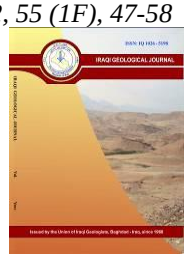
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Investigating and Mapping Abo Al-za'ar Archaeology Hill Using GPR Technique

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Abstract

The Ground Penetrating Radar survey can increase the amount and quality of the information when applied to archaeological prospection. In comparison to other geophysical methods, the Ground Penetrating Radar method's effectiveness rests in its applicability to a wide variety of site variables as well as the complementary nature of the data. One more benefit of the use of Ground Penetrating Radar for this investigation is that an archaeological location is usually shallow, which facilitates the Ground Penetrating Radar with an enhancement in the resolution achieved. An area with dimensions of 31×19 m dimensions was taken in cooperation with the Heritage and Antiquities Authority. This area was regularly divided into a group of lines in North-South and West-East, representing the radar device's path. The Tall Abo_Al-Za'ar district was surveyed using Seventy-two parallel and two antennas, 450 and 750 MHz, used respectively, for each survey. The results of this research showed the presence of several zones, the first represented by the upper layer, which ranges from 0.5-1 m, which is the burial area, as is evident in the Ground Penetrating Radar Image, interspersed with broken parts of the materials from which the walls of the area made. The second zone is located directly below the burial layer, and it is clear that there are archaeological walls made of clay at different depths. The last zone, located below the depth between 4-5m, represents the water-saturated area, which decreased the specific resistance, which caused loud noises and the inability to know what was in this range. The 2D view of the Tall Abo_Al-Za'ar district shows that the archaeological anomalies are distributed randomly and with different widths, and it was not possible to know the thickness of the walls in the area due to the high humidity

Keywords: Geophysics; Ground penetrating radar; Archaeological hills; Babylon, Iraq

1. Archaeological Background

Babylon is indeed an Akkadian term that translates as the doorway of God. It remained the seat of Babylonia, an old kingdom that thrived in the Close East, flanked by the Euphrates and Tigris rivers in southern Mesopotamia (Encyclopedia Britannica, 2002). According to the earliest accounts, Babylon was founded as a metropolis about the Twenty-third century BC. Previously, it was a provincial capital governed by the kings of Ur. The Bible reveals a lot about Babylonians from around 2000 BC through the destruction of Babylon (about 500 BC).

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2. Introduction

Geophysical surveying is a reasonably quick, non-invasive, and low-cost approach for obtaining many types of information about subsurface structures. Ground-penetrating radar is a safe, high-resolution geophysical tool of archaeological study that is a beneficial supplement to current excavations. Vickers and Dolphin were the first to use an archaeological survey in their work (Vickers et al., 1970). Where covered-up cultural materials are uncommon, contentious, or just off-limits, the Ground Penetrating Radar (GPR) has become a highly essential geophysical technology for archaeological research (Ernenwein, 2006). In addition, the use of GPR in engineering, mining, and environmental geology research has been widely documented and proven useful. GPR is a geophysical approach for studying subsurface archaeological and geological deposits that involve sending pulses of electromagnetic (EM) 'radar' waves into the earth to determine subsurface structures' forms, locations, and sizes. In archaeology, radar is used. Microwaves have wavelengths ranging from a millimeter to a meter, and are commonly connected with radar. As a result, brief pulses of radar ray may be smaller than 1 meter long, allowing us to resolve bits and pieces to this level of precision (Goodman and Nishimura1993). The high frequency means high resolution. However, the investigation target depth is important to estimate the suitable antenna frequency. GPR images are characterized by point reflection anomalies like dense or reflective buried items, planar reflection covered-up trenches and pits, or pieces situated at the top of the arc. These point reflection anomalies are concentrated mainly near the surface. Corresponding to these GPR images.

Abo Al-Za’ar hill is located in the north of Hilla city, Babylon, about 102 Km south of Baghdad at longitudes (44°26'52.55") and latitudes (32°30'13.28"N), which is located within the Mesopotamian Plain, on the stable shelf as stated by the physiographic unit of Iraq (Jassim & Goff, 2006). The area is surrounded from the north, east and south by a group of residential houses, while from the west, it is bordered by the railway and the horizontal Hilla silo (Fig. 1).



Fig.1. Aeromap of Babylon showing the study area location in the red rectangle

This investigation aims to explore and sketch the place of covered archaeological lineaments in a new zone in abo Al-Za'ar hill and estimate the GPR method's helpfulness in identifying the subsurface's dimensions of archaeological structures. Flood plain and Aeolian sediments from the Quaternary deposits cover the study region. The sediments consist of gravel, sands and silt lithological. Quaternary sediments have a thickness of 20-25 m. The first meter of these strata is mostly silty clay and sand from local waterways and generally homogeneous. The flood-plain deposits of Al-Hilla River dominate the western half of the area. The deepest meter of sediments beneath the earth's surface revealed several discrepancies in sedimentation outside and inside the outside wall. The area outside the wall is made up of about 1.5 m of sandy deposits, whereas the area inside the wall is mostly silty-clay. These resources acted as an outer wall that saved the interior from flooding (Boniger and Tronicke, 2010). Quartz, feldspar, carbonate minerals (calcite, dolomite), chert, and heavy minerals make up the sand and silt-fraction. Montmorillonite, chlorite, kaolinite, and illite are the clay minerals that make up the clay fraction. Together the carbonate and clay minerals appear to be Remnants in origin (Jassim and Goff, 2006). Pre-Quaternary deposits were discovered at a depth of 25.0 m below ground level, mostly made up of sands and silty clays (Fig. 2).

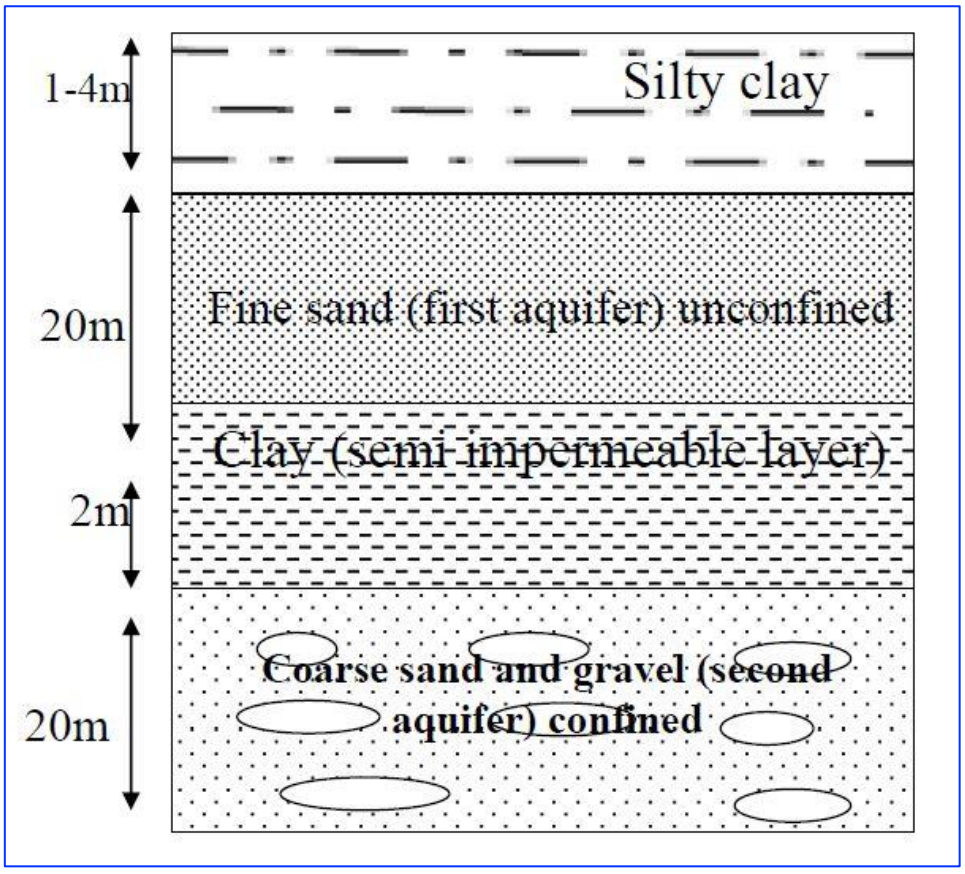


Fig. 2. Lithological section of the most common sediments in the study area

3. Materials and Methods

Firstly, reconnaissance field trip was carried out to detect all the phenomena and information to help design the site survey. Extent, location, and impact of any surface features such as archaeological structure, sources of noise that prevent measurements and the equipment's of possible fairly high are studied, some of remains of clay sun-backed things were found on the surface of the earth. The topographic survey took a period of day. This survey included the established of profiles and points of measurements and the study area nearly flat no need to a topographic correction.

The area with dimensions of 31×19 m was taken as determined by the Antiquities Authority (Fig. 3). The kind of GPR used in the research was Malå Geoscience, a Swedish style (RAMAC /GPR). The current survey used two types of antenna 450 MHz and 750 MHz. For ease the fieldwork and conduct rapidly, the surveyed part of Tell Abo_Alza'ar hill was devide to seventy-two parallel profiles in trending N-S and E-W are picked up the round-trip survey with one meter between each other. Each one of these GPR profile lines consists of some segments for detailed viewing. Each segment has a different length. On each GPR line, the survey starts from the first segment and finishes at the last one. In this location the survey starts at the 1st segment of the 1st GPR profile (DAT_1600) and finishes at the last segment of the 70th (last) GPR profile (DAT, 1671). The survey procedures used the setting parameters described previously (Fig. 4). The fieldwork was carried out in July, 2021.

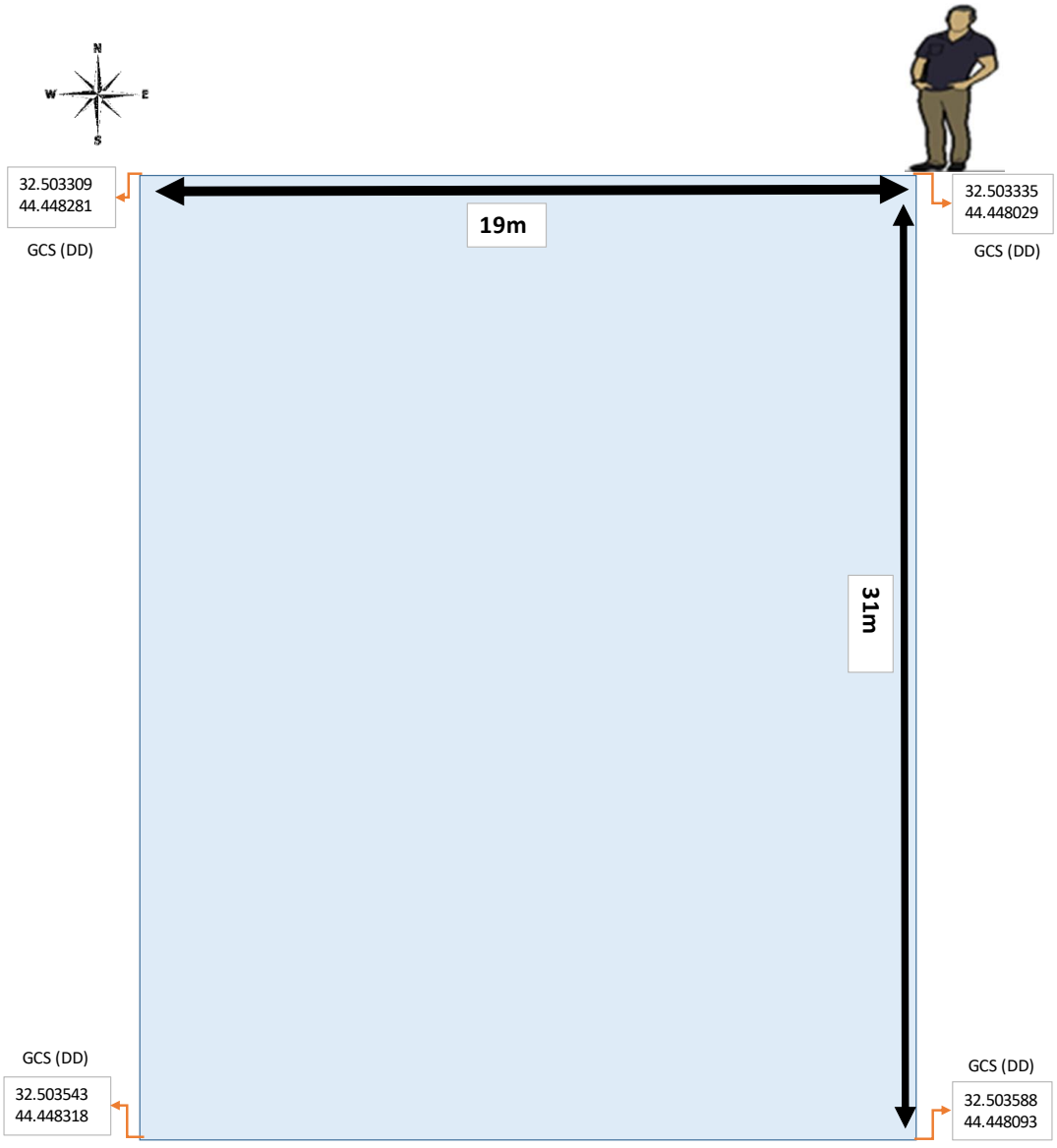


Fig. 3. Fieldwork setup within the boundary of Tel Abu Za'aar area

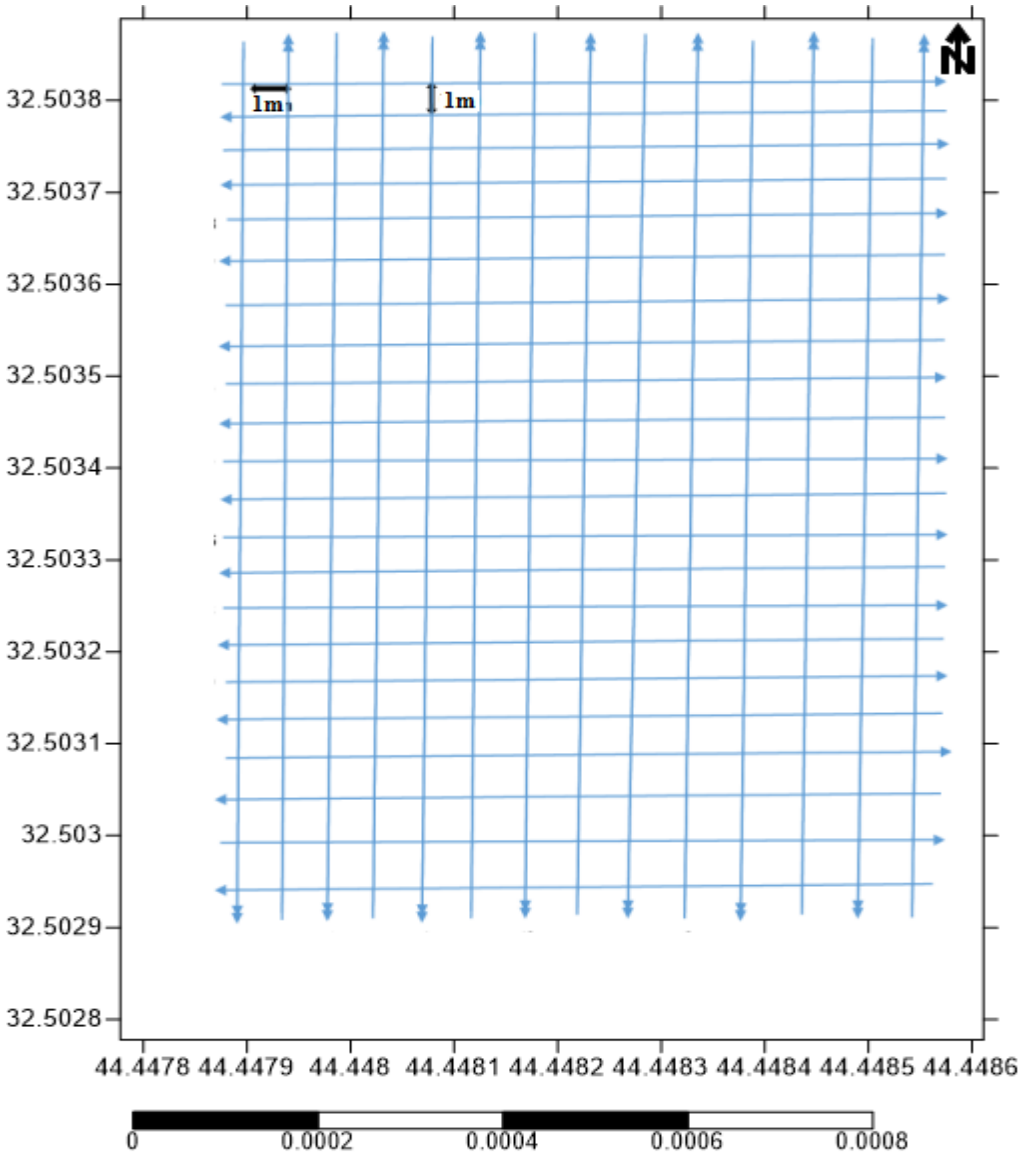


Fig. 4. Sketch shows the GPR profiles of survey design for Tel Abu Za'ar hill

4. GPR Data Processing

RAMAC Ground Vision program used to process the GPR data (version 1.4.6). Seventy-two GPR data recordings fed into RAMAC Ground vision, each record subjected to a consistent set of processing methods to amplify the signal and improve the record's quality. Background removal, band-pass filters, median filter, and automated gain control were applied to each record individually. To remove high-frequency components, a band-pass filter was used. Fig. 5 depicts a typical data processing pipeline for GPR. The purple highlighted areas in data processing include data editing, basic processing, advanced processing, and visualization/interpretation processing. Processing is typically an iterative process, with data passing through the loop numerous times before being finished at the visualization stage. After initial testing on chosen data samples, batch processing with limited interactive control may be extended to huge datasets. Basic data processing processes are frequently done to raw data (often automatically) and incorporate little operator bias into the data without requiring additional underlying information, such as trace editing, filtering, or data correction (Harry, 2009). Most collecting modalities are relevant

to these operations in general. The processed files were stored in RAMAC Ground Vision's proprietary format.

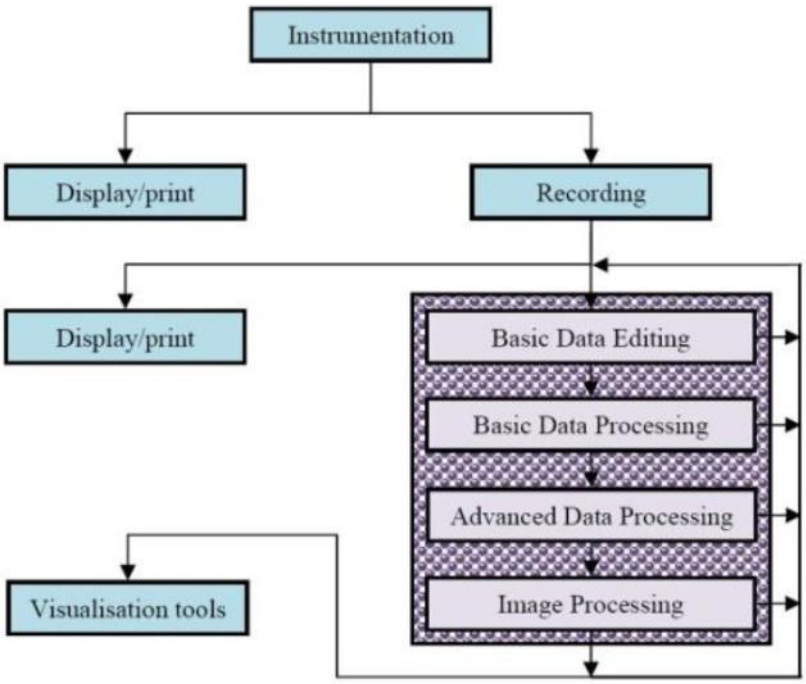


Fig. 5. Sketch of GPR Raw data processing steps (Harry, 2009 and Annan, 1999)

Most of the main filters that were used in this set are

- Time zero adjustment
- Amplitude correction
- Time varying gain
- DC removal filters
- Bandpass filters

These filters make the data more acceptable for interpretation, as shown in Figs. 6 and 7 below. In all GPR profiles, the valued velocity (by the reflected wave approach) is utilized to translate the TWT (perpendicular scale of the time in the radar section) into the real depth of underground archaeology. This value is set to 0.1 m/ns.

5. Discussion

5.1. Antenna 450 MHz Results

Thirty-six GPR profiles have been conducted using antenna 450MHz of directions X and Y, the standard measuring setting used for this GPR survey

- Antenna frequency: 450 MHz
- Time windows: 144 ns
- Velocity: 0.1 m/ns
- Trace interval: 0.035 m
- Sampling frequency: 5120 MHz
- Antenna separation: 0.180 m
- Number of samples: 736

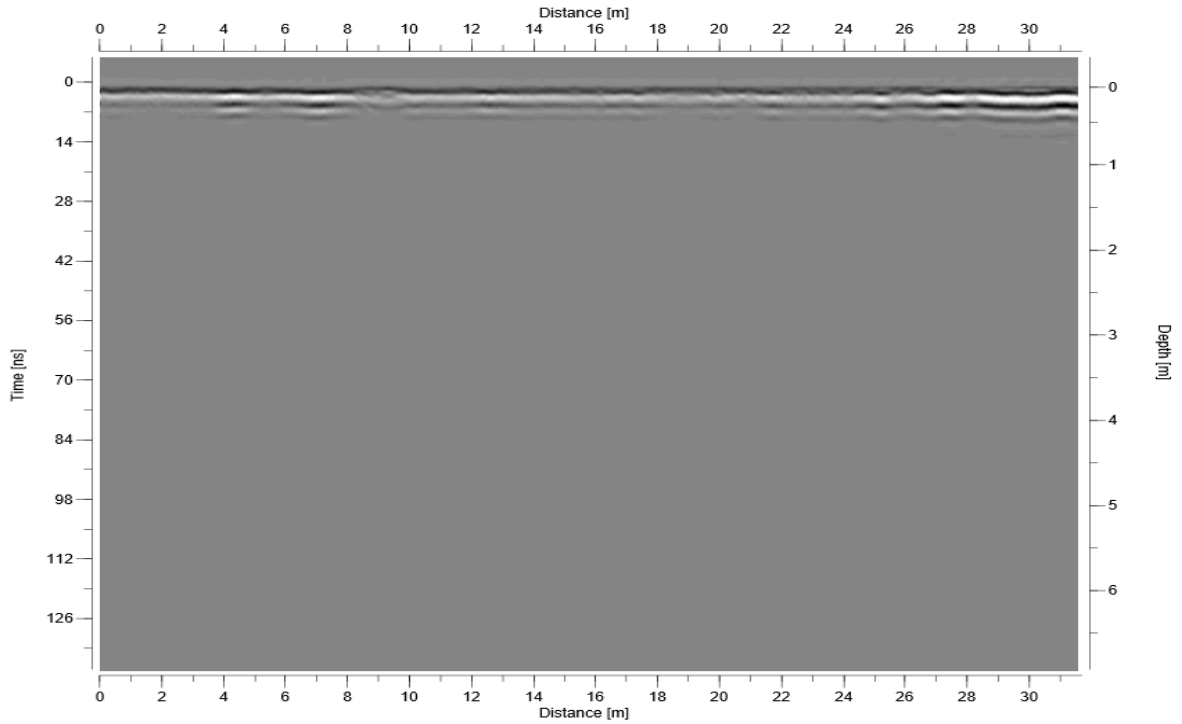


Fig. 6. GPR profile (DAT, 1601) before applying processing filters (raw data)

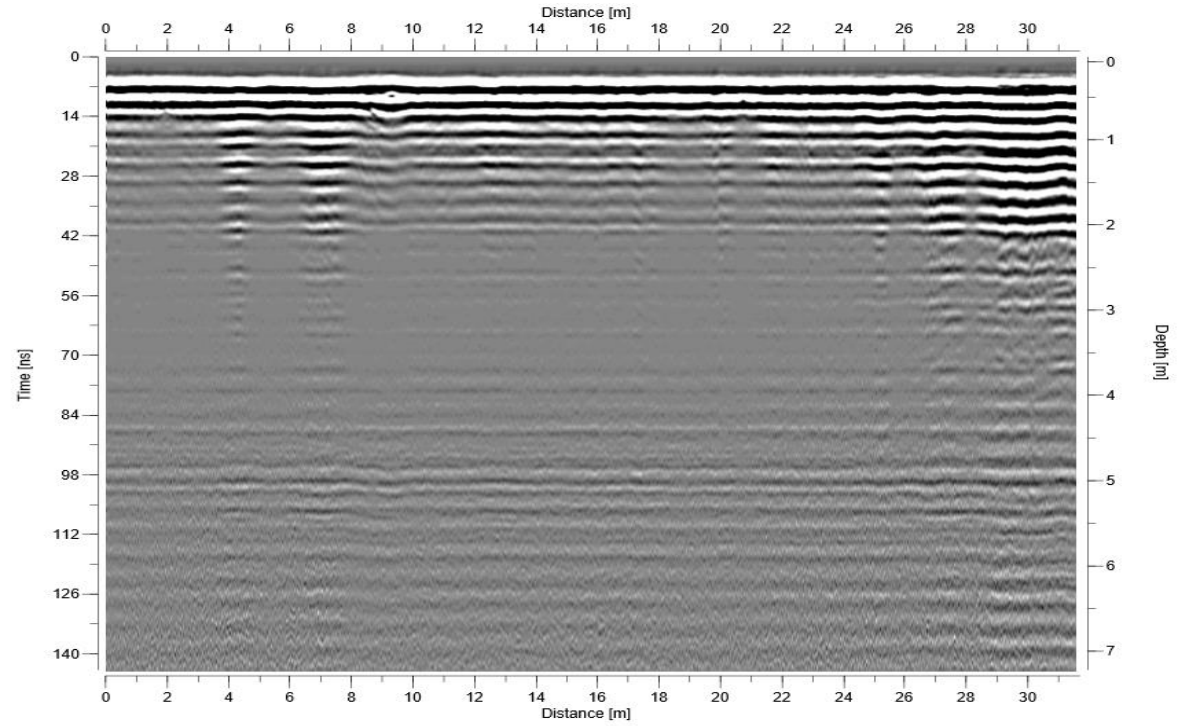


Fig. 7. GPR profile (DAT, 1601) after applying processing filters

Principally the GPR records were displayed by 2D sections. These side views were read by (RAMAC Ground vision), adding not the same filters in direction to enhance the profiles and decrease noise. Amounts of the filters had been let off because they increased the absence of simplicity of the signal. Most of the main filters used in these sections are Time-zero, Dc-removal, Background removal, and Amplitude correction. Below are the anomalies in study area Figs. 8 and 9.

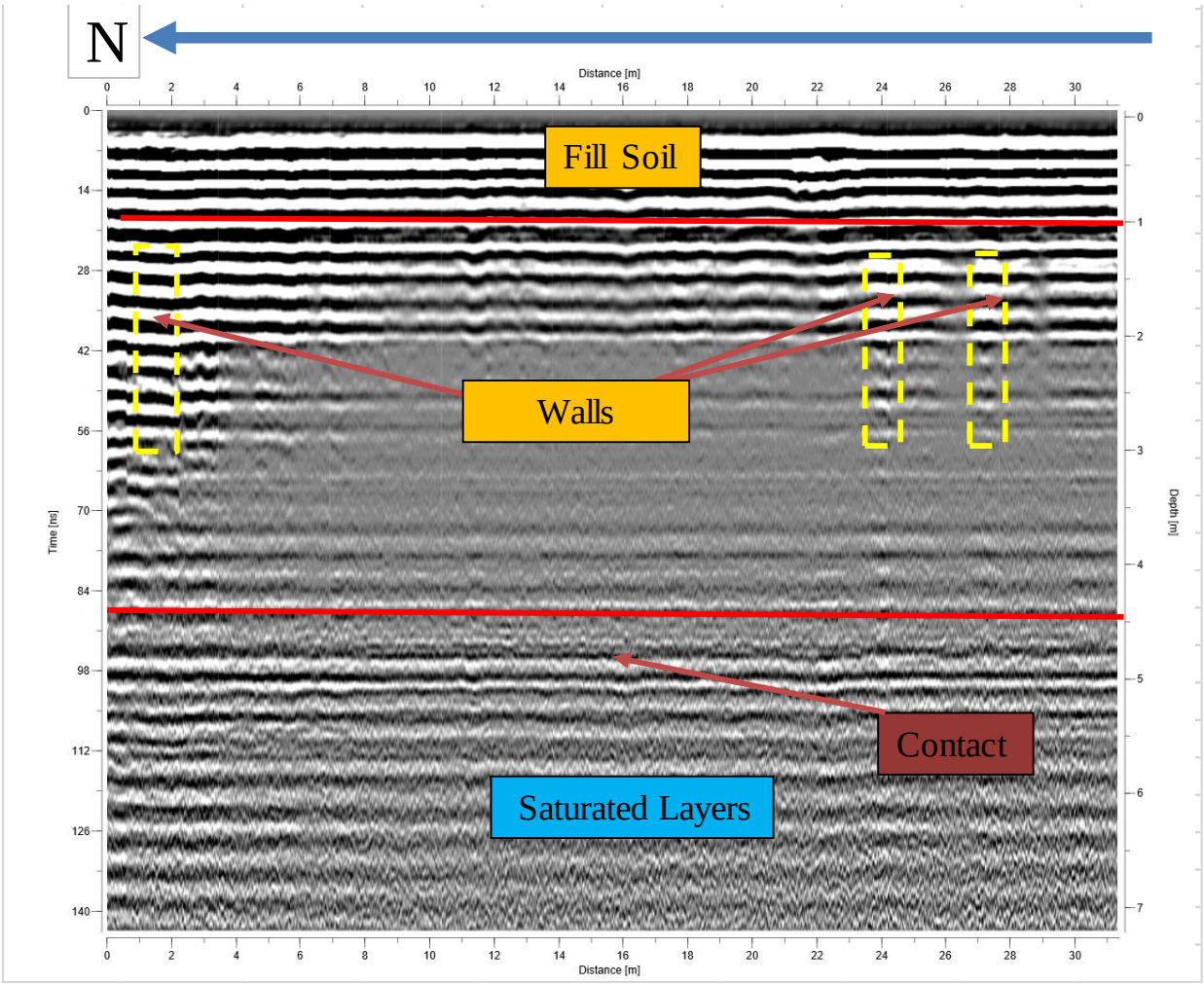


Fig. 8. Archaeological anomalies along the GPR profile (DAT, 1600)

5.2. Antenna 750 MHz Results

Thirty-six GPR profiles have been conducted using an antenna 750 MHz in directions X and Y, the standard measuring setting used for this GPR survey

- Antenna frequency: 750 MHz
- Time windows: 63 ns
- Velocity: 0.1 m/ns
- Trace interval: 0.049 m
- Sampling frequency: 9600 MHz
- Antenna separation: 0.140 m
- Number of samples: 600

The GPR data was initially represented using 2D profiles, which were explained using RAMAC Ground vision with several filters used to improve the profiles section and minimize noise. Parts of the filters were left out since they exacerbated the signal's lack of clarity. Most of the key filters in this set include Time-zero, Dc removal, Background removal, and Amplitude correction (Figs. 10 and 11).

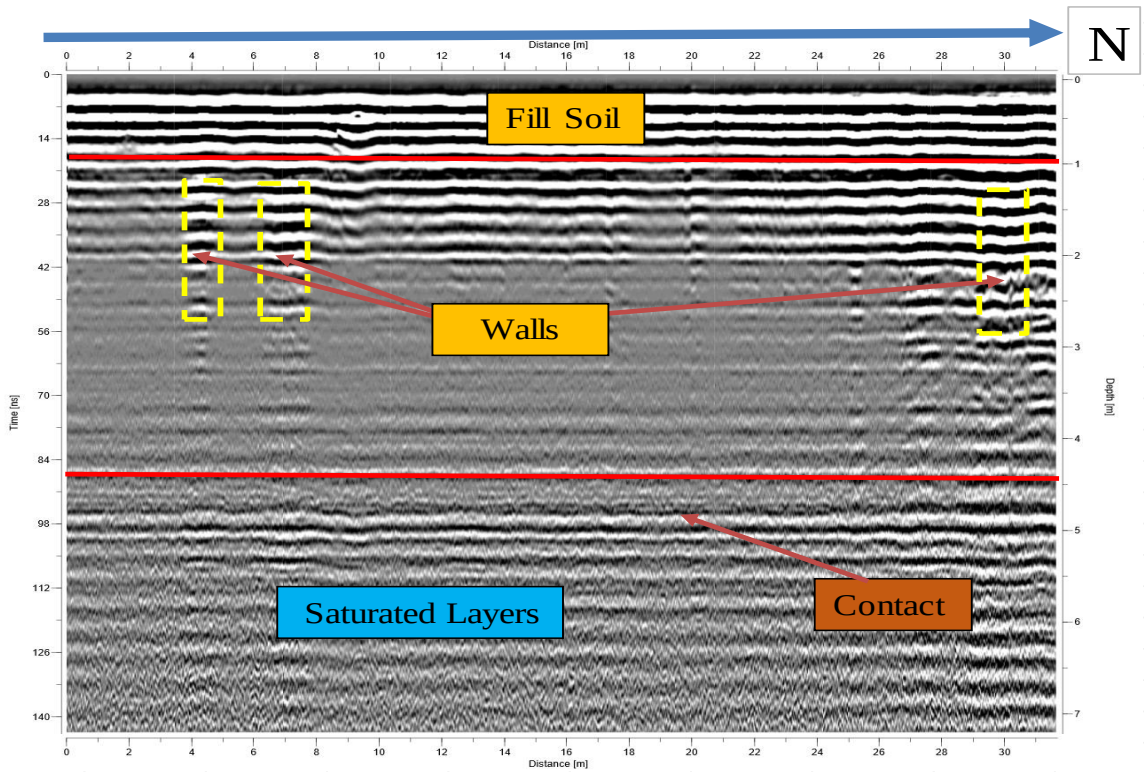


Fig. 9. Archaeological anomalies alongside GPR profile (DAT_1601)

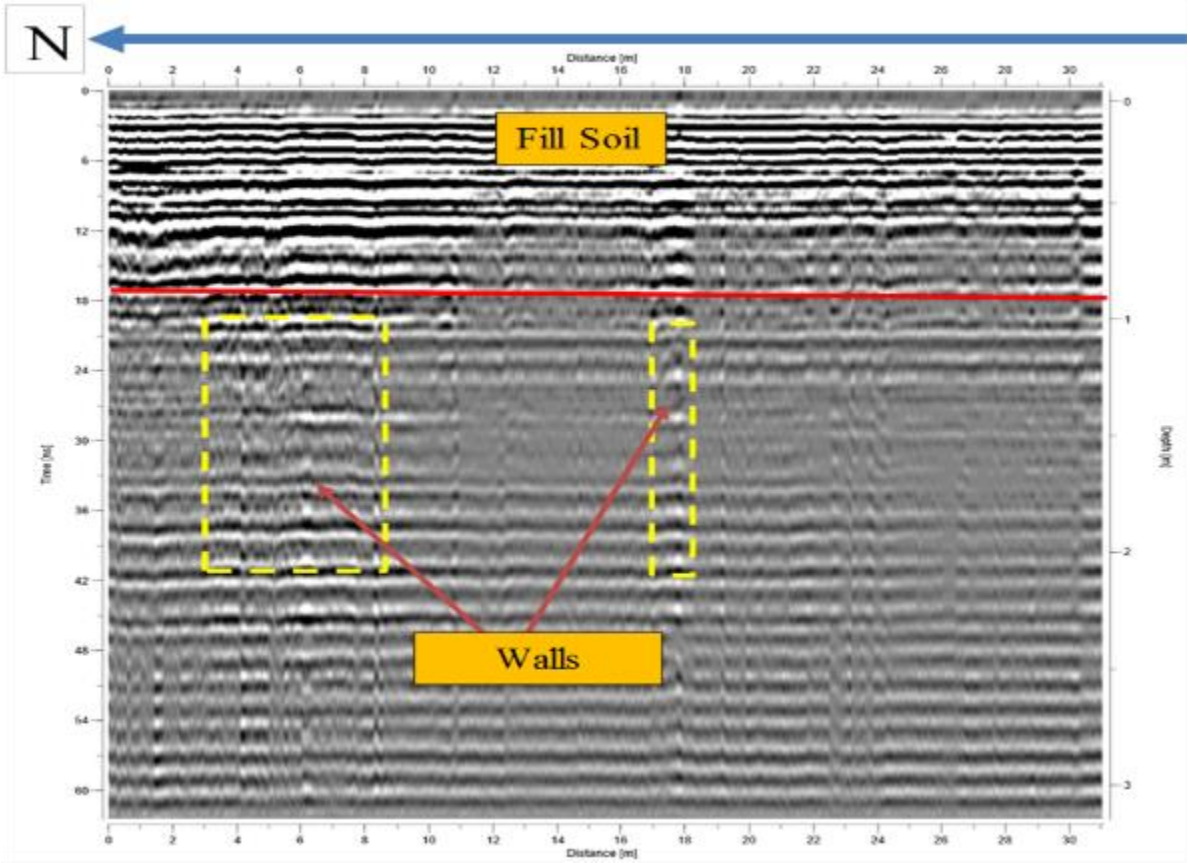


Fig. 10. Archaeological anomalies alongside GPR profile (DAT_1646)

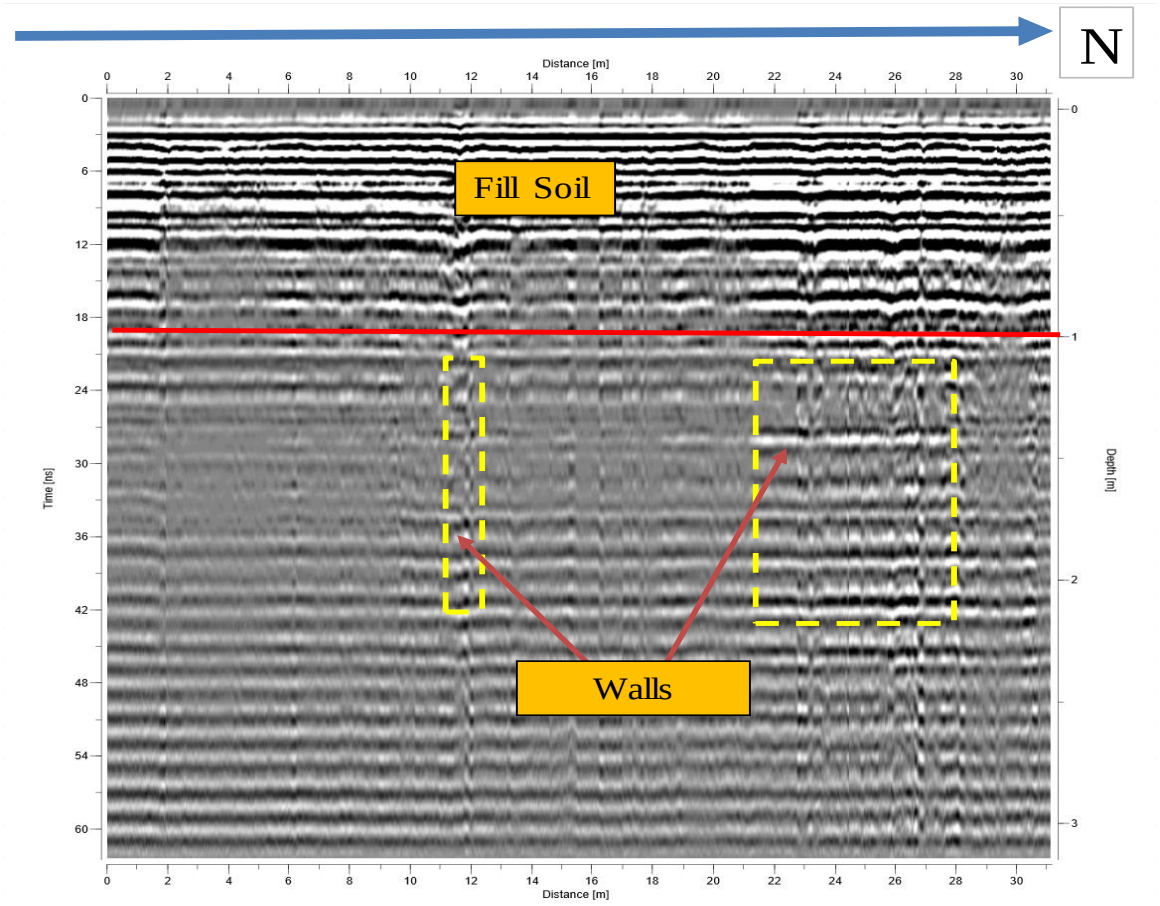


Fig. 11. Archaeological anomalies alongside GPR profile (DAT_1647).

5.3. 2D Views of the Archaeological Anomalies

Map of 2D outlook of the archaeological anomalies details in the study region are formed by using data of the GPR profile (from GPR line DAT_1600 to GPR line DAT_1671). The map structures represented in the 2D models, created by the ARCGIS program by dropping the anomaly coordinates for each profile. This information represents the location anomalies in the study region (Fig. 12). The almost subsurface features in the final 2D map show these probably shapes of walls. This means the wall can be used for any civil building, such as temples or big palace.

6. Conclusions

Based on the findings of the present study, the following conclusions are made:

- GPR images illustrate anomalies by reflections continuous with different widths. The GPR images indicate archaeological structures vertically extending through the images.
- The results of using a 450 MHz antenna are good and are better than an antenna 750 MHZ in this study because the given image has more resolution and anomalies more evident.
- The GPR technique is good, but the survey needs to support by another method from geophysical methods.
- In general, the GPR survey data are critical to understanding the form and location of subsurface structures, which may aid archaeologists and geophysicists in future investigations.
- According to the interpretation of GPR images models of the study area, the top zone was found to be including dried clayey and sandy soil with broken and weathered different archaeological resources such as fragmented brick and slag mixed with fundamental boulders. High conductivity

can see in the second zone. This second band is most likely affected by moisture in the area, which increases soil conductivity. The thickness of this layer varies depending on where you are on the site. The archaeological walls in the third lower zone are delineated. Most major abnormalities might be related to buried clay brick wall archaeological relics.

- The GPR results show a good resolution and integrated interpretation.
- The final images of processing are high spatial resolution and clear anomalies attributed to covered archaeological structures.

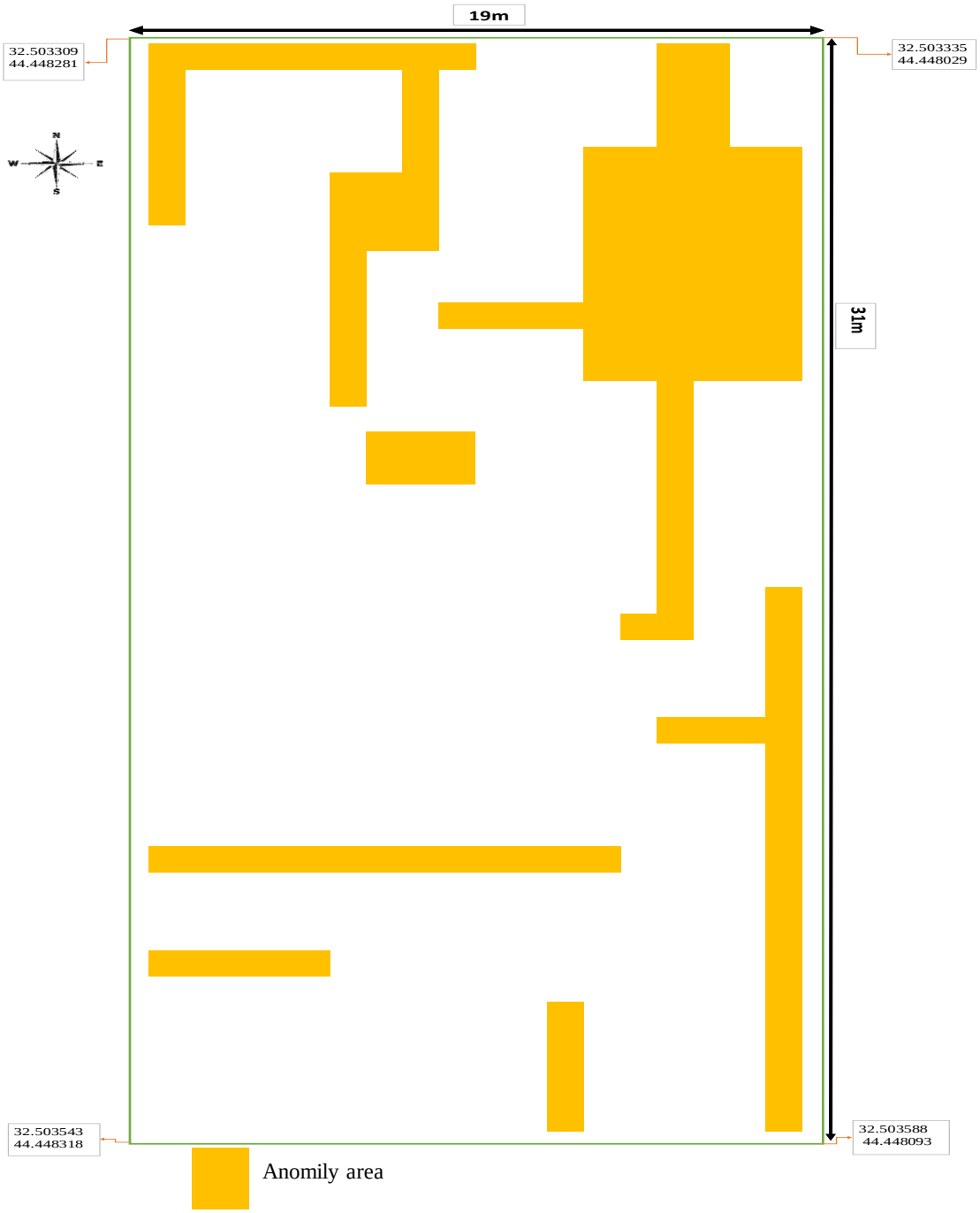


Fig. 12. Archaeological anomalies structures represented in the 2D models

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