The Shallow Engineering Investigations Using GPR Technique in Fallujah City, Central Iraq

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Abstract

The shallow engineering investigations in Fallujah city in the Anbar Governorate were applied to the GPR technique. Fieldwork, including twelve profles, has been investigated. Depending on the type of antenna 250 and 500 Hz, the penetration depth ranges from 3 to 6 m. Some anomalies at different depths (1, 3, and 6 m) reflect weak zones. Another anomaly extend from the ground surface and continues to depth of 6 m. This was observed on the surface of the earth represented by fractures and cracks as a result of the arrival of groundwater to the surface. Due to the many construction phases in the city that occur in different years and may reach a depth of approximately 6 meters, in addition to the burial phases that occur at regular intervals to treat groundwater leaching lead to clear collapse areas that serve as a reference for the weak zones.

Keywords: GPR technique; Fallujah city; weak zones; engineering investigations; Iraq.

DOI Number: 10.14704/nq.2022.20.10.NQ55179 **NeuroQuantology 2022; 20(10): 2036-2044**

INTRODUCTION

Engineering geophysics is the research of subsurface materials and structures that may have engineering implications using geophysical technologies (Reynolds 1997). Geophysics tries to figure out the body's internal composition and a structure, as well considering the nature of the processes form the visible features on the surface (Matzner, 2001). A non-destructive geophysical technique is ground-penetrating radar (GPR). for photographing the subsurface at high resolution. It can thus be utilized in urban and a sensitive situations (Kearey et al., 2002; Griffin and Pippett 2002). The GPR geophysical technology, which was first specially designed for high-resolution subsurface imaging is now commonly used to assess the condition of foundations, pavements, concrete slabs, and walls.

GPR is a method for taking high-resolution images of the subsurface. (Davis & Annan 1989).The GPR is a high-frequency electromagnetic technique that scans the inside of the earth by piercing the surface with pulses of electromagnetic waves (Annan, 2002, 2003; Neal, 2004). Before being reflected back to the surface and picked up by a receiver, these waves experience changes in the sub surface's dielectric characteristics (Atekwana et al., 2000; Cassidy,2007).

This study aims to use GPR survey to detect areas of weakness in shallow depths in Fallujah city, central Iraq. The weakness areas include voids and fractures as a result of erosion and melting of parts of the soil layers due to the infiltration of groundwater to these depths.

MATERIAL AND METHODS

The study area is located within the administrative boundaries of Fallujah city it is located between two latitudes (33° 21' 9" - 33° 17' 47" N) and two longitudes (43° 49' 33" - 43° 44' 58" E) (figure 1). Five stations were selected within the study area and a radar survey was conducted on them.

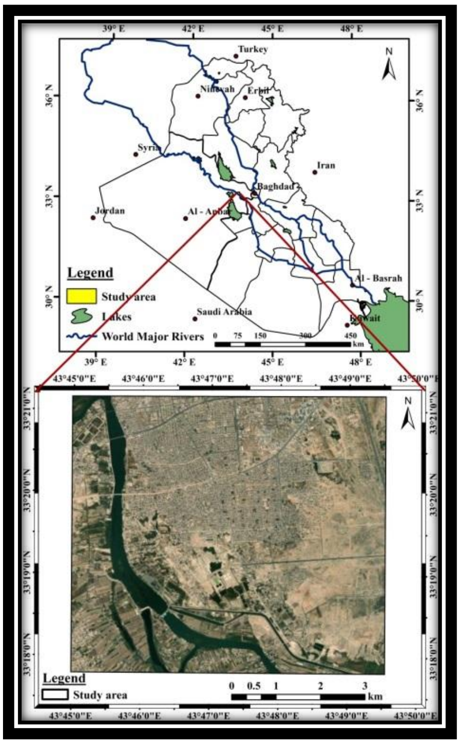


fig.1: location of study area

Quaternary Deposits: These deposits, which extend as far as the Euphrates River and are outcropped in Salah Aldin and Al Anbar governorates, are mostly Pleistocene deposits in the northern half of the area under investigation. They include sand, shale, clay, and gravel in some portions. The thickness of these layers varied and increased in density as we neared the Euphrates River (Buday and Jassim, 1987).

Distance (or depth in the ground) can be precisely estimated if the velocity through the ground is known and the energy pulses' travel periods are measured; (Olhoeft,2000., Conyers, 2004). Even though there are other factors that can affect the depth of investigation in a GPR survey, choosing the right antenna type and operating frequency is one of the most crucial decisions to make in order to obtain a sufficient depth of investigation of the important features.

To acquire the GPR data, MALA/Sweden-type devices were used in the fieldwork (RAMAC). Two types of antennas were used separately, operating at 500.MHz and 250.MHz. The higher frequency allows for better resolution at a shallow depths, whereas the lower frequency allows for a greater investigation depth.

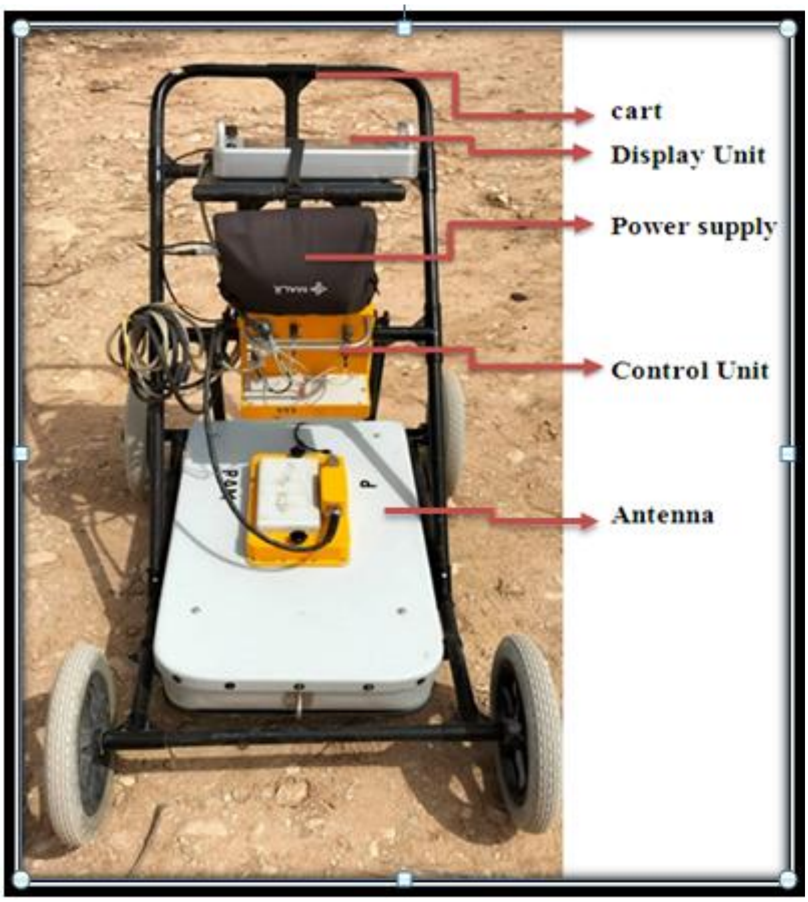


Fig.2: RAMAC/GPR Instrument

In this paper, a GPR survey was carried out by using RAMAC/GPR in the study area, Fieldwork, including twelve profiles, has been investigated. in the four building sites. with a dimensions (25 x 50m), 5 lines were selected in an east-west direction, with a length of lines is 50 meters, and a distance between the lines is 5 meters however, two transverse lines were measured at each site in a north-south direction. The initial test was carried out using a 250 MHz antenna and its notes were taken. Then the same lines were scanned using a 500 MHz antenna. The first antenna, 250 MHz, was used to investigate the best possible depth to reach through this area, and the second antenna was used at 500 MHz, in an attempt to get the best possible investigation with high resolution.

GPR DATA PROCESSING

The GPR data was collected to improve, and process using the ReflexW™ software program. Twelve GPR data profiles were loaded, and each record underwent a standard series of processing operations to enhance the signal and improve the record quality. The GPR processing pipeline is depicted in. Each profile was subjected to a number of processing steps, including Dewow filtering, Time-zero correction, Background Removal, Gain Function, and FK filter (figure 3).Dewow filtering was used to correct low frequency and DC bias in the data, time-zero correction to adjust the start time to fit the surface, 1D and 2D filtering to enhance the signal to noise ratio and visual quality, and gain function to enhance data display and interpretation (Jol,2009).Without the need for extra subsurface information, often in the form of trace editing, filtering, or data correction, the basic processing stages are normally implemented to the raw data (often automatically) and inject minimal operator bias into the data (Harry,2009). Most collection modes can be used with these steps. The proprietary ReflexW format was used to save the processed files.

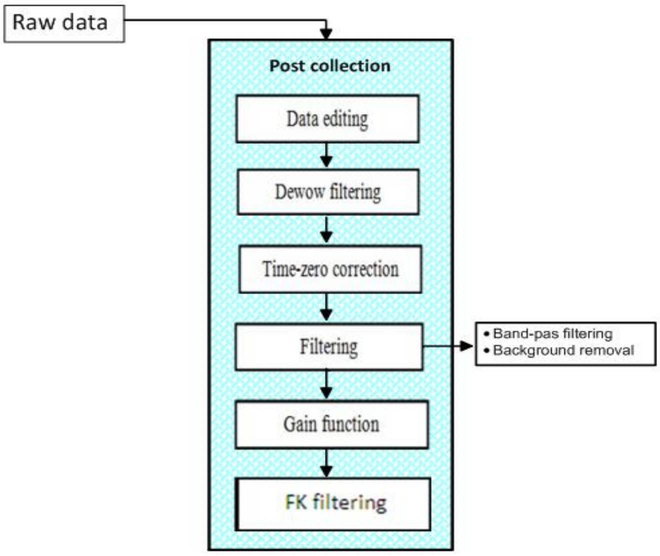


Fig. 3: GPR data flow using ReflexW processing program.

RESULTS AND DISCUSION

The radargrams that show the estimated true depth of subsurface features are produced in the final stage of the raw data processing. 2D sections are used to display the raw data from this investigation (radargrams). The quality of the profiles created using GPR directly from the field, without any processing, is demonstrated by the raw data (profile328), (Figure 4).

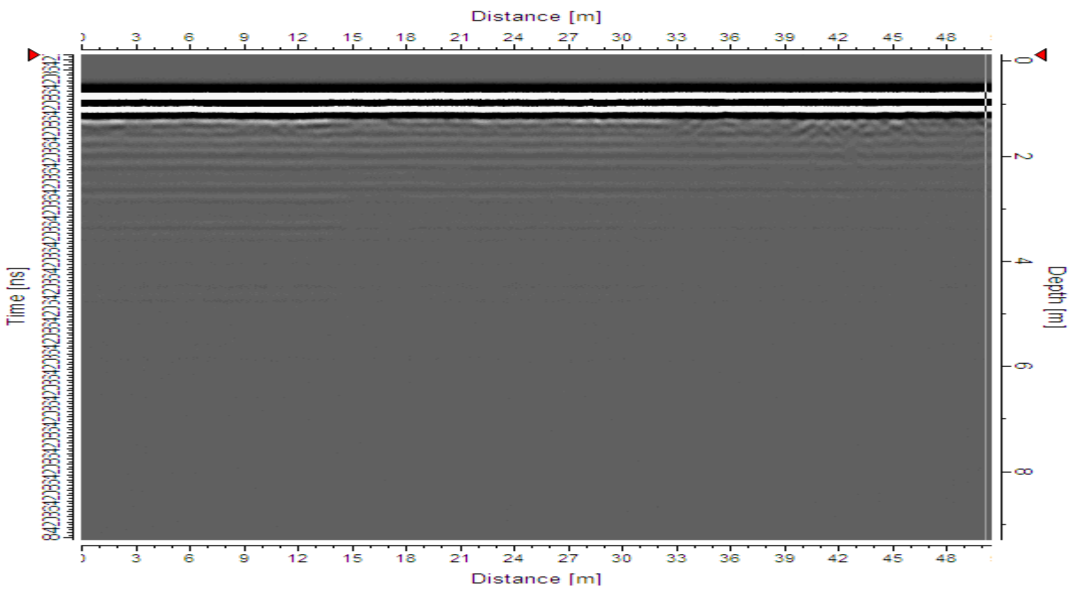


Figure 4: Raw data of GPR profile (328), before processing.

There are twelve radar grams were processed, using the Reflexw software (Figs. 5-9). Interpreting GPR data is a difficult process that sometimes involves personal solutions and other times it's fairly straightforward. Depending on the type of antenna 250 and 500 Hz, the penetration depth ranges from 3 to 6 m. After processing the radar gram data, it was discovered that an anomalous feature was present throughout the survey region. Because of the shallower contact and greater contrast between the loose and compacted soil layers, the first interface becomes significantly more visible.The profiles show topsoil strata, which indicate fill materials, at a depth range of 0 to 2 m .along the profile. The saturated soil was recognized starting from the depth of 2.5 m. It is also noted that there is some weak zone, which is clearly reflected in the profiles of two used antennas (250 and 500 MHz), which is expected to result from the presence of gaps in this soil. After treatment, many objects buried in the soil also appear in the study area and they are at shallow depths of 1 to 2 m (profile328). Also appearing in these profiles are some anomalies resulting from the impact of objects above the surface, such as (profile336, figure6).

It is also believed that there were metal objects buried in shallow depths that led to the doubling of electromagnetic waves and formed a state known as a ringing starting from a depth of (0.5 to 5 m) (Profile 330 Figure 5b). The saturation of the soil and the perfusion of groundwater close to the surface, in addition to the salinity rate in the soil, led to an increase in the values of electrical conductivity and thus attenuation of electromagnetic radar waves at shallow depths, and we did not obtain reflections in more depths.

Figure 5A (Station 1St) shows some anomalies at different depths (1, 3, and 6 meters) that reflect the weak areas at the station (1St). Figure 5B shows another anomaly that extends from the surface and continues to a depth of 6 meters. This was observed on the surface of the earth, represented by fractures and cracks as a result of the arrival of groundwater to the surface.

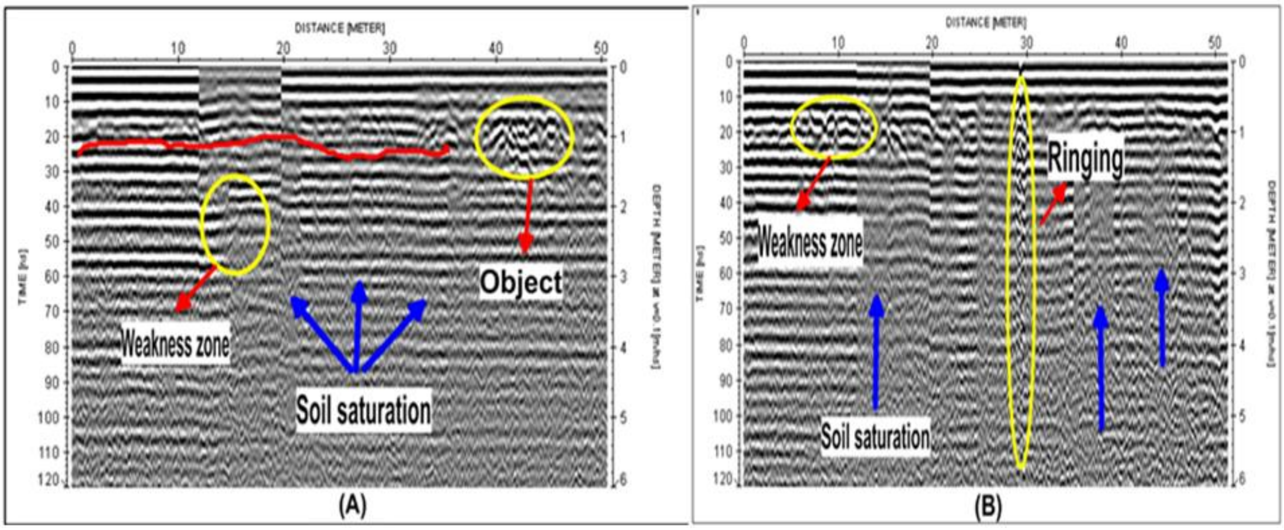
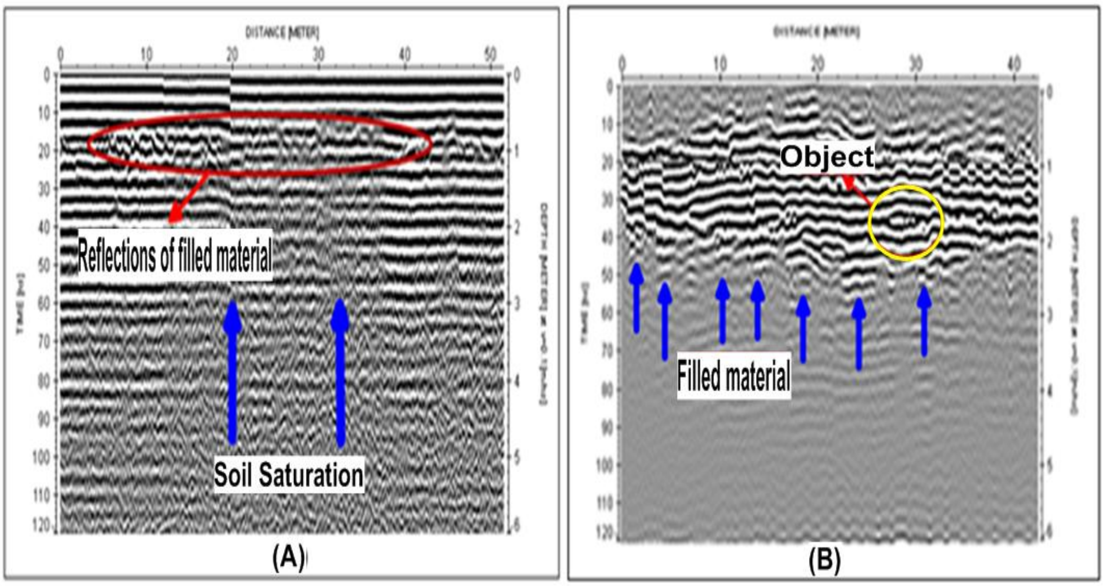


Fig.5: show the radargram (A) profile (328) and (B) profile (330) of antenna 250 MHz at station (1St)

At station 2St, figure 6 shows anomalies with a horizontal extension at a depth of 1 m and a thickness of up to 2 m. In addition to some saturated areas at a depth of 6 meters, which represent a weak area.The third station 3St, Figure 7 shows similarity with the second station (2St) in terms of being affected by the horizontal anomaly caused by the weak areas, but its thickness is 3 meters and its depth is 1 meter.

As for the third and fourth stations (Figures 7 and 8), they are characterized by more weak areas in terms of horizontal and vertical extension. Where the weakness is found in most of the cross-sections in the region. The reason is the widening of the area of weakness for the villages of the two stations of the Euphrates River. Where it represents an area saturated with water. Near these stations, surface water appears at the surface.



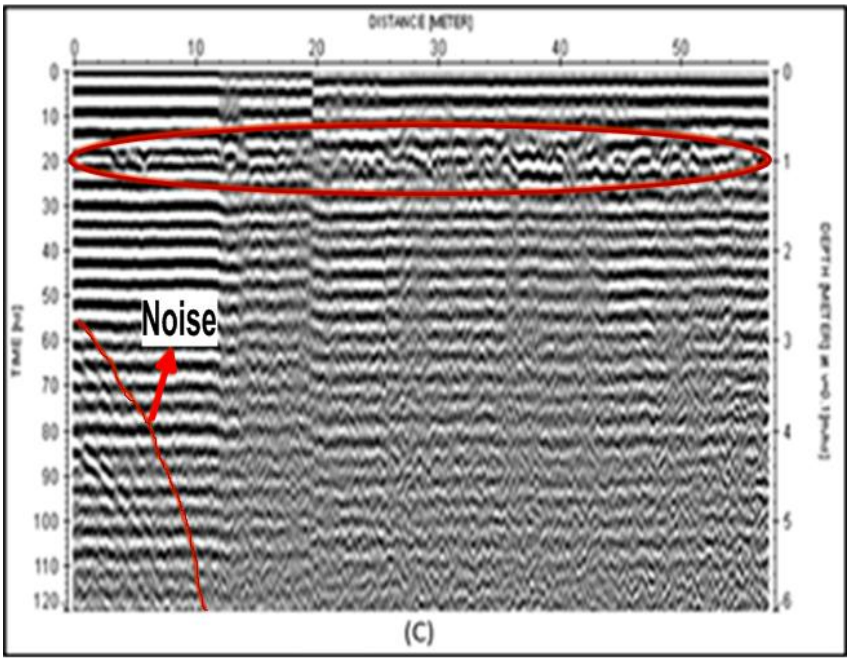


fig.6: show the radargram (A) profile (332), (B) profile (334) and (C) profile (336) of antenna 250 MHz, at station (2St).

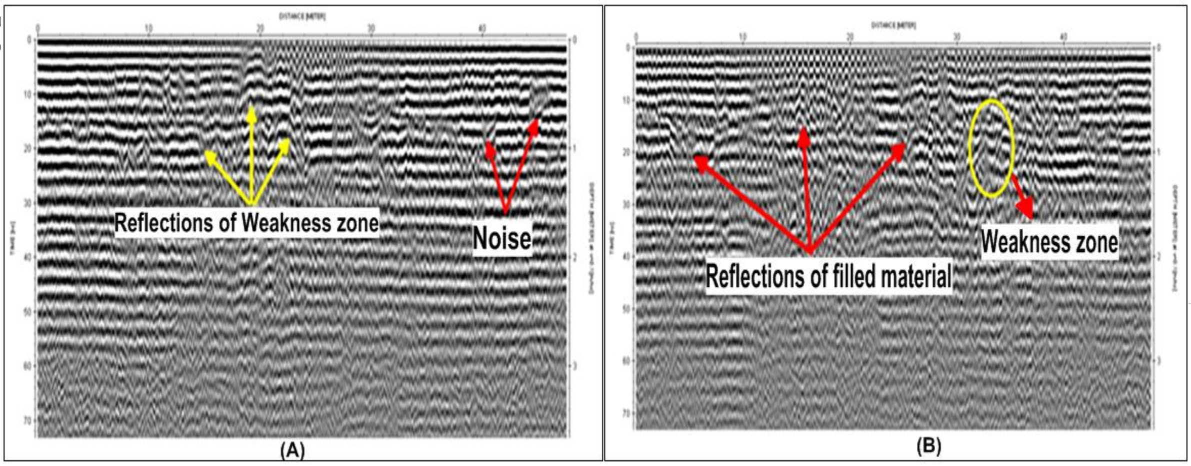
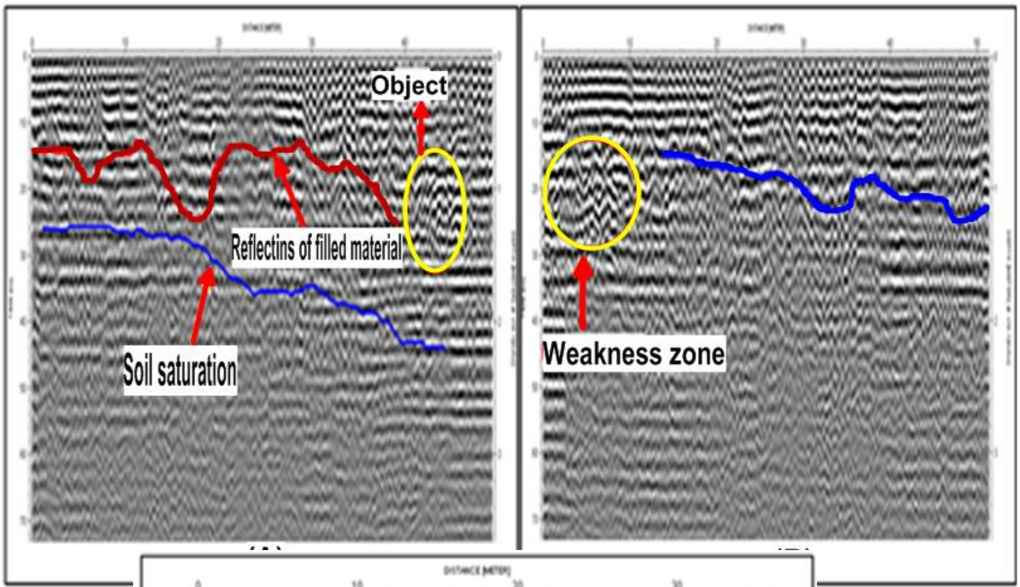


Fig.7: Show the radargram (A) profile (349) and (B) profile (350) of antenna 500MHz, at station (3St).



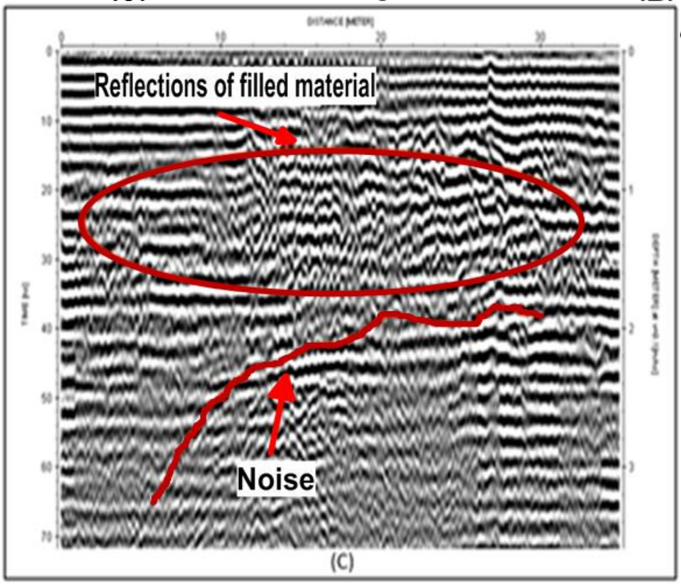


fig.8: show the radargram (A) profile (351) , (B) profile (352) and (C) profile (353) of antenna 500MHz, at station (4St).

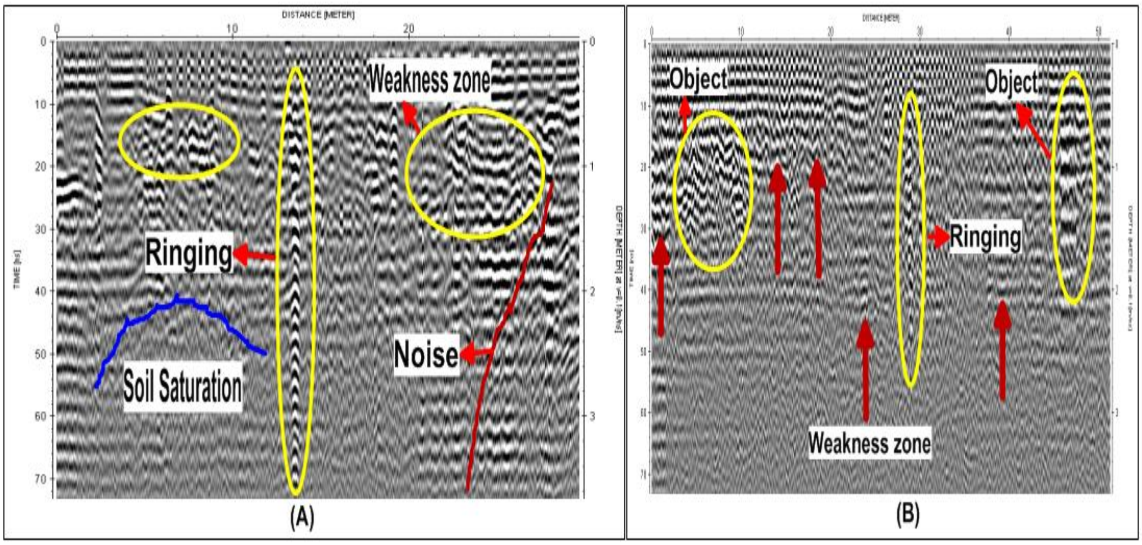


fig. 9: Transverse line on the study area show (A) profile of antenna 250 MHz.
(B) profile of 500 MHz, at station (1St).

conclusions

In this study, shallow engineering investigations in the city of Fallujah in the Anbar Governorate were applied to the GPR technique. The following list serves as a summary of the main conclusions:

1. It has been demonstrated that GPR is a very easy-to-use technique for identifying buried bodies, weak zones, and soil subsidence.
2. The majority of radargrams' raw data does not initially show the presence of subsurface substances or structures. However, once the data had been processed and the proper filter and other interpretation tool parameters had been applied, many of the analyzed subsurface structures became visible, demonstrating the excellent resolving power of the method.
3. Due to the many construction phases in the city that occur in different years and may reach a depth of approximately 6 meters, in addition to the burial phases that occur at regular intervals to treat groundwater leaching lead to clear collapse areas that serve as a reference for the weak zones.
4. The presence of groundwater close to the surface leads to the formation of weak areas in this site.

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