Ground Penetrating Radar Survey Report:

Khirbet er-Rasm, Israel

Data Acquired June 26, 2003

Report compiled August 12, 2003

Survey and Report Published by Mnemotrix Systems, Inc.

Introduction

Khirbet er-Rasm is a Hellenistic archaeological site located in the Judean Shephelah, on a hill south-southwest of Tel ‘Azeka close to Tel es-Safi.

Base map provided courtesy of Tel es-Safi Archaeological Project

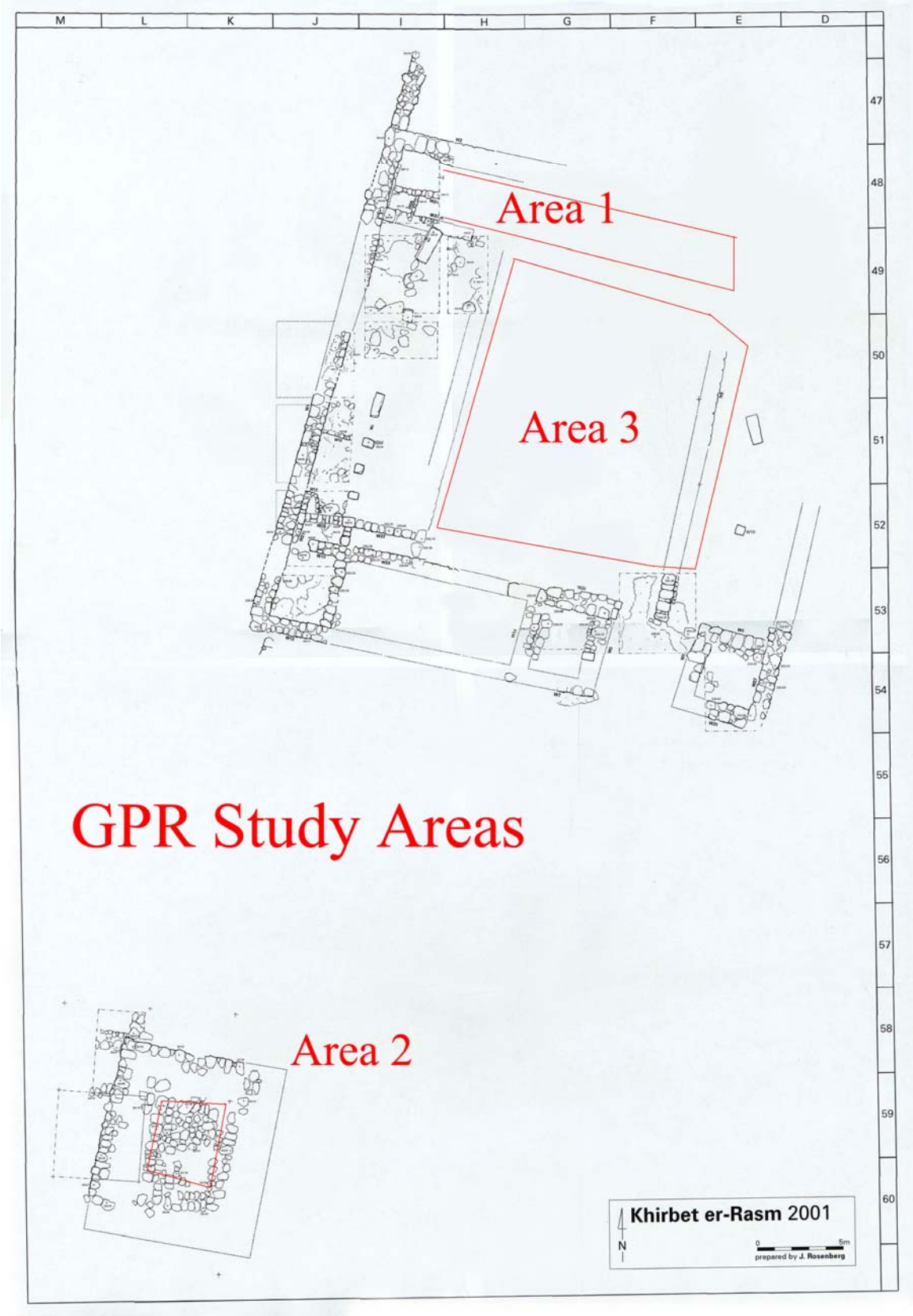
The site is headed by archaeologists Dr. Avraham Faust and Adi Erlich of Bar-Ilan University, who enlisted the support of Mnemotrix Systems, Inc. for GPR (Ground Penetrating Radar) studies to be done to augment the existing archaeological record, and to assist in decision making for future seasons. Under the guidance of both Dr. Faust and Professor Erlich, this geophysical survey was conducted in June of 2003.

Khirbet er-Rasm is situated in the midst of the British Park (park Britania) where work has been completed in the form of surveys and excavations since 1997. Excavations are only in their beginning phase, yet important finds have already been made. The site is a rural complex where known features have been found including storage areas, a courtyard, walls, and an enigmatic structure thought possibly to be a memorial of some sort. The remains of this large structure (c. 30 x 30 m) on the summit of the hill and a few smaller structures along its edges were exposed in excavations completed in 1999. An extensive hiding complex was discovered in the 2000-1 seasons within the kirton and nari (soft and hard) limestone rock

that makes up the site in addition to many other important pottery finds since 1997. The main area of the site can be seen from the air in the figure below.

Actions Taken

After discussions with Dr. Faust and Professor Erlich, three main areas (GPR Study Areas 1, 2, and 3) were chosen for current study using GPR techniques, and can be seen on the archaeological site map on the following page. The goals of the geophysical survey were first to investigate where existing walls in the vicinity of Study Area 1 might continue, and as time would permit, to explore the sub-surface of the enigmatic structure of Study Area 2, and to look for caves that may run underneath the unexcavated portion of the courtyard, Study Area 3. Study Area 1 was given the major focus.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Area 1
Area 3
GPR Study Areas
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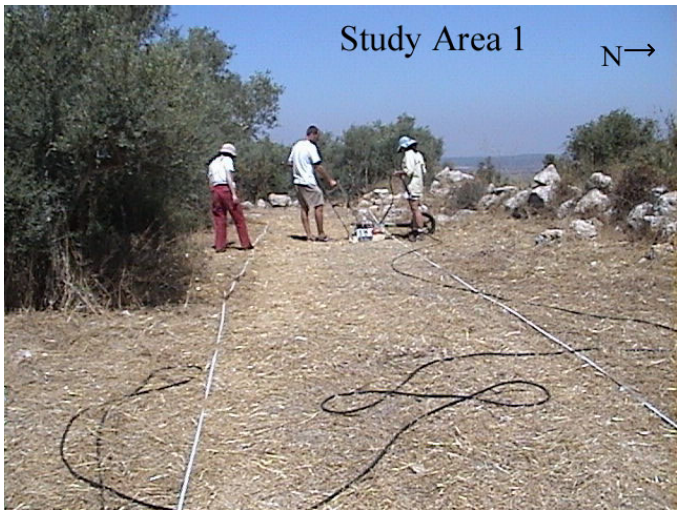
prepared by J. Rosenberg

Study Area 1:

GPR Study Area 1 is a long section near the entryway to the site from the road. Some walls have already been located nearby, so it was thought that this area would show where a continuation of these walls might be. Therefore a 22 x 2.5 meter grid was marked out, in which tight, overlapping survey lines in perpendicular directions could be acquired.



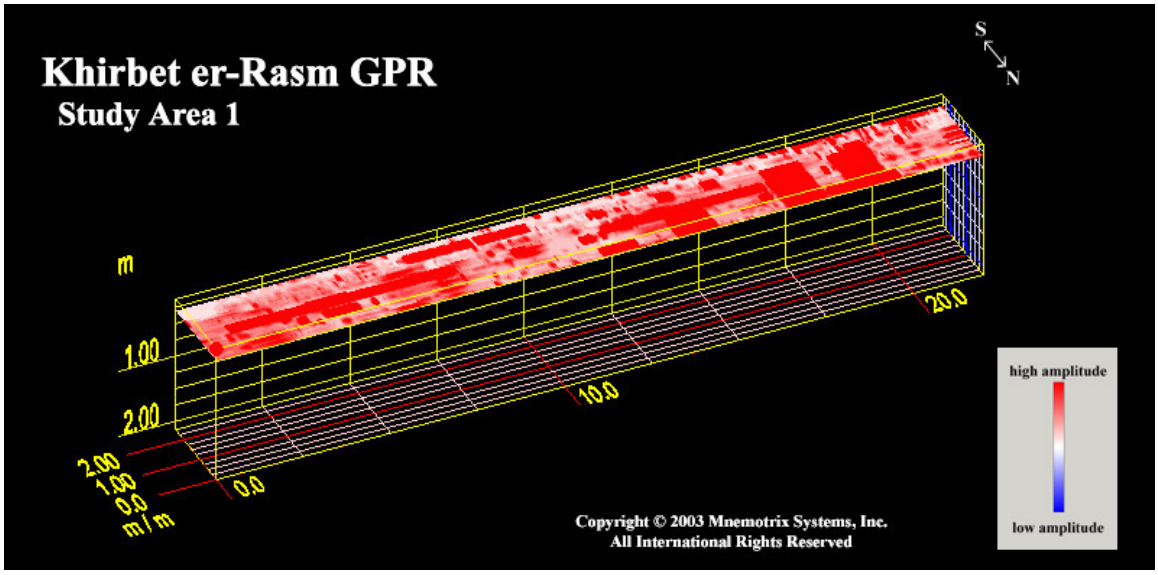
A 400 MHz antenna (with a 100 nanosecond pulse range) was chosen for this task, which can be seen with the survey wheel in the above figure. This setup was chosen in order to have very high resolution at a relatively shallow depth of 1-3 meters below the surface. The Study Area was chosen for its ease of accessibility in addition to the understanding that known walls ran perpendicular to the area in a north to south direction. Thus a survey that would transect these features in a west to east direction was believed to be most beneficial in determining their continuation in the sub-surface.

Within the grid, which was marked out in the dimensions of 22 meters (East-West) by 2.5 meters (North-South), GPR signal data was acquired in a tight set of 12 overlapping parallel lines taken first East to West, and then transected by 36 lines in a perpendicular direction North to South. These sets of data were put together into a 3D cube for follow-up study in a post-processing environment.

During post-processing, the GPR signal data collected for Area 1 was analyzed closely as to depth (vertical axis) and movement along the horizontal axis in a 3D cube.

A velocity analysis shows that the estimated signal depth of useful data was approximately 2.25 meters, traveling through ground made up primarily of limestone.

High amplitude colors signify a strong reflection of the material, while low amplitude colors signify a weak reflection in the surrounding material or matrix. Therefore where the reddest hue is present, there exists a strong difference between layers of sub-surface material, which can be viewed as an anomaly. An overview of the area and the features/anomalies within can be seen in a 3D cube in the figure below.



An in-depth visualization of the anomalies of Area 1 is shown in an animation which can be seen on the Mnemotrix website, where this report resides at this address: http://www.mnemotrix.com/geo/shepela.doc. If you are connected to the Internet while reading this report, you can view this animation by clicking below.

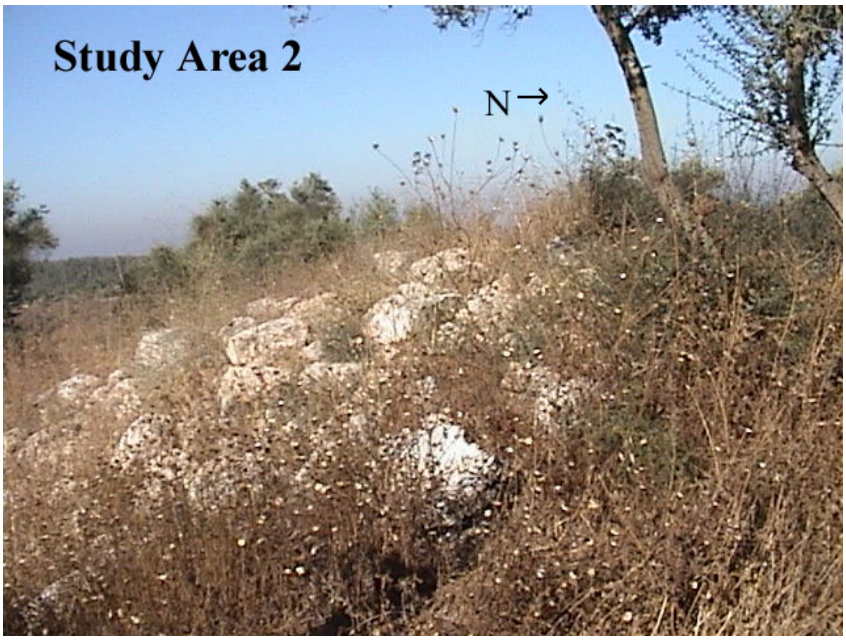
Click here to view the Vertical Depth Profile Animation

As the vertical depth slices proceed from the surface down to a depth of approximately 2.25 meters, the presence of long rectangular anomalies can be traced. An intentionally shallow profile was used for the collection of the data in Study Area 1, since the major focus of interest, walls, were known to be only a few meters down.

Although only a ground truth study can confirm the reality, it would appear from viewing the animation that the walls that are thought to be in this vicinity can be seen in the form of the reflections which are visible in the 3D view of this survey.

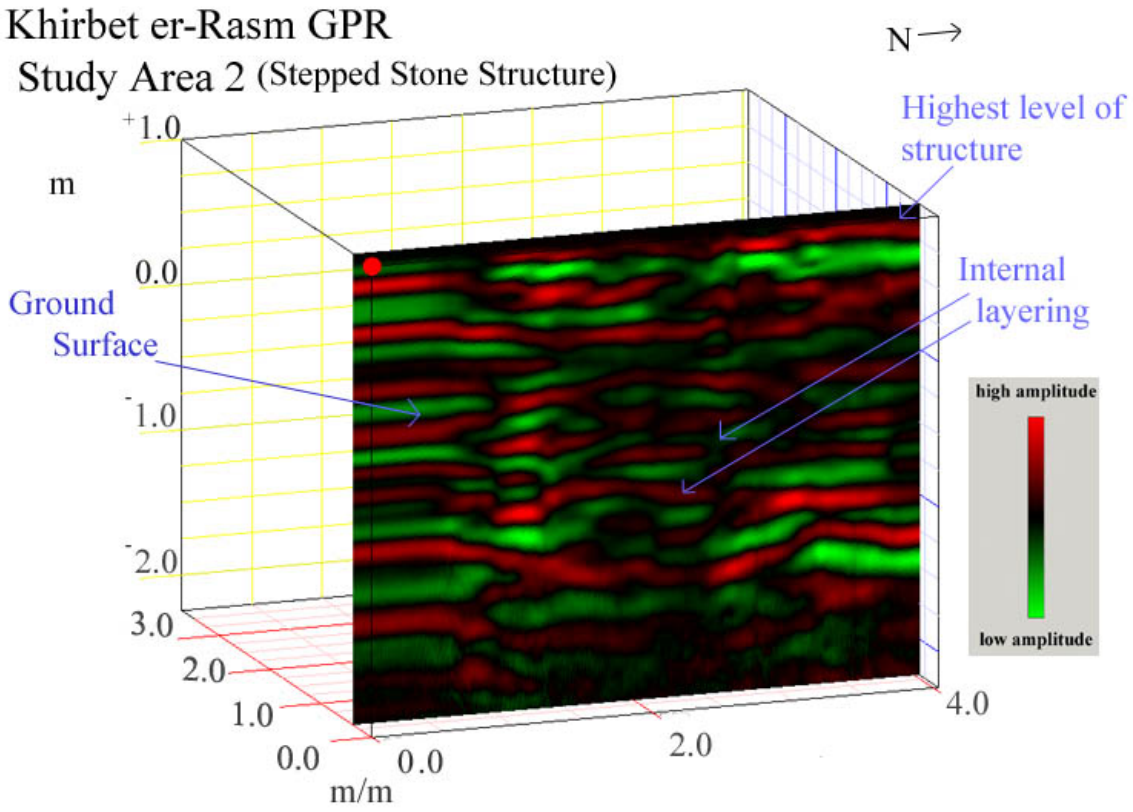
Study Area 2:

Study Area 2 was undertaken to aid in the further understanding of the enigmatic stepped stone structure located south of the first area. A 200 MHz antenna was used here in order to see deeper into the subsurface (150 nanosecond pulse range) which allowed for useful data down to a depth of about 4.5 meters. This area was barely accessible, but we were able to run some survey lines along the top-most level of the structure. The large nari blocks, as can be seen in the figure above, are rough and difficult to smoothly traverse.



Dimensions of the surveyed area were 4 meters (North-South) by 3.73 meters (East-West). As different from Area 1 where a tight intensive study of the area was done, the survey lines taken covered less of the available area, and served more as a preliminary test, than a complete study.

As mentioned, the goal of the survey at Area 2 was to further our understanding of the enigmatic structure in any way possible. Below is a view of the stepped stone structure thought to be a memorial by Dr. Faust and Professor Erlich.

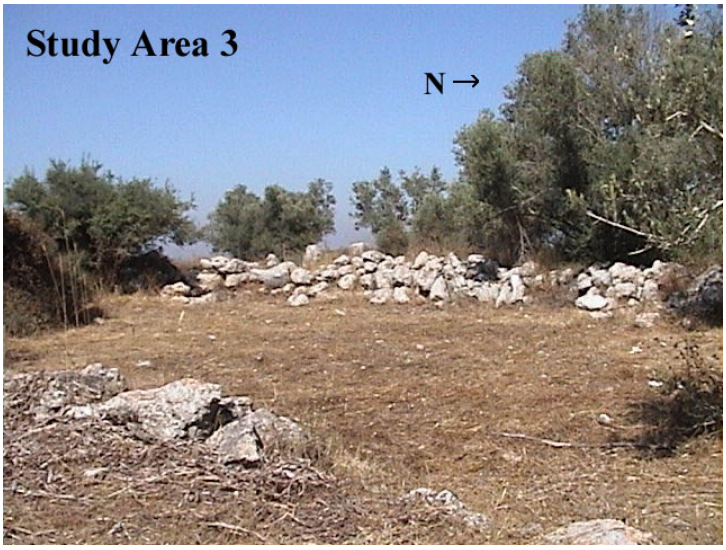


What is shown above is one horizontal slice across the eastern portion of the structure. The survey was done over the top of a structure which is about 1 meter above ground. Therefore the depth of the signal extended from the topmost layer of the stepped structure through ground level, and continued down a few more meters. About 4 to 4.5 meters of useful signal data was acquired in total.

What is clearest is that there is a somewhat thick layering of materials, as indicated by the alternating amplitude lines of the signal in the figure above. This could indicate the compilation of the limestone blocks making up the structure. Another more thorough survey would have to be done to get a better idea of whether this layering constitutes a "solidity" throughout the structure, or whether there is either empty space, or other objects within.

Study Area 3:

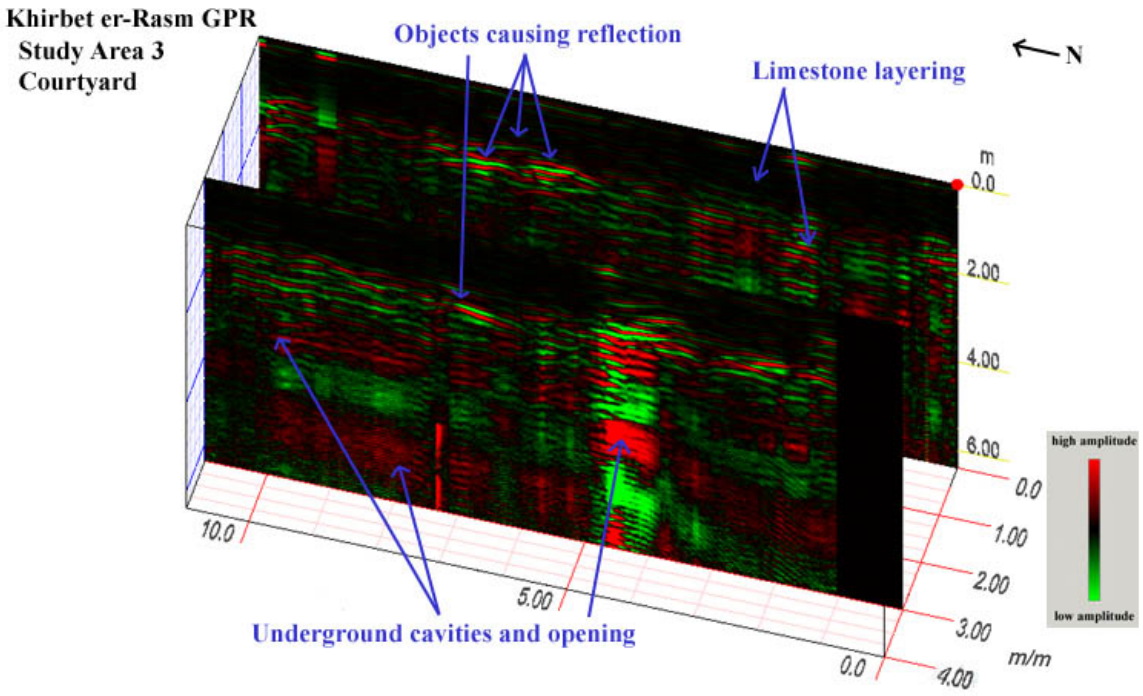
Although there was not much time left to allocate to this area, it was hoped that we could get some confirmation to the archaeological hypothesis that there might be



caves running beneath what is referred to as "the courtyard" area which lies between the first long section of Area 1 and the stone structure of Area 2. Given more time a more intensive 3D survey grid could be applied to this area. Even so, we were able to run random test lines across the area, to zoom in on an area which appeared to indicate there may be some caves running beneath the surface, within the soft nari limestone. The whole courtyard test area became known as Study Area 3 and was roughly 9 meters (North-South) by 12 meters (West-East).

Below is a view of the GPR survey lines which most indicate the presence of

underground cavities. This was located near the walkway to the eastern side of the site, within the courtyard area. This area was test surveyed with both the 200 MHz and the 400 MHz antennas, offering a deeper and shallower signal, both of which seemed to provide consistency in features. The figure below is signal data acquired with the 400 MHz antenna, using a 100 nanosecond pulse window.



As is shown, there is limestone layering throughout, but these are thinner towards the surface. About 2 to 3 meters down, this layering becomes thicker, in addition to the quickly moving signal shown in red. It is believed that this may be the opening into a passage or storage cavity because it is a point of particularly strong reflection (evidenced by the strong red color). These cavities appear to run across at least 8-10 meters of the surveyed area, but were not particularly seen in the courtyard further west.

Summary and Recommendations:

The results of this survey are optimistic in that they would seem to confirm those postulates that have been made by the chief archaeologists on the site. It was hoped that we would find evidence of the continuation of the walls, possible underground caves, and that the stepped stone structure would be of interest. All of these things would appear to have validity.

However, the best use of this data will be in conjunction with the actual findings at the site, so that we can correlate the signal data taken with the actual finds, and thereby better understand the meaning of the patterns we are seeing.

It seems that it would be worthwhile to continue to locate the walls that appear to be evident in Area 1. It may also be of interest to discover the actuality of any underground caves and thereby derive their use in past times. A more intensive GPR survey of the courtyard area could determine exactly where to excavate. When it comes time to research the enigmatic stepped structure, it could be useful to survey more thoroughly to gather information as to how to best approach such an activity.

The most salient conclusion that all the surveyors came to is that this is a most interesting site, containing many different features of interest, which seem to be fairly accessible from an archaeological point of view. Any discrete correlations that can be made between the GPR signal data and the archaeological or geological features found will be valuable not only for the archaeological record of this site, but for the general understanding of this terrain and how it can be viewed using GPR technology.