
e-mail: Samir_Hijab@yahoo.com
[2] Chief Senior Geophysicist, Iraq Geological Survey, P.O. Box 986, Baghdad, Iraq
e-mail: abbas.yass@gmail.com

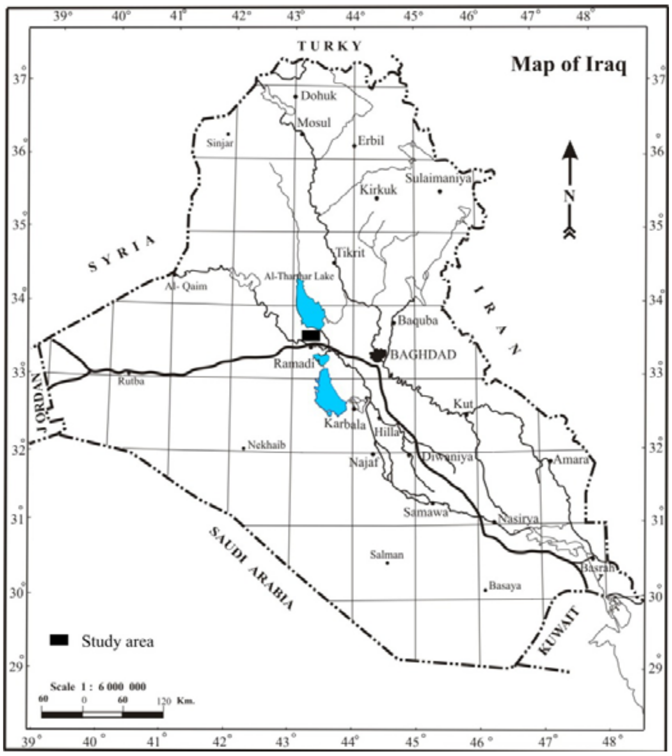

Fig.1: Location map

The aim of this study is to detect grave markers (if they do exist) at location, which was supposed to be a lost cemetery, consequently, to confirm the existence of the graves and delineate their edges.

This research throws some light to the results that could mislead the delineating of the target, especially, the excavation processes were conducted instantly at each proposed location.

Geologically, the area under investigation is situated in the Quadrangle of Al-Ramadi. The surface geology of the studied area comprises Quaternary deposits represented by flood plain deposits that composed mainly sand with silt clay deposits (Sissakian and Salih, 1995).

METHOD AND FIELD WORK

Seven profiles of GPR survey were conducted in the candidate area according to the previous information that is expected for existence of buried graves. They were arranged in two sets (Fig.2). The first set includes three profiles parallel to each other; the length of each one is about 100 m, while the second set includes four profiles. Their length ranges from (30 – 100) m (Fig.2). The distance between each adjacent profile is 10 m. The distribution of the profiles was chosen in cooperation with the side requiring investigating.

Penetrating the depth and the ability to resolve targets at a depth are strongly dependent upon the local soil conditions. Soils may be completely attenuated GPR signals where by the method cannot be used (MALA, 2008). The studied area, which consists of sand with silt clay deposits, is a hopeful area to utilize GPR, due to the relatively poor conductivity of the soil. Penetrating the depth and the ability to resolve targets at depth also depend on the frequency of the used antenna. Table (1) shows different frequencies of antenna with estimated depth and radial resolution with velocity of 100 m/µs of the GPR waves through the rocks.

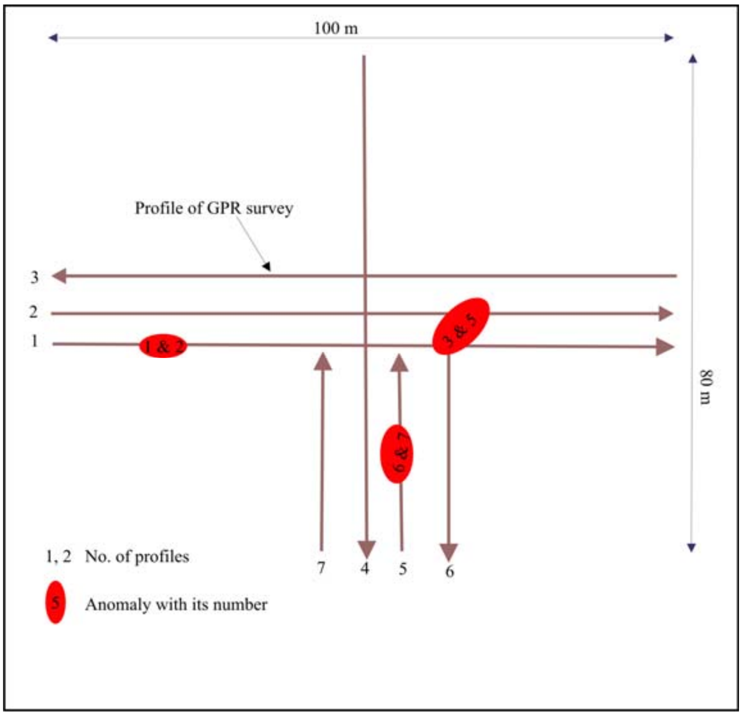

Fig.2: Sketch shows distribution of profiles and features of the GPR survey in the studied area

Table 1: Aproximate penetration depth and radial resolution for different frequencies of antennas (MALA, 2008)

Antenna frequency (MHz)	Approximate Radial Resolution @,c=100 [m/μs] , $\lambda_c/4$ [cm]	Approximate max penetration depth (m)
25	100	50
50	50	40
100	25	25
250	10	8
500	5	6
800	3	2.5
1200	2.1	1
1600	1.6	0.5
2300	1.3	0.4

Where λ is the wavelength in centimeter,
c is the velocity of GPR wave in m/μs

Choosing the suitable antenna that transmits the desired frequencies could be a crucial factor in delineating the target (Olhoeft, 1999). Primarily, the depth/resolution requirement and the soil condition at the site determine the choice of antenna frequency. A 500 MHz shielded antenna was used in this survey to provide an optimum depth of investigation (Table 1). Velocity of about 100 m/μs was used in calculating the depth of penetration due to geological situation; it may represent the average velocities of the GPR waves through the materials, which are available in the studied area (Table 2).

Table 2: Materials with corresponding velocities of GPR waves (MALA, 2008)

Medium	Velocity (m/μs)
Air	300
Fresh water	33
Limestone	75 – 113
Granite	113 – 134
Concrete	95 – 150
Clay	74 – 150
Silt	63 – 100
Sand	55 – 150
Ice	150 – 173

Precautions were taken before taking the measurements in the field; cell phones were supposed to be turned off, because they give noise signals even if no communications were made (Olhoeft, 1999). The antenna was very close to the surface, or nearly in contact with the surface to prevent aerial waves, which may be received by the receiver of the antenna after they had been transmitted from the transmitter of the antenna and collided by bodies on the surface (MALA, 2008).

MALA GPR system, radar control unit Pro-Ex, was used in this survey to acquire the data. MALA XV monitor was used for viewing and recording the data. The point interval, which was used during the measurements, was equal to 0.05 m and the sampling frequency was equal to 5000 MHz (MALA, 2008). Seven images for seven profiles were successfully acquired during the work.

DATA PROCESSING AND INTERPRETATION

The anomalies, which were formed as a result of GPR waves, could be examined to be spurious anomalies (resulted from aerial waves) or real anomalies (resulted from subsurface bodies) (MALA, 2008), it depends on the velocity analysis of the GPR waves that form the object. Reflex software was used to calculate the resulted wave velocity from each object.

After processing the records of the GPR by applying several corrections such as back removal filter, subtract mean trace, filtering and DC correction to enhance signals from interesting features and to remove unwanted signals in data, only three images have been depended (Figs.3, 4 and 5). They represent real anomalies reflected from the subsurface. The velocity analysis was carried out using the method of calculating the acquiring velocity from the hyperbolic events of the radargrams (Gracia *et al*., 2003). When the GPR passes over a small object in the ground, the resulting feature in the radargram is a hyperbola; the shape of the hyperbola is defined by the geometry of the object and the velocity of the waves (MALA, 2009). One hyperbola or more were measured at each profile at different depths by Reflex 2D Quick software. The calculated velocity was of about 100 m/μs as it has been estimated. A wave velocity of about 300 m/μs is considered an aerial wave (the speed of light), in this case, the related anomaly should be neglected (MALA Geoscience, 2009). It is worth to say that the anomalies, which are shown in the figures above, couldn't be acquired without processing.

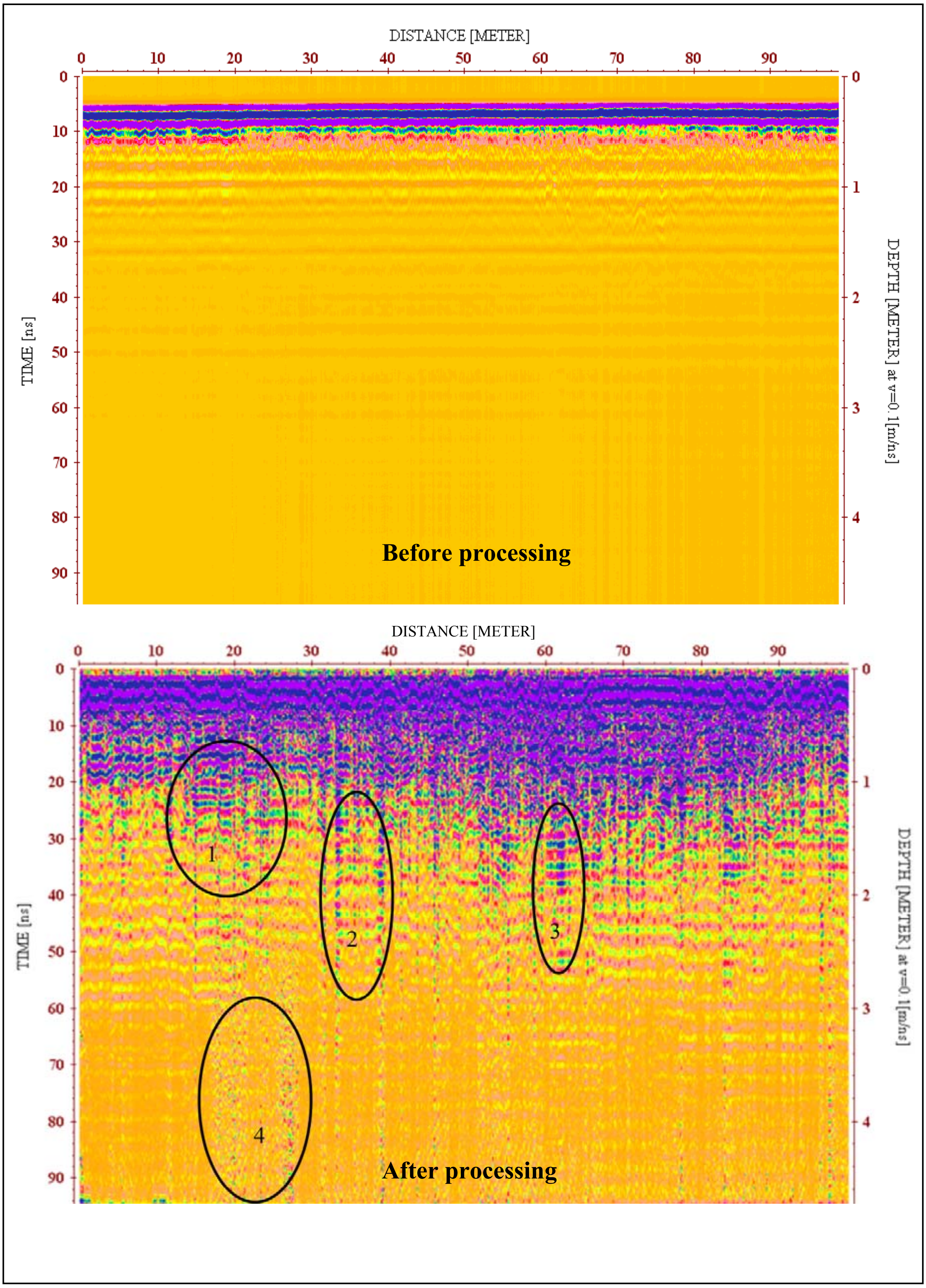

Fig.3: Profile No.1, anomalies acquired from GPR survey

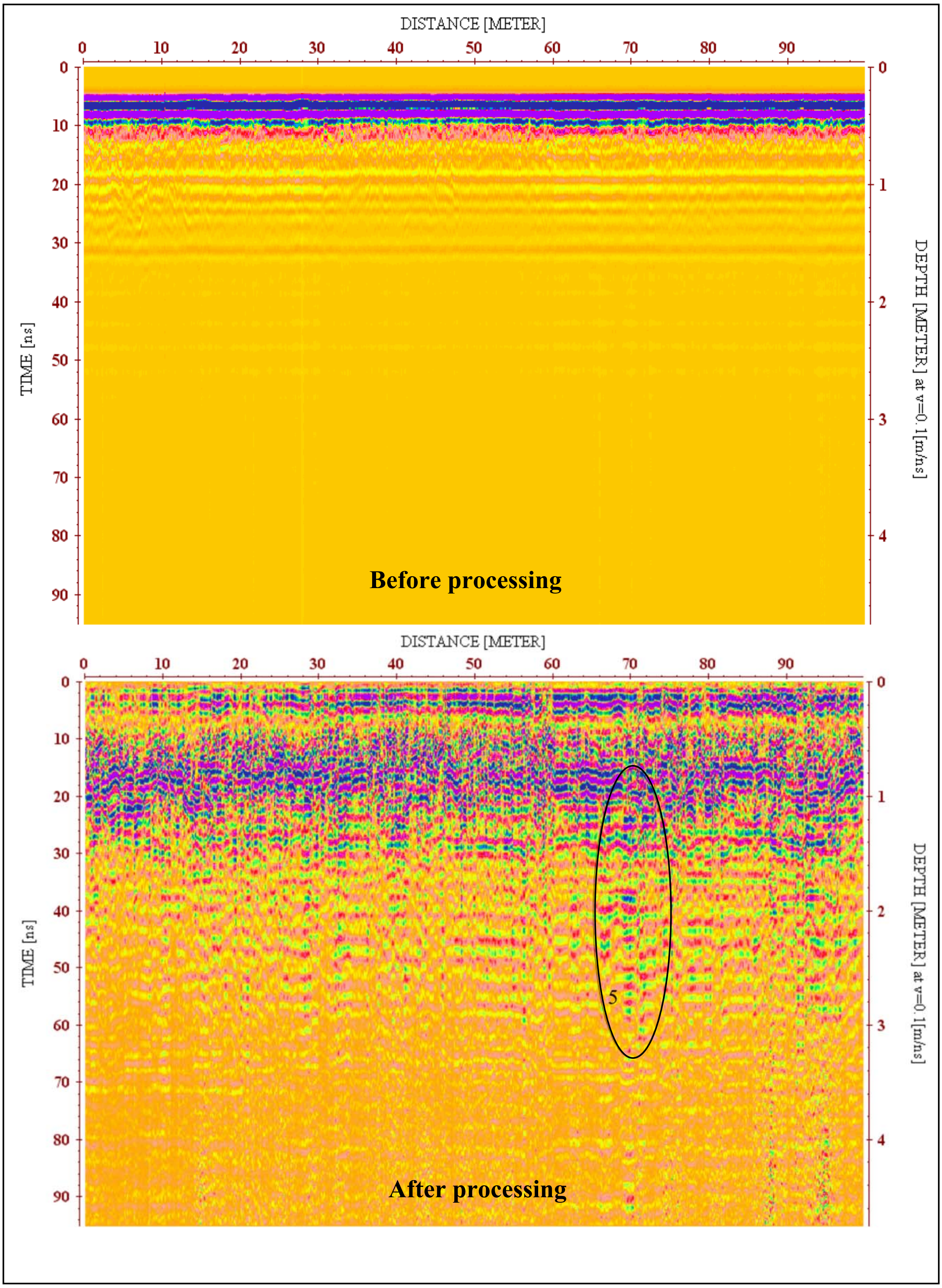

Fig.4: Profile No.2, anomalies acquired from GPR survey

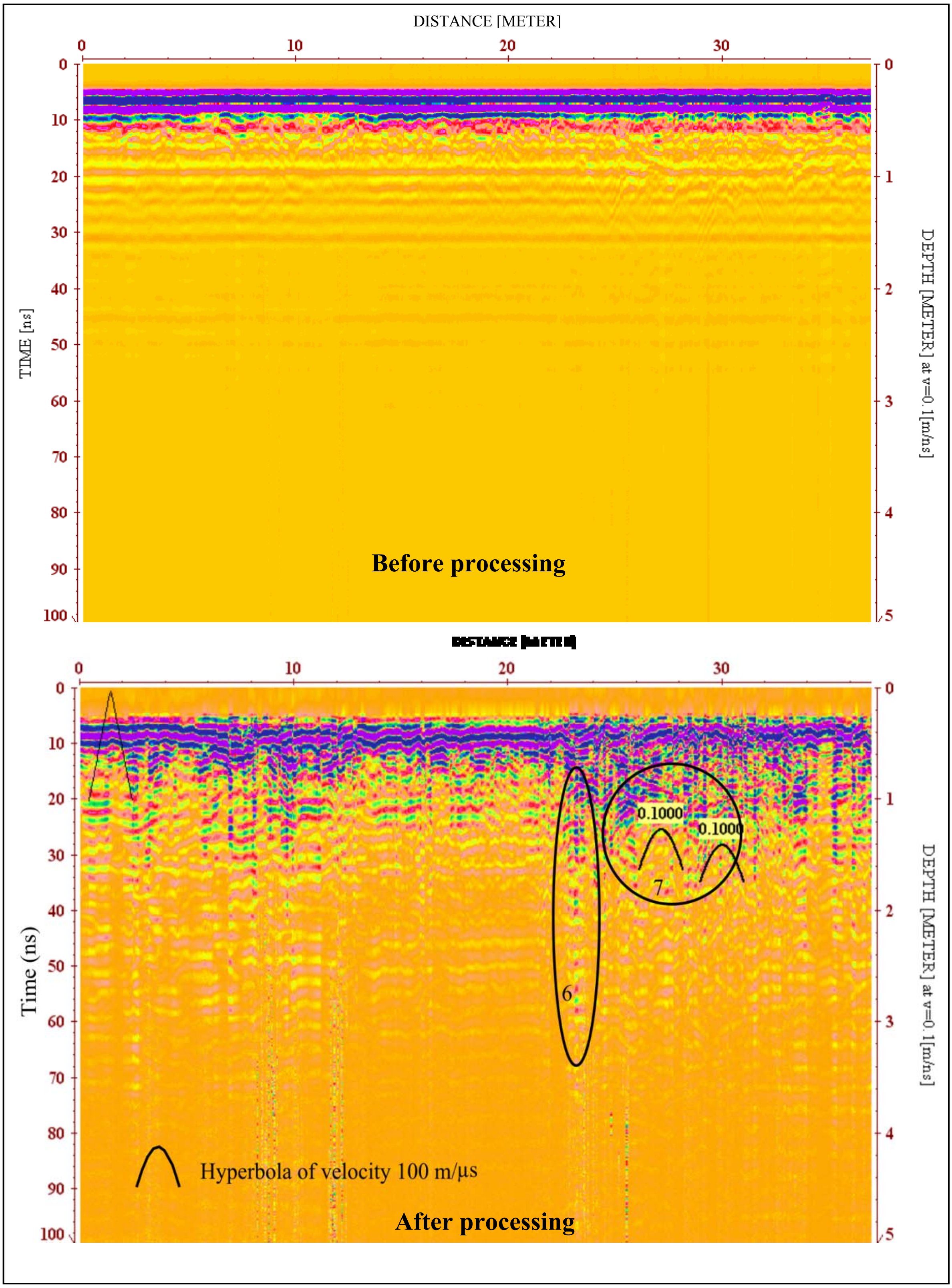

Fig.5: Profile No.5, velocities determined at anomaly 7
by using Reflex 2D Quik software

RESULTS

Several anomalies were detected at the three profiles (Figs.3, 4 and 5). All those anomalies were excavated immediately at the location, they were as follows:

- Profile No.1, four anomalies were recorded in this profile (Fig.3), anomaly 1 and 2 were related to very hard lenses of clay that even the trench digging machine could hardly peel them. The depth of those anomalies coincided with the interpreted depth of the cross-section, it is 0.75 m. Anomaly 3 (Fig.3), unlike anomaly 1 and 2, it was related to a very soft gypsious sandy clay rocks and coincided with the estimated depth (1 m). Anomaly 4, which consumed time for excavation by the trench digging machine because of the existence of hard clay; it was not related to anything. It was interpreted that it might be due to noise signals of somebody's cell phone near the location. An example on the noise caused by cell phones is the image in (Fig.6), on the left; the cell phone is on, obtaining service, but not being used in standby. On the right, the cell phone is turned off. In the middle, a cell phone was being used.
- Profile No.2, one anomaly (anomaly 5) was detected at this profile (Fig.4). It may coincide with anomaly 3 at profile No.1 (Fig.3). Both anomalies are laid at the same location in the studied area, which is very soft gypsious sandy clay rock.
- Profile No.5, two anomalies were found in this cross-section (anomalies Nos.6 and 7) (Fig.5), they were related to hard boulders which diameters range from (0.5 – 1) m. The depth of these anomalies had coincided with the estimated depth (1.3 m).

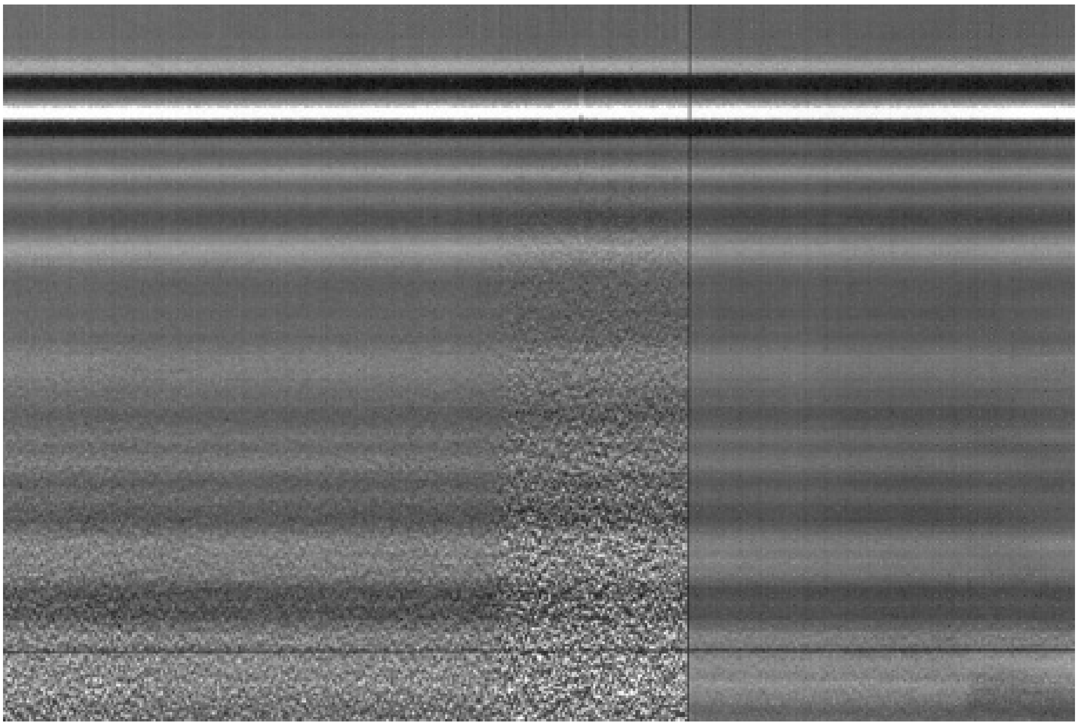

Fig.6: GPR Record shows noise signals from cell phone on the radargram during the measuring (Olhoeft, 1999)

DISCUSSION

In most cases, the best technique for locating buried graves is by using ground penetrating radar (Johnson, 2003). The GPR method is sensitive to unwanted signals (noise) caused by geological and cultural factors (MALA, 2008). Signal sources can be caused by boulders, tree roots or any other inhomogenety that can cause unwanted reflection. The bodies, which acted as point objects, are presented in the graph as a hyperbola (Persson, 2005). The shape of the hyperbola depends on the diameter of the target, and the angle between the survey line and utility (MALA, 2009). The hyperbolas of different type of bodies have nearly the same shape; reverberations from buried metallic objects (Fig.7) may be similar to reverberations obtained from the locations of a mass grave in shape and size. The distinguishing between those objects is rather difficult.

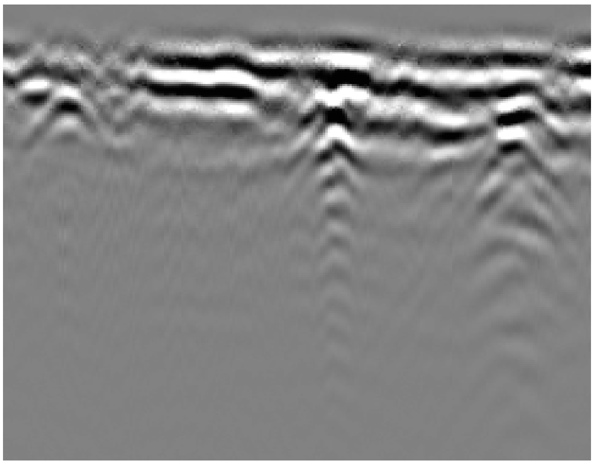

Fig.7: Reverberations from buried metallic objects (Souter, 2007)

Unwanted signals could be caused from aerial waves even though the antenna is shielded (MALA, 2008). Air reflections, which may cause the unwanted signals from the ground; can include reflection from nearby vehicles, building, power lines, electromagnetic transmission from cellular phones and two way radios, could be obtained with GPR records (MALA, 2008). Shielded antenna is used to limit these types of noises. The geophysical anomalies may be reinterpreted as excavations proceed.

GPR data is not always easy to acquire (Olhoeft, 1999). Selecting the frequency of the antenna for radar survey is not simple. There is a tradeoff between spatial resolution, depth penetration and system portability (Sensors and Software INC, 1999). Defining the generic target (Point target or rough planar target) the desired spatial resolution was specified. In this research the generic target is considered as a point target. The requested resolution can be divided into radial resolution and lateral resolution (MALA, 2008). Determining the velocity of waves equal to 100 m/μs an antenna of 500 MHz can give radial resolution of about 0.05 m and a lateral resolution of about 0.3 m at depth may reach to 6 m respectively (MALA, 2009).

Penetrating the depth and the ability to resolve targets are very important so as to acquire good results (MALA, 2008), they depend on the velocity of electromagnetic waves through different materials. To obtain accurate results and right interpretations, velocity analysis was performed at the studied area during the work. The velocity analysis was carried out using the hyperbolic events of the radargram. The aim of those velocities estimations is to obtain the minimum error in the final interpretations of the profiles (the depth of the feature). The quality of the velocity estimates is directly proportional to the quality of the depth estimates (MALA, 2009).

CONCLUSIONS

- As a result, there was no feature to any grave markers in the studied area, at least along the suggested profiles.
- Although the studied area is relatively small (it is about 100 × 80 m), three different types of rocks were found. The anomalies 3 and 5 which are laid in a weak zone that surface water could penetrate through; it is believed that those anomalies may be related to subsurface conduits. The studied area may contain several subsurface conduits that could cause several anomalies of unimportant signals.
- The studied area contained many objects, this have caused the difficulty in the interpretations of GPR survey. Obtaining comprehensive information about the studied area would have been necessary to predict better results.
- Knowledge of the geological situation of the studied area is important not only to decide whether GPR can be used or not, but it would have lead to estimate of preliminary velocity of the waves of GPR before starting the survey, consequently, choosing the suitable frequency of the antenna, finally to be aware of the resolution that we were dealing with.

Calculating the accurate velocity during the processing will fix the depth of the objects, the cross-section may give the exact depth of the object.

REFERENCES

Gracia, V.B., Drigo, R.G. and Vendrell, D., 2003. GPR velocity and frequency analysis in industrial archaeology. Study of the Euetib buildings, European Geophysical Society, Geophysical Research Abstracts, Vol.5, 3958pp.

Johnson, W.J., 2003. Geophysical detection of graves – basic background and case histories from historic cemeteries. Council for West Virginia Archaeology Spring Workshop, Charleston, West Virginia: MALA, Sweden.

Jol, H.M., 2009. Ground Penetrating Radar theory and application, first edition, Elsevier Scince Publication.

MALA., 2008. ProEx – Professional Explorer Controller Unit, Operating Manual Vol.2.0, Mala, Sweden.

MALA, 2009. Training course, October 20/10 – 2/11, Mala, Sweden.

Olhoeft, G.R., 1999. Maximizing the information return from ground penetrating radar: Applied Geophysics, Vol.43, p. 175 – 187.

Persson, K., 2005. Integrated geophysical-geochemical methods for archaeological Prospecting, KTH Architecture and the Built Environment.

Souter, C., 2007. Report on the 2007 Western Australian Museum, Department of Maritime Archaeology: Western Australian National Museum, No. 224.

Sensors and Software INC., 1999. Ground Penetrating Radar, Survey Design, Mississauga, Canada.

Sissakian, V.K., and Salih, S.M., 1995. The geology of Al-Ramadi Quadrangle scale 1: 250 000. GEOSURV, int. rep. no. 2315.

About the authors

Mr. Samir R. Hijab graduated from University of Baghdad in 1976 with B.Sc. degree in Geology, Geophysics. He joined GEOSURV in 1978. Currently, he is working in Geophysical Division in Geology Department. He has more than 45 documented reports in GEOSURV's Library. His major field of interest is engineering geophysics.
e-mail: Samir_Hijab@yahoo.com
Mailing address: Iraq Geological Survey,
P.O. Box 986, Baghdad, Iraq

Dr. Abbas M. Yass graduated from University of Baghdad in 1984 with B.Sc. degree in Geology, and M.Sc. in Electrical Resistivity Method in 1989 and Ph.D. degree in gravity and magnetic methods in 2002 from the same university. He joined GEOSURV in 1990. Currently, he is working in Geophysical Division in Geology Department. He has more than 10 documented reports in GEOSURV's Library. His major field of interest is gravity, magnetic electrical resistivity and GPR methods.
e-mail: abbas.yass@gmail.com
Mailing address: Iraq Geological Survey,
P.O. Box 986, Baghdad, Iraq