Ground Penetrating Radar Survey Report:

Northern Israel Burial Tomb Project
Nazareth Vicinity

Data Acquired June 11 and 12, 2008

Report compiled July 20, 2008

Survey and Report Published by Mnemotrix Israel, Ltd.
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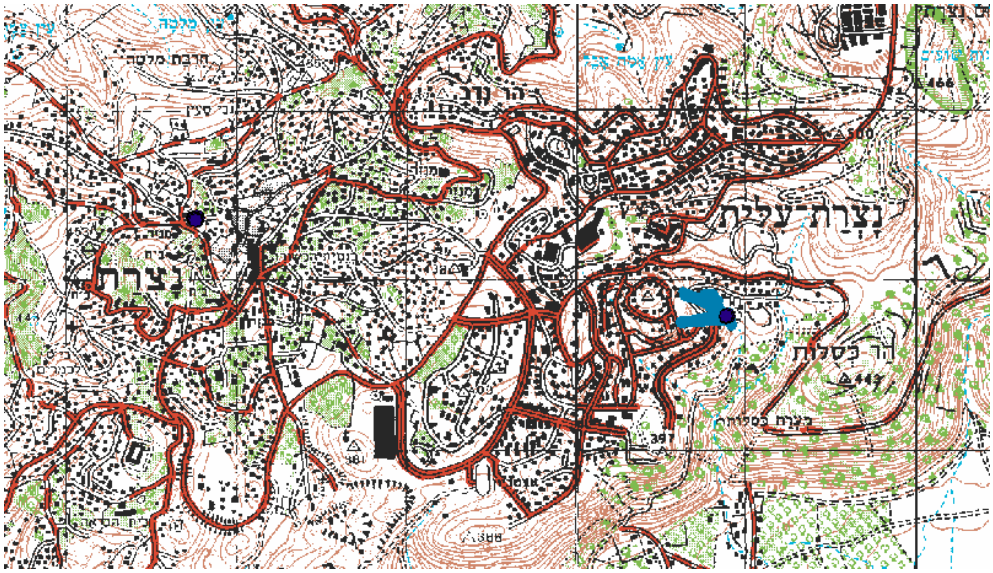
Ground Penetrating Radar (GPR) Study:
Nazareth Vicinity Burial Tomb Project
20 July 2008 Report of 11, 12 June 2008 Study

Background

It is a matter of record that 1st century CE burials have been located in the Nazareth area, or Natzeret, as it is pronounced in Hebrew. Historical and archaeological research shows that these tombs have similarities though found in at least 2 different locations, both dated to 1st century CE through pottery and other recorded finds. One place is in the city now known as Nazareth, beneath one urban courtyard. The other location is outside the city limits, quite a bit to the east in the hilly areas known as Natzeret Illit. The latter is much less known and little excavated. Historical record shows that Jewish families were relocated to this area in the time of Herod.



Map of Nazereth and Nazereth Illit to the East. Blue highlighting marks the points where two GPR surveys were undertaken by Mnemotrix Israel, Ltd. in June 2008, near the recorded location of 1st century CE burial tombs. The modern city of Nazereth is in the western portion of the map.

Under the archaeological guidance of Dr. Rami Arav, an archaeologist from the University of Nebraska in Omaha, we began work on June 11, 2008 in Northern, Israel in two locations near Nazareth. The prime goal of this ongoing project is to locate burial remains from a 1st century CE burial tomb in the surrounding area. Background information has been collected in order to locate areas of previous excavations knowing that burial tombs are indeed clustered throughout the area. It was known that a particular burial cave was excavated in the early 1990's by Nurit Feig, a member of the Israel Antiquities Authority, and thus it was decided that completing a GPR survey in the area of this tomb would be a worthwhile effort.

Secondarily, it was known that another tomb had been discovered near another now urban site within the city limits of Nazareth, which dates to the 1st century CE. This tomb had been discovered and partially excavated by IAA archaeologists. The

continuation of the burial tomb was left untouched adjacent and superseding the outer wall of the religious grounds. Thus it was determined that a GPR survey along this wall could possibly locate this continuation in a non-invasive manner.

Having decided on this initial plan, the members of the Mnemotrix team arrived at the sites on June 11th and 12th, 2008, and undertook the GPR Surveys covered in this report.

Nazareth Vicinity Survey Area 1 (East)

This site is located on one of the hills near the Galillee adjoining a residential area. A hill slightly to the east contains a winepress and several large cisterns dating most likely to antiquity. Figure 1 below shows the main area of data acquisition at the site with labeled anomalies to be discussed.

Upon arrival at the site it was decided that a long profile line along the edge of the ridge would be useful in determining where we should focus. It was found that the area just to the slight northwest of the large pine tree in the site was the most "interesting" in terms of GPR data acquisition. A smaller test grid was completed along a portion of the 63 meter long line. This smaller grid became encompassed in the larger grid seen in Figure 1. This grid was 10x10 meters wide. Three main anomaly areas were identified in post-processing that will be discussed in the next section.

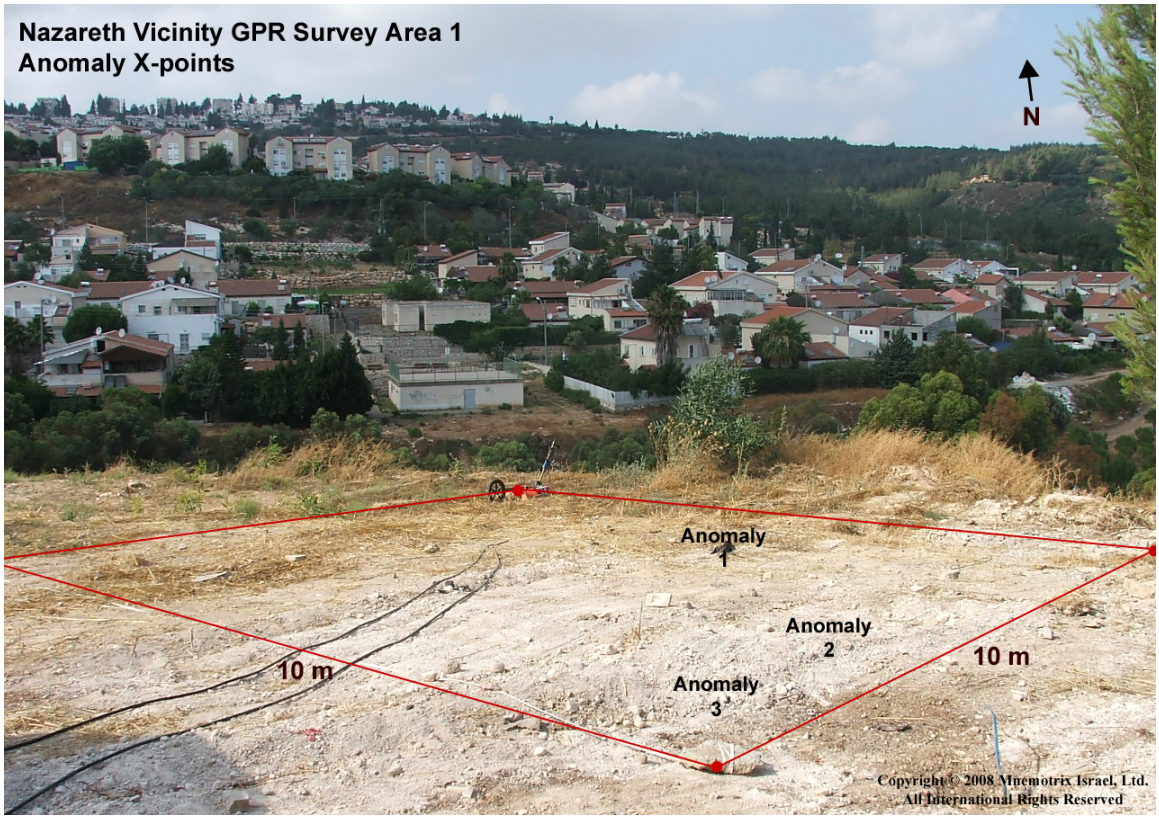


Figure 1: View of Nazareth Vicinity GPR Survey Area 1, looking generally North. Edge of pine tree can be seen on right of picture.

GPR Survey Actions Taken

A 400 Mhz GSSI GPR antenna was used for this project. A 100 nanosecond window was chosen, which would give us a viewing window of about 2-5 meters. We chose a dielectric constant of 5.5 as we would be sending the GPR signal through construction fill dumped at the site, in addition to sand and finally the limestone bedrock common in this area. After minor clearing of the site from debris, data acquisition began. Data was acquired every 1m covering an area of 10x10 meters in a generally north to south direction. A guideline cord was used in the field to mark placement within the grid during acquisition.

The grid was located as close to the extent of the tree as possible. This was because during acquisition of the GPR data along the ridge generally west to east, it was found that the area of interest was located quite close to this tree. It was a concern in the field of whether we were indeed imaging the root-system of the tree and not something more archaeologically related. However it was found that this type of pine tree tends to have shallow roots. After careful study of the sub-surface anomalies, we can be certain that the anomalies do not find their origin at this tree.

Post-Processing and Analysis

During post-processing all GPR data profile lines were filtered for background removal and their 0-positions (start point from the antenna as the GPR signal enters the sub-surface) were corrected. A 3D file of the grid was created where all lines were connected for spatial analysis of the site.

It has been found that there are three major areas of interest within this grid (See Figure 2). The authors believe that it is highly possible that two of these anomalies may in fact be individual graves due to their generally east-west orientation.

As we view anomaly areas 1 and 2 from ~1.5 – 2.5 meter depth we can see that they are in fact oriented in an east-west direction, which was a burial custom of the period, in addition to being oriented to the south towards Jerusalem. These anomaly areas are about 2 meters long and roughly one meter wide. In addition, their signatures, or characteristic hyperbolic profiles, are very similar to other graves that the team has imaged in previous projects.

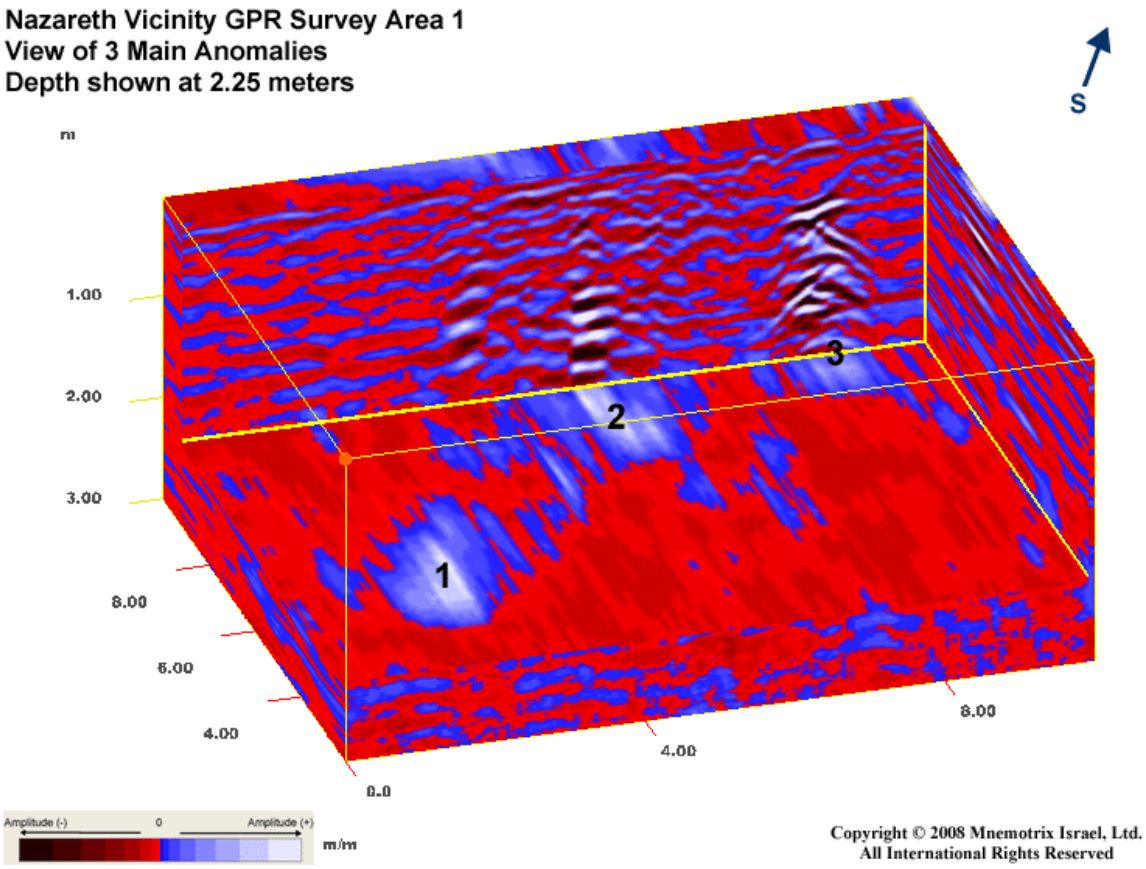


Figure 2: View of Nazareth Vicinity GPR Survey Area 1, Anomalies 1-3. These are also seen in Figure 1 in a field-view.

These anomalies can be seen more clearly in Figure 3 in the vertical Y-slice. Clearly visible horizontal but repeating in depth, flattened hyperbolas are imaged here that show Anomaly Areas 1 and 2 as probable graves. The third area is possibly also a grave, although the view is less clear than 1 and 2 thus we are reticent to call it this. Only future excavation can give us a 100% understanding of these sub-surface reflections.

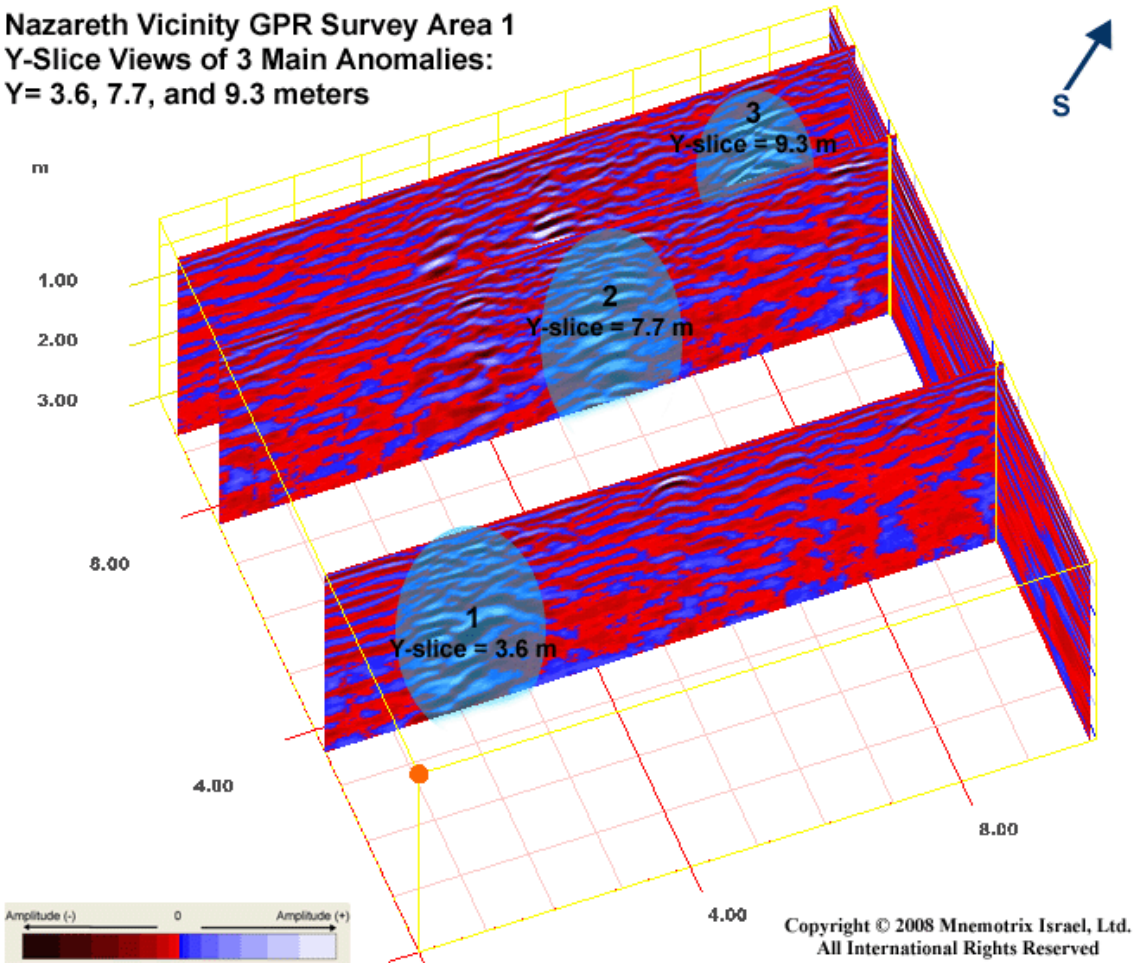


Figure 3: View of Anomalies 1-3 at Nazareth Vicinity GPR Survey Area 1. Anomalies 1 and 2 are most likely burials. Future ground-truth excavation can provide us the final identification.

Nazareth Vicinity Survey Area 2 (West)

The second day of work and the second site was focused in the courtyard of an urban area of Nazareth. As mentioned earlier, during salvage excavations to prepare the road outside of the facility as a street, a 1st century CE tomb was discovered. Two niches were excavated including bone remains. The continuation of this tomb was left intact and the site's outer wall was left in place preserving the rest of the tomb below the courtyard that we worked in (See Figure 4). Based on similar types of tombs of this period, we expected to find about 8-10 more niches arranged around a central open space. This tomb would have been carved into the local limestone bedrock with possible amounts of fill above and whatever sub-structure might have been present in the courtyard as time had passed.

Permission to non-invasively investigate was given and we were supervised by staff of the facility. The courtyard itself is bounded on its northern and eastern sides by very tall outer walls (See Figure 4). The GPR grid was based at this corner and extended

13 meters west of the eastern wall and 13 meters south of the northern wall forming a 13x13 meter gridded area. In the NE corner also exists a bedrock outcropping which we attempted to image and map in the GPR data. A concrete shed is located adjacent to the SE corner of the grid on the southern side. A metal mesh fence exists about 1 meter south of the SW corner. A rounded wall is located several meters west of the NW corner. It was noted by the facility staff while in the field that some years ago a well or cistern was filled in with stones in the general area of the courtyard. A wild pistachio tree exists in the western half of the grid, along the central axis. Because of this tree and the small size of the courtyard in general, it became difficult to attain a clear field photograph of the area.

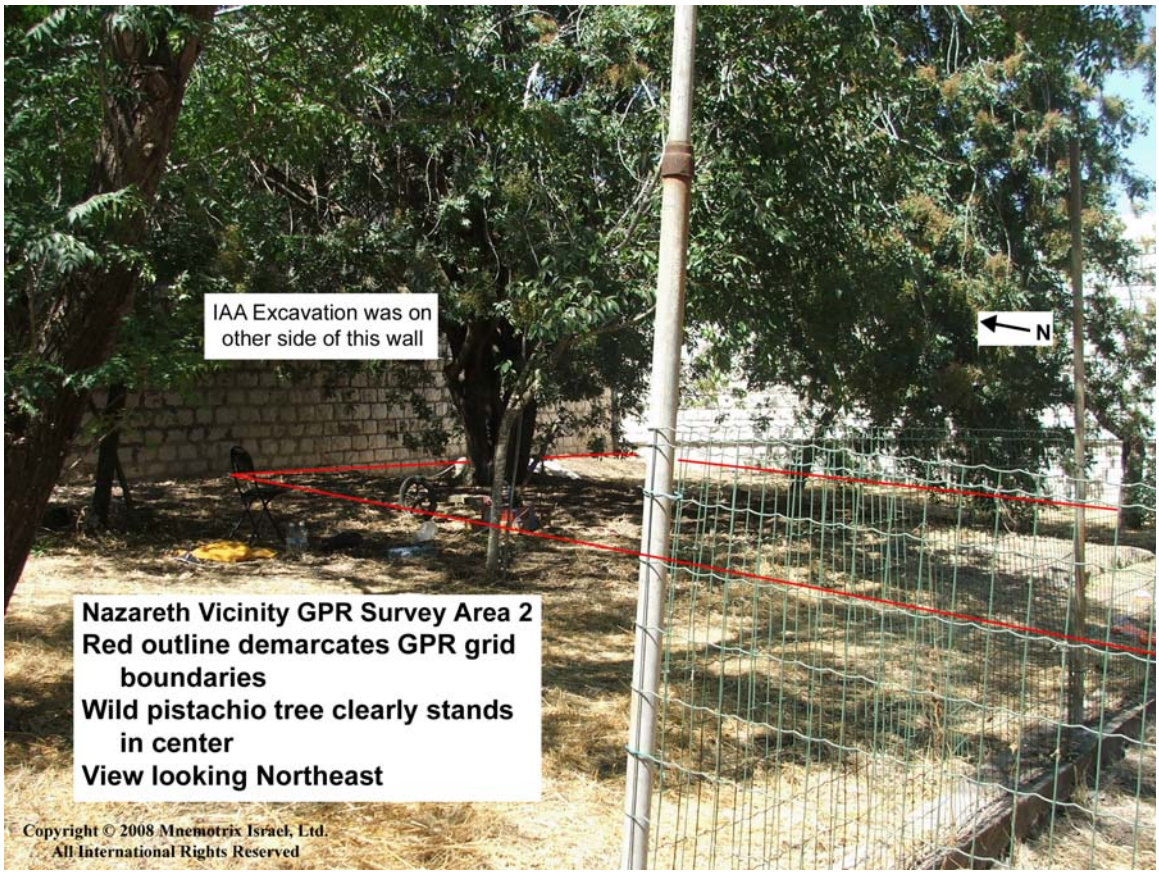


Figure 4: View of the Nazareth Vicinity GPR Survey Area 2.
Because of the pistachio tree it was quite difficult to obtain a clear field picture on which to place anomalies seen in the GPR data. General area is outlined in red. The view is looking northeast with the northern boundary wall to the street towards the left.

GPR data was acquired in two interlocking sets of data, collected with the 400 MHz antenna and a viewing window of 100 nanoseconds. The dielectric was set to 5.5 as this is consistent with the limestone bedrock of the region. Line spacing was 0.75 meters apart and was used in order to gain a high-resolution view of the sub-surface.

Post-Processing and Analysis

Standard post-processing included linking the individual GPR profile lines together to create a 3D file of the courtyard. After this, 0-positions were corrected for each file and a background removal filter was applied to the data. This would essentially filter out any background noise created by cellular phones or security radar in the area.

After careful analysis of the 3D file we can say that the bedrock clearly viewable in the field can be traced along the northern boundary of the grid into the subsurface. The subterranean room from the adjoining building on the southern boundary is also clearly seen in its proper location. There are three main anomaly areas that seem to form points within the general proposed outline of the tomb that lies under the surface in this area. This outline is clearly marked in Figure 5. Different color tables are used here to visually enhance each anomaly area. Further explanation and mapping of the anomaly areas are visible in Figures 6 and 7.

There are several main features seen in the GPR data from this survey site.

1. "Tomb": general outline of what we are referring to in the report as the main tomb area. This is clearly marked in Figure 5 and again in Figure 7 by a dark blue dashed line.
2. "Entrance": continuation of what we expect to be the previous findings from the IAA excavation. This continuation is referred to in this report as the "entrance". This is seen in Figure 5 and in Figure 7 by two blue arrows on the northern grid boundary.
3. "Well": we were able to image and locate the well that the sisters told us of. This is seen clearly in Figure 6 and in 7 demarcated by purple text, arrows, and a black circle.
4. "Pill" Anomalies: constant "pill" shaped anomalies appear throughout the survey and demarcate what we think could be open niches that had not collapsed and thus possible areas of excavation that would lead to products relating to the project goals. These are marked in Figure 7.
5. "Tree": the wild pistachio tree seen in Figure 4 is imaged clearly and circled in Figure 7.

What is referred to here as the "tomb" seems to have an "entrance" along the northern boundary of the grid in line with the outer wall of the nunnery. Slightly northeast of this "entrance" seems to be the whole of the "tomb". The roof of the "tomb" appears around 0.85 meter depth and the floor may be located close to 2.5 meter depth, with an offset of around 30 cm in any direction (x, y, z).

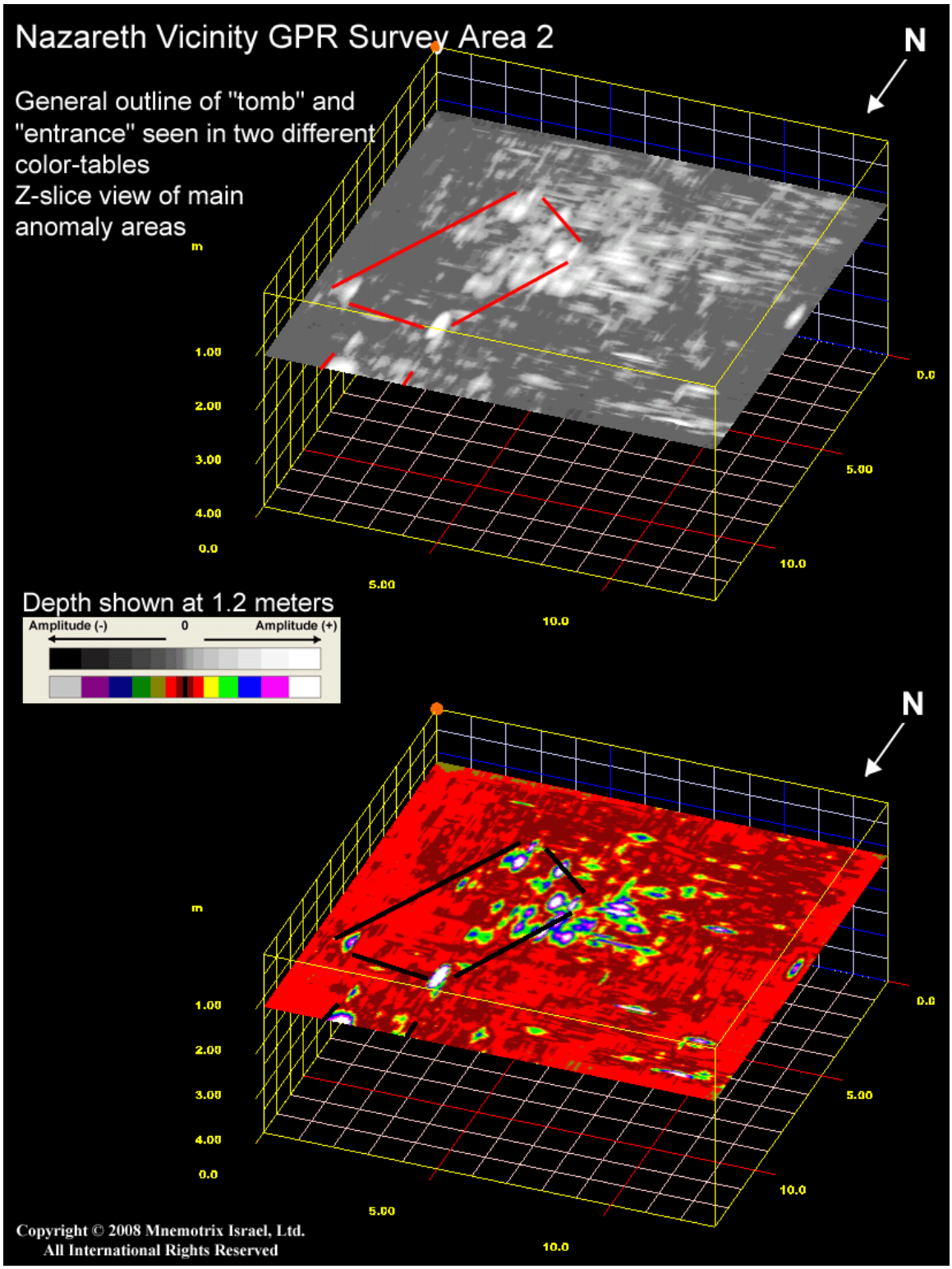


Figure 5: View of Nazareth Vicinity GPR Survey Area 2. Outline of the general area of the "tomb" anomaly inside the grid and the "entrance" seen on the northern boundary. Most likely this is the location of previous IAA excavation.

On the southwestern point of this anomaly area is the well that was mentioned to us by the sisters. It can be seen by a circle of bright white anomalies that have been highlighted in Figure 6. The well appears to run into or cut one of the possible niches of the "tomb". The well is clearly imaged in the GPR data where it was expected to be from measurements in the field. Figure 6 shows the well clearly with its center focused at point X=6.0 m, Y=4.94 m. The anomaly from the well disappears ~1.7 m depth, which makes sense as this well was filled in with rocks by the sisters themselves. Had the well been filled to the top surface, there is much chance that the GPR would not be able to image the feature significantly well enough for identification. This is because GPR is the best at imaging anomalies of significantly different materials. What we see here is likely to be the top of the original well and we are imaging the air in this gap as something significantly different from the surrounding matrix. The well appears to have cut into the anomalies that we have labeled as the burial niches of the 1st century CE burial tomb discovered and partially excavated by the IAA in recent years.

Looking at the data from the side profile, there are several flat hyperbolic features, similar to those seen in the 1st site location and graves imaged by the Mnemotrix team in past projects. When looking at the same data in a flat "z-slice" we can refer to these as "pill" anomalies due to their parabolic shape and similarity to what we believe a niche grave should look like in GPR. Many of these "pill" shape anomalies disappear by ~2.5 meter depth, suggesting this is the furthest reaches of the tomb feature we are concerned with here.

Figure 7 shows a map location of the major anomalies seen in the GPR data. This figure can be taken to the field for decision support of locations worth excavating if permission is granted to in fact pursue this action. Recommendations regarding this location are discussed further in the next section.

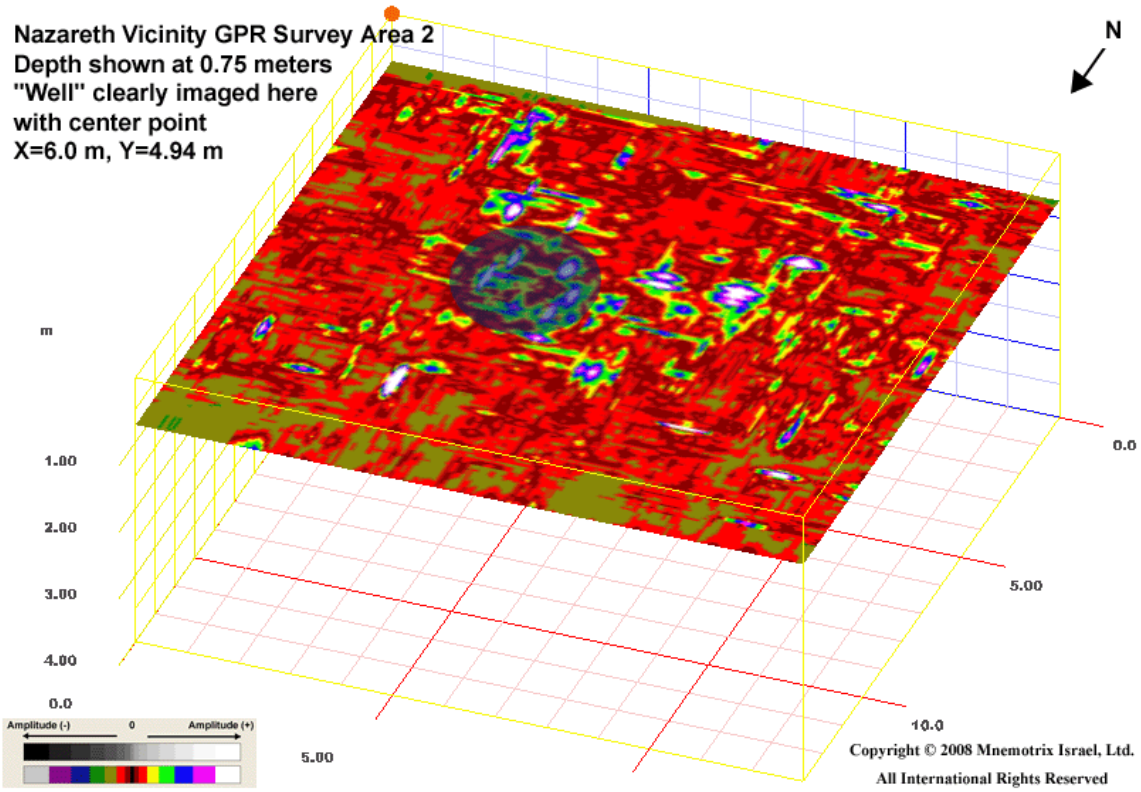


Figure 6: View of Nazareth Vicinity GPR Survey Area 2. The "well" is imaged and highlighted by a circle in center of grid. White anomalies mark the outside circle of the well clearly. It appears that this well is within the general area of the "tomb" and most likely cuts into part of the remaining burial niches of the southwestern corner.

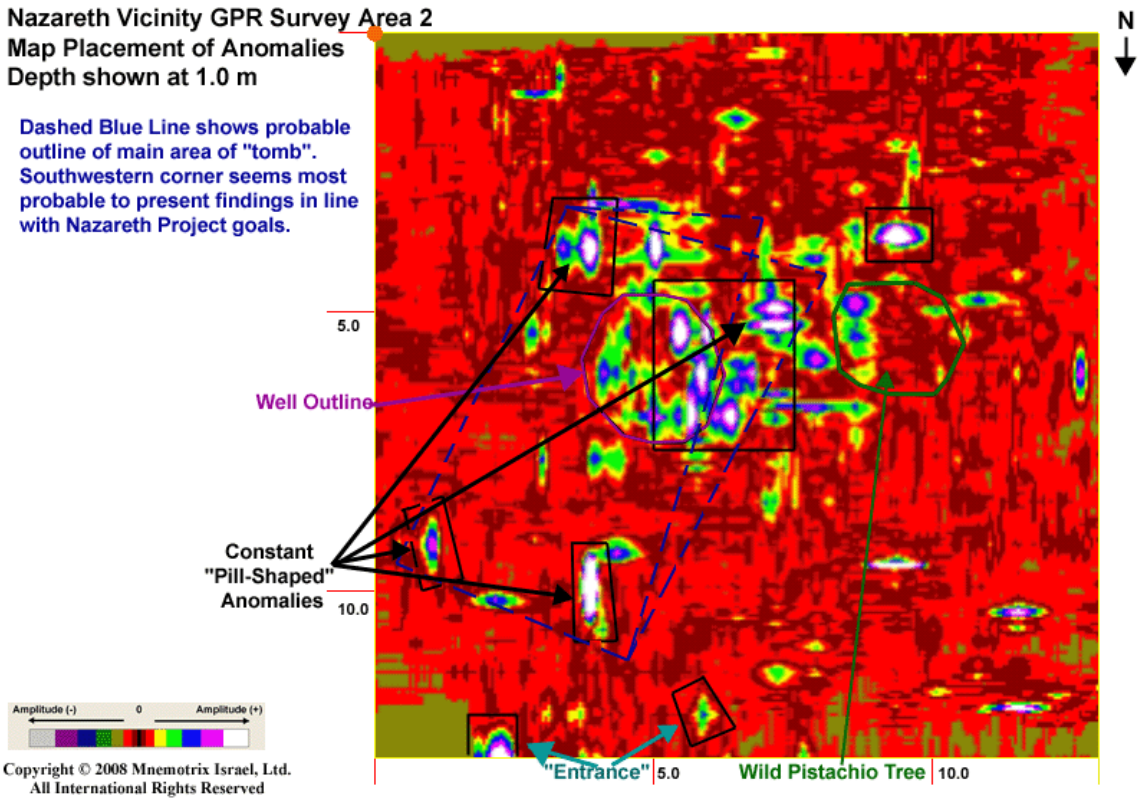


Figure 7: Map placement/location of major anomalies at Nazareth Vicinity GPR Survey Area 2. Southwestern corner of the dashed blue outline seems most probable to present valuable excavation material along lines of the Nazareth Vicinity Burial Project goals.

Conclusions and Recommendations

It seems that either the well known by the facility's staff at the second site and imaged in the GPR data cut into existing niches of the 1st century CE tomb believed to continue into the facility's courtyard, or was slightly to the outside of the tomb boundary. If only one area is granted for excavation, the Mnemotrix Team recommends beginning in this location, demarcated by the rectangular boundary pointed to by one of the "pill-shaped" anomaly arrows. As one can see in Figure 7, the area is not greater than 3 meters wide (square boundary box of "pill-shaped" anomalies), given the general recognized ground-truth offset of 30-50 cm. The target should be located within the first 1.5 meter depth, if not more shallow. If more areas are granted permission for excavation it is our recommendation to begin locating the "Constant 'pill-shaped' anomalies" clearly marked in Figure 7.

Based on the findings here described, it seems clear that there are only certain niches of the tomb in the 2nd site data that are still open and a good portion of them are actually filled in with debris from the years past. This is why we recommend excavation of the "pill-shaped" anomalies as they are similar in hyperbolic structure to other identified burials that the Mnemotrix team has located in the past.

The three main anomaly locations discussed above in first site location could be spots to focus on with excavation. If only a limited area is possible to be excavated, the southeastern corner anomaly, the northwest and the northeastern corners should be investigated first. Their central origin points can be seen more clearly in Figure 1.

This study has its greatest value in its purpose to image the sub-surface in preparation for excavation. Indeed, GPR is being used here to hone in on worthwhile locations of effort to unearth 1st century CE remains of the ancient citizens of this northern region of Israel. Eventual ground-truth excavation if done will shed more light on our findings here.