

Ground Penetrating Radar Survey Report:

The Horns of Hittin Archaeological Project Northern Israel



Data Acquired 26 June, 2008

Report compiled 17 August, 2008

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**Ground Penetrating Radar (GPR) Study:
The Horns of Hittin Project**
17 August 2008 Report of 26 June 2008 Study

Background

The Horns of Hittin Archaeological Project is a beginning excavation focused on the landmark that played a pivotal role in the battle for the Holy Land during the Crusader period. The project is in its beginning seasons as Project Director and Landscape Archaeologist Rafi Lewiss tries to put together the events of its past. Since the Crusader period much else has occurred here.

One of the most often used purposes of Ground Penetrating Radar in archaeology is for pre-excitation. In this way we are able to use the technology to give us a better sense of where it is most efficient to exert energy and resources for excavation in a particular area. Traditional excavation will follow this action and the datasets will be combined into a dynamic data-model that will assist in decision support for the site.

Of primary concern during this season were the remains of an ancient cistern that was present and last seen and documented at the site during the period of the establishment of the State of Israel in the late 1940's. Military use of the Horns by the Israel Defense Forces in more recent times has also occurred and the visible location of this ancient cistern was lost. Thus Mnemotrix Systems Israel, Ltd. was asked to perform an archaeogeophysical survey in the hopes of locating this ancient cistern and giving a view to the sub-surface at the site.

Description of Survey Area

The site is located slightly west of Tiberias, near Lake Kinneret in Israel. The ancient city of Nazareth can be seen to the southwest of the site. There are two Horns, or hilltops, that are the geological remains of an ancient volcano. Thus much of the stone matrix is basalt with a dark soil above. In addition, because of its location close to the northern boundary of the country and various military bases, there is a certain amount of surveillance radar that is a constant in the area. This was important to note as it potentially could be a barrier to the ground penetrating radar signal's penetration into the sub-surface or would mask it entirely. This was attended to during post-processing and will be discussed further in that section. The site has always been strategic from ancient to modern times. For this first 2008 season all GPR actions were based on the Southern Horn.

GPR Survey Actions Taken

In this survey, the key goal was to see if we could locate the lost cistern that was last seen in 1947. From Lewiss' experience at the site combined with aerial knowledge of the site in past and modern times, two main areas were determined as the focus of surveying. Two GPR grids were completed in this study. Results from the first grid proved most beneficial and will be discussed first in this report.

A 400 MHz GSSI GPR antenna was used for both gridded areas. A 100 nanosecond window was chosen, which would give us a viewing window of about 2-5 meters. We chose a dielectric constant of 8 as we would be sending the GPR signal through basalt and soil, for the most part, in this area.

Grid 1

In this first area we plotted a grid 5x15 meters running in a generally east-west direction along the Horn. Figure 1 below shows a panoramic view of the grid.

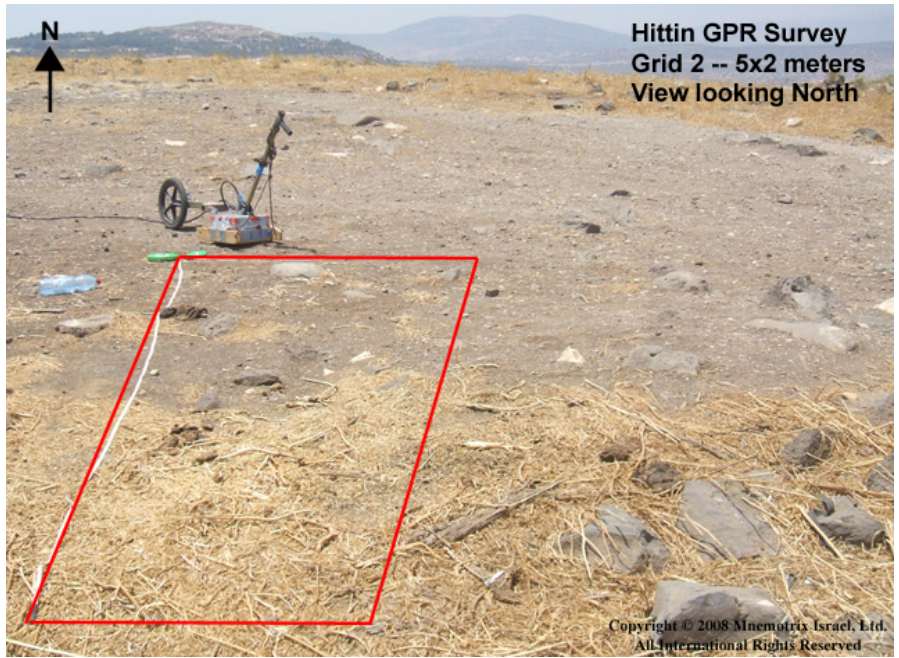


**Figure 1: Grid 1 of the Hittin GPR Survey, 2008.
Panoramic view looking south on the southern Horn.**

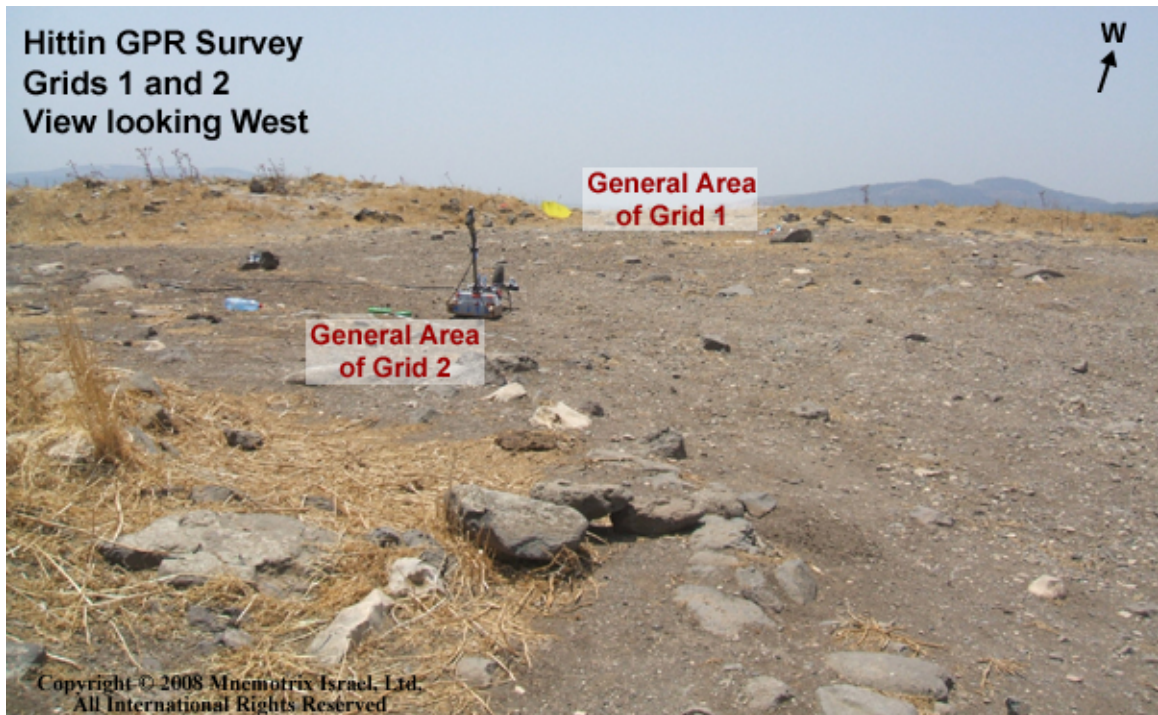
The eastern portion of the grid is clearly rockier towards the surface. Based on the topography at the location, it was hoped that we would transect the rectangular shape of the cistern if we oriented the grid in this way. Data was collected every half meter in a south to north direction.

Grid 2

This second grid was located to the east of the first. This grid was much smaller, 5x2 meters, oriented east-west (see Figure 2). Data was collected every half meter in an east to west direction. Figure 3 shows both areas in relation to each other on the southern Horn.



**Figure 2: Grid 2 of the Hittin GPR Survey, 2008.
View looking north on the southern Horn.**



**Figure 3: Hittin GPR Survey, 2008,
Areas of Grids 1 and 2 on the southern Horn.**

Post-Processing and Analysis

For both grids, standard post-processing was completed including correction of the zero-position as the radar energy first enters the sub-surface and horizontal background removal. Horizontal background removal was used in order to filter out the constant "ringing" caused by the high iron contents in the basalt. Deconvolution was also used as a means to filter out constant horizontal banding often caused by reconnaissance radar. This helped to make the sub-surface view more clear so that archaeological features might be seen more easily.

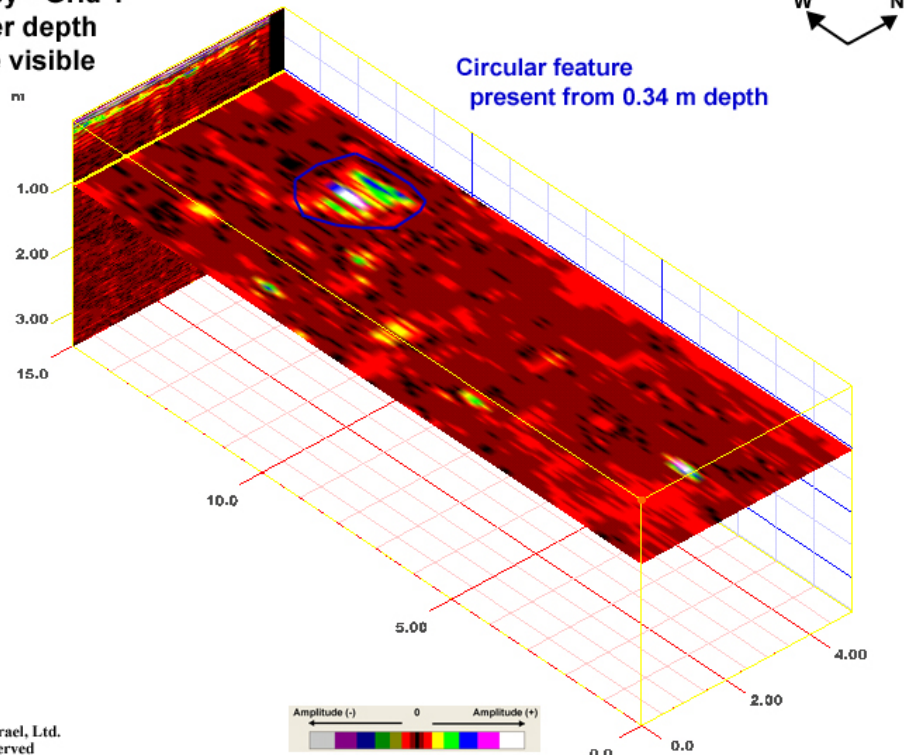
Adding to the complexity of the site itself, iron grounding pegs were placed throughout the Horn by the military in modern times to protect from electrocution during storms. These pegs were noticed often while physically surveying the site and show up strongly as ringing features in the GPR data. For our purposes, we must essentially ignore these points as they have no archaeological value towards the location of the cistern or other ancient features.

Grid 1

The main anomaly seen here was a circular feature with a linear extension. The circular feature begins to be seen around 0.35 meter depth and continues to get stronger as it proceeds further into the ground. The image is visible in Figure 4 below. What is most interesting is that by 1.74 meter depth the circular feature gains a linear extension, seen clearly in Figure 5. The feature continues until around 2.25 meters and has fully disappeared by 3 meter depth. It is located from 11 to 14 meters proceeding east to west in the grid and close to the northern boundary.

GPR works in Archaeology to point out areas of future focus. It seems that this feature is the most interesting from our findings this season and certainly could be the remains of the cistern as it has a similar shape. The rest of the grid did not prove fruitful in terms of sub-surface consistent features. Other high-amplitude reflection points in the grid we presume are actually grounding points mentioned earlier in this report.

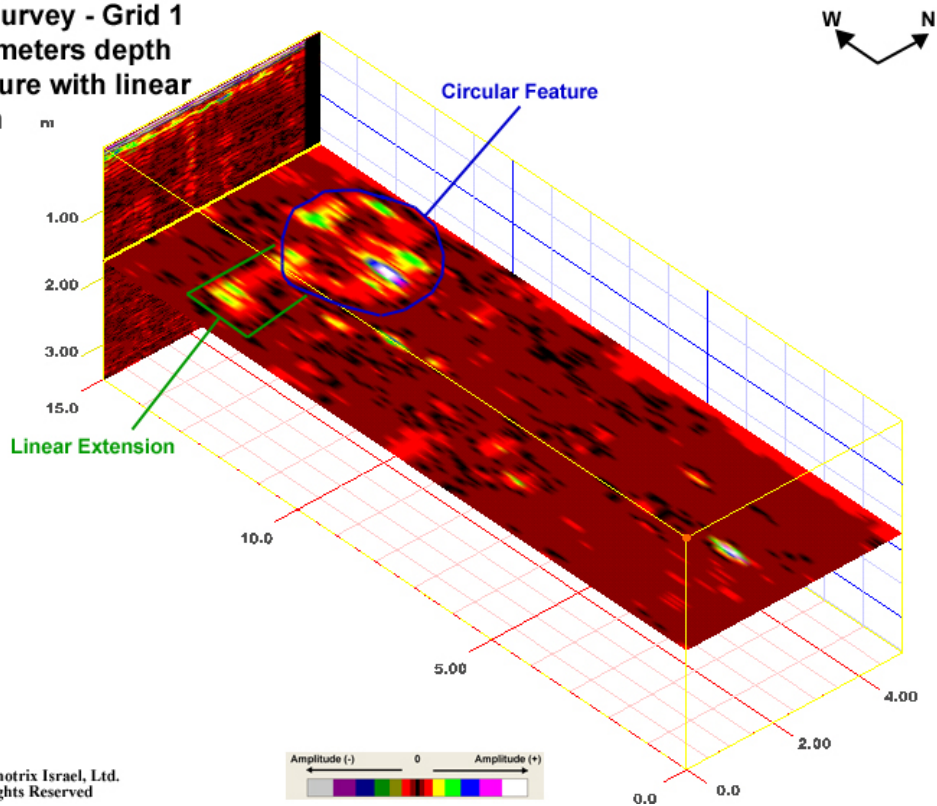
Hittin GPR Survey - Grid 1
 Z-slice ~1.0 meter depth
 Circular feature visible



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Figure 4: Circular feature in Grid 1. This anomaly is potentially the lost cistern.

Hittin GPR Survey - Grid 1
 Z-slice 1.74 meters depth
 Circular feature with linear extension



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Figure 5: Circular feature and linear extension seen at ~1.75 meters depth. This consistent anomaly is present strongly until ~2.25 meters depth.

Grid 2

Full post-processing and filtering similar to that done on Grid 1 were implemented here. This second area was chosen as another potential location of the cistern, however it did not prove to show consistent anomalies that we would professionally label as sub-surface archaeological features with the acquired data to hand.

Summary and Recommendations

Grid 1 proved beneficial towards our goal of locating the ancient cistern. Although we are unable to guarantee that this circular feature and linear extension that we are seeing is the cistern, we are able to hone in on a specific area for future ground-truth excavation, whose dimensions qualify this anomaly as a distinct possibility for the cistern, and if not the cistern then qualify it as an area definitely worthy of excavation and investigation.

Our strongest recommendation would be to excavate in the western third of Grid 1. As there is a common offset of actual features in the sub-surface to what is seen in the GPR data, we would recommend to excavate as much of this western third as possible, and expect to see the beginning of the feature at a depth of somewhere between 0.20 to 0.80 meters. The feature could potentially continue to about 3 meter depth. Exact dimensions and placement of the features in real time within the grid will be key for future archaeogeophysical surveys at the site and in the academic field in general.

The area of Grid 2 did not reveal any consistent anomalies worth discussion based on acquired data. However, this area of the southern horn could be reinvestigated using GPR in future seasons when more time is available. As noted, the survey area was much smaller and taken up at the end of the day.

It is important to stress the size of the Horns of Hittin as an unexplored archaeological site, as well as its difficulty of access, especially in the heat of the summer months. It is steep and rocky and hot during excavation season. This may be one reason it is one of the lesser investigated sites. Still, it is known that thousands of men died right in this location, and must be buried in the area with whatever was left to them at the time of the battle, and yet no one has uncovered them. With only one day of GPR study allocated we have already pinpointed one area of definite interest. With the assistance of GPR planned well over time, we feel sure that a planned excavation can unearth answers to mysteries almost a millenium old.