Ground Penetrating Radar Survey Report:

Tel Burna, Israel

View of Tel Burna GPR Survey Site, Shephelah, Israel.

Data Acquired 4-6 June, 2013

Report compiled 26 July, 2013

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Chief GPR Surveyor, Jessie A. Pincus, PhD

Ground Penetrating Radar (GPR) Study:
The Tel Burna Archaeological Project
26 July 2013 Report of 4-6 June 2013 Study

Background

Tel Burna is a site in the Shephelah breadbasket region of the southern part of Israel (see Figure 1). It dates to the Bronze and Iron Age periods, 13th - 7th c. BCE and has been suggested by scholars to be the Biblical site of Libnah. Libnah is mentioned in the Old Testament as an Israelite desert camp that Joshua encamped and fought against (Joshua 10:29-31; Joshua 12:15). Later it was given as a city to the children of Aaron, it joined the Edomites in a revolt against the King of Judah, and finally during the reign of Hezekiah, Libnah was besieged by Sennacherib (2 Kings 19:8, Isaiah 37:8).

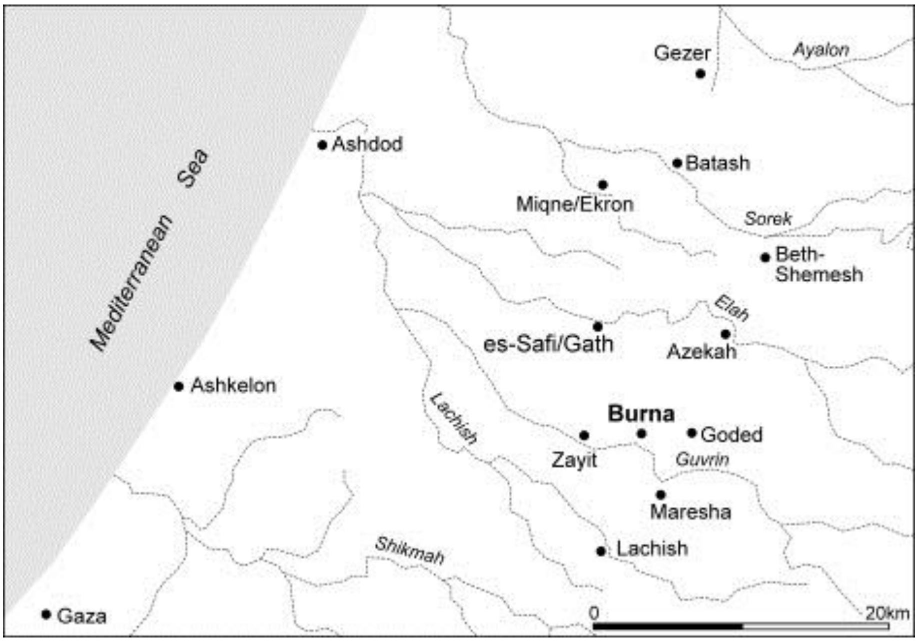

Figure 1: Map provided courtesy of the Tel Burna Archaeological Project. Available at: http://telburna.files.wordpress.com/2011/04/new-map1.jpg

Today the tel has a flat-topped shape, has an extensive size, and there are clear casemate wall fortifications dating to the 7th c. BCE surrounding it. Thus far silos, floors, a Late Bronze period cultic area, figurines, and other intriguing artifacts have been unearthed at the site. The site is ideal for a case-study in archaeological geophysics method and interpretation in the region because (1) we are involving the method early in what is expected to be a long timeline of ongoing excavations; (2) it appears we have only a few occupation layers with significant architecture built directly on the bedrock; and (3) there is a relatively unconvoluted geological and pedological context.

After conversations with the Director of the Tel Burna Archaeological Project, Itzick Shai, it was decided that out of the two areas actively being excavated a ground penetrating radar (GPR) survey of Area B would be most optimal at this time.

The goal was to locate the extent of the archaeological material on the leveled area, while also providing better insight to the cultic area presently being excavated. Area B has proven to have been occupied during the Late Bronze Age IIB (13^{th} c. BCE), as evidenced by the large public building associated with cultic remains, and a complex of walls.

Thus it was decided that as much of the area outlined in red in Figure 3 as practical would be surveyed using GPR by Dr. Jessie A. Pincus of Mnemotrix Systems, Inc., a company focused on archaeogeophysical data acquisition and modeling. The survey was executed under the auspices of Mnemotrix Israel, Ltd.

Description of GPR Survey Area

As is common in the Shephelah, the bedrock is a soft chalk with a marl crust. The bedrock is sometimes as shallow as 20 cm depth and can be seen in the GPR data as extending to 1.9 meter depth in some places. As the site is characterized by a lack of settlement, the topsoil tends to be a sandy-loess. The excavations have shown the presence of animal burrows throughout the site. See Figure 2 for an example side-profile. The area for the GPR survey is located to the NE of the present excavations in Area B (see Figure 3). Further figures will show the exact location in relation to the excavation results of the 2013 Field Season.

Figure 2: Side profile of the soil in Area B, looking east. Notice the two layers of cobbles and the dark animal burrow in the bottom right corner.

Figure 3: Outlined area of the 2013 GPR Survey to the northeast of the excavations in Area B.

GPR Survey Actions Taken

As mentioned, the key aim of the survey was to determine the extent of the archaeological remains in Area B to the north and east on the flat terrace. We were keen to potentially image the continuation of walls that were already excavated.

A 20 x 30 square meter area was marked out. The northeast corner of excavation square 7NN is the (20, 20) correlation point of the GPR grid (see Figure 4). As can be seen at the time of acquisition, dry brush was thick throughout the survey area. Due to the change in elevation, data was not acquired in the excavated square whose corner points are (15, 25), (10, 25), (15, 30), and (10, 30).

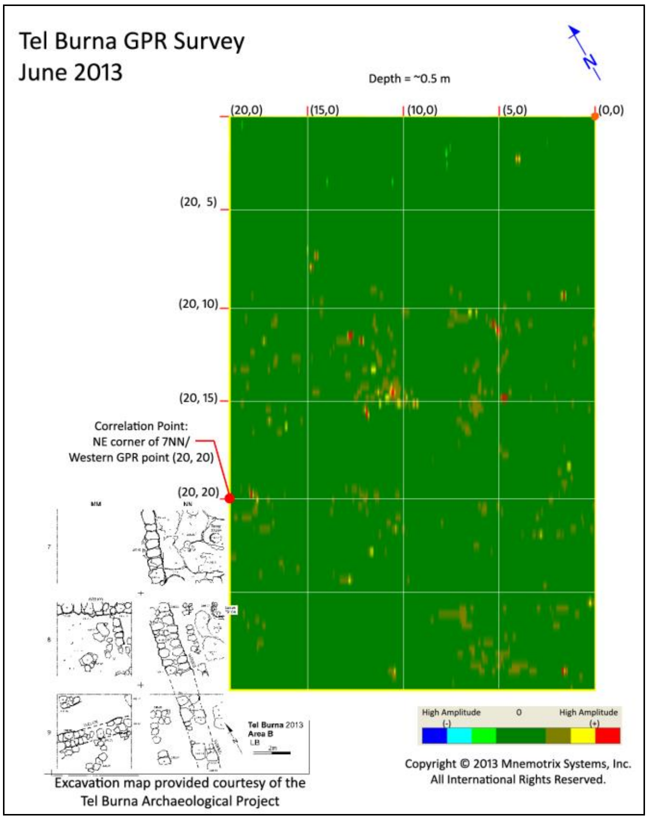

Figure 4: Excavation map and GPR z-slice at ~0.5 meter depth.

A 400 MHz antenna was used for all data acquired. The equipment used is the SIR System 2000, made by Geophysical Survey Systems, Inc. A shallow viewing window of 45 nanoseconds was used with an estimated depth scale of 0-2.5 meters. This was based on the soil type and geological situation at the site. In reality it appears we have good data until about 1.9 meter depth. Data was acquired in profile lines from the east to the west, moving south. These lines of data, each creating a vertical profile, were collected every 0.30 meters throughout the grid. During post-processing the numerous vertical profiles were appended together to create a 3D-cube used to view the data from the surface down and from side to side.

Post-Processing and Analysis

Standard post-processing methods were used, mainly employing FIR High Pass and Low Pass filters. Determination of which filters to use was completed by studying the spectrum of the acquired radar data and filtering out the extraneous frequencies that were causing noise in the data. Once the files were filtered they were appended into a 3D file and gain was employed to enhance the reflections that still remained in the dataset. This 3D file was then analyzed for archaeogeophysical interpretation.

Ground penetrating radar works by sending electromagnetic energy into the ground from a sending antenna that works together with a receiving antenna. This unit is pulled along the ground in transects at a steady pace across a gridded area. The energy reflects/bounces off sub-surface objects or materials that are significantly different from what the energy was previously traveling through. The larger the difference in properties (e.g. conductivity, density, etc.) between the two materials, the greater the reflection received. Materials that are particularly conductive of electromagnetic energy (e.g. high water content) will allow a deep penetration of the signal. If there is high clay content, for example, the signal will more likely be absorbed, and penetration will significantly stop at that level. As the GPR signal travels through the sub-surface, the more significantly different the new material is from the previous material the signal was just traveling through, the higher the amplitude reflection. For every positive reflection there is a reciprocal negative amplitude reflection. Data is transferred from the antenna to a controller computer via a cable. Anomalies are then mapped and grouped according to the strength of difference in amplitude and an interpretation of the data has been included on the figures when relevant. Color tables are used to highlight certain frequencies. In this case reds and blues show a significant change in the amplitude of the reflection (see Figures 4). Greens indicate homogeneous material.

In the case of Tel Burna we have a soil with high sandy content and limestone bedrock, which has proven in other surveys by the author to be a good matrix for successful penetration and resolution of the sub-surface with GPR. Useful archaeological data seems to extend in some places until about 1.9 meter depth. There are several main anomalies that have been identified and are discussed in the subsequent pages of the report and figures. A video is available to see how these anomalies change throughout depth, and has been attached to the report.

The first 18-19 meters of the grid appeared to be quite empty of archaeological material. There are two wall features that may be continuations or parallel counterparts to the walls seen in the excavation thus far. Additionally there is a feature that may be a possible casemate wall room or a small building. Its dimensions are roughly 7 x 5 meters. These main features are seen in Figure 5, as a flat view looking down on the data at an average 0.9 meter depth. Figure 6 shows several side-profile Y-Slice views (showing depth) of the possible room or casemate wall feature. Figure 7 shows typical views of the bedrock surface throughout the survey, one instance of a possible continuation of W29305, and the surface of what is thought to be remains of a wall or a leveled surface extending to the east from the excavated squares.

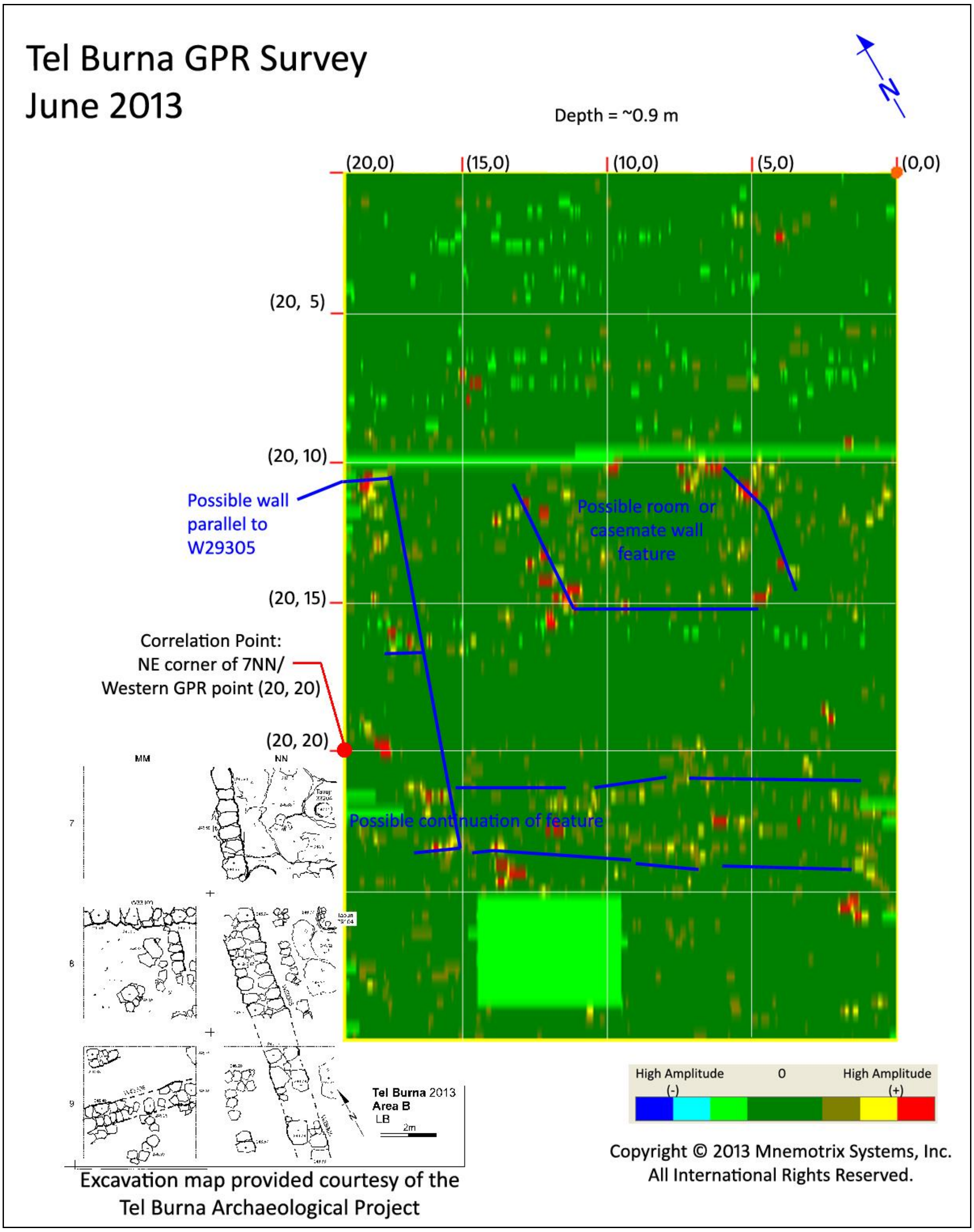

Figure 5: Major features seen in the GPR data, z-slice depth is ~0.9 meters.

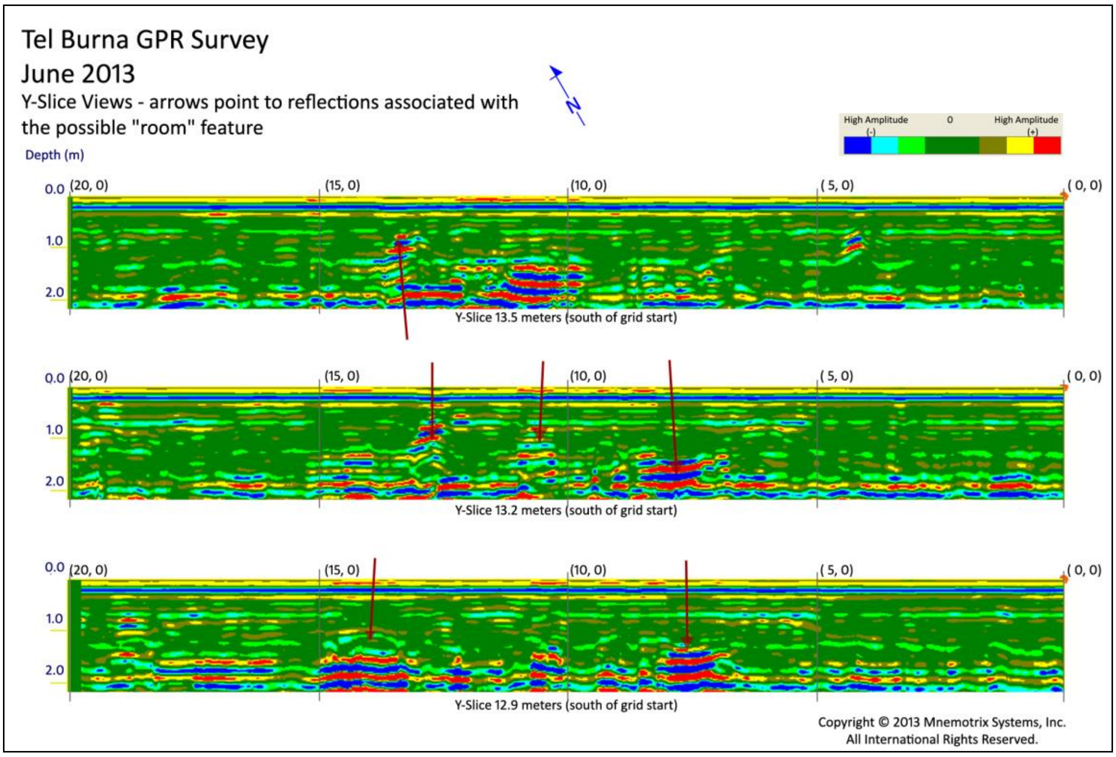

Figure 6: Y-slice views of the possible room feature remains.

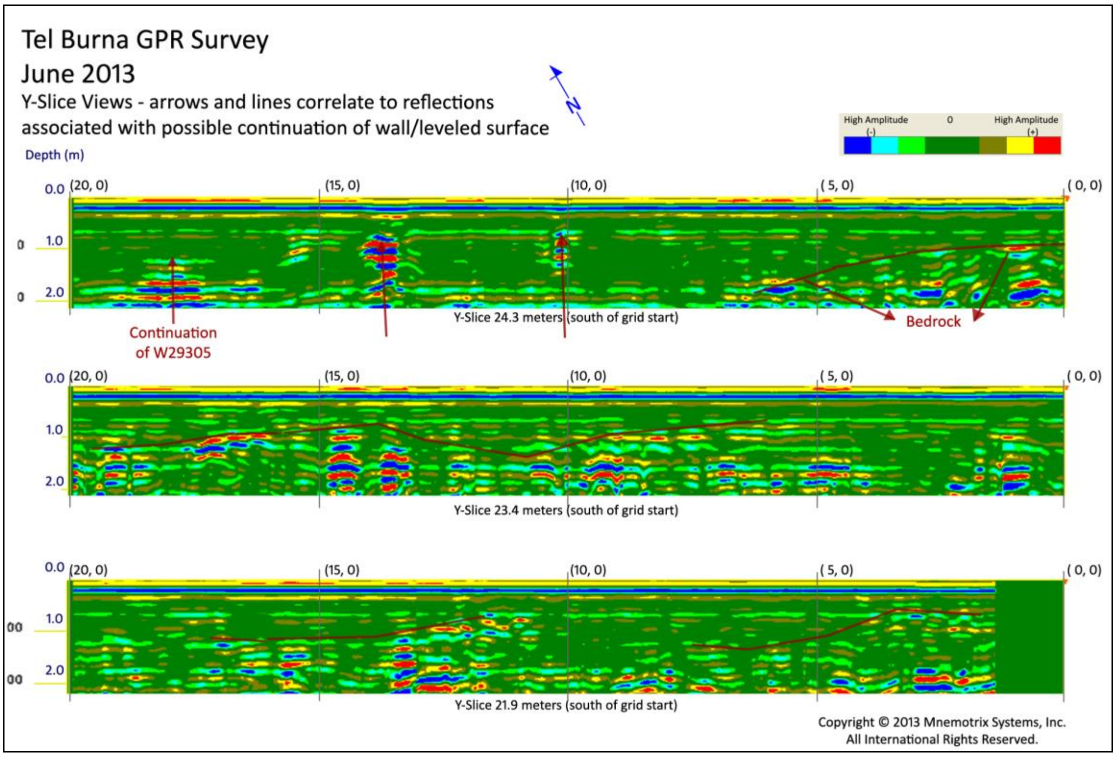

Figure 7: Y-slice views of the possible continuation of wall or leveled surface feature, extending east to west in the grid.

Recommendations

Based on the results of this archaeogeophysical survey there are some recommendations for next steps. In favor of continuity our recommendations for excavation are the following:

1. Excavate 3 squares with NW corner (20, 10), NE corner (5, 10), SW corner (20, 15), and SE corner (5, 15). The two eastern squares are likely to reveal what is being interpreted as a casemate wall or room feature. It may also in reality be the conjunction of several walls.
2. Focus on the square to the south [NW (15, 20); NE (10, 20); SW (15, 25); SE (10, 25)] that joins with the already excavated square. It would be best to branch from the existing excavations in the west in order to trace the feature, although if time resources are limited we suggest excavating this square only.
3. If the first choice is followed then we will also be able to ground-truth what may be a wall parallel to W29305.

This report has presented the major features worth excavating from an archaeogeophysical perspective at Tel Burna. Questions are expected in order to fully understand the results and Mnemotrix looks forward to following up with Itzick Shai as the ongoing investigations of Tel Burna develop.

Acknowledgements

We would like to warmly thank Dr. Matthew Suriano, Chris McKinney, and other volunteers for their hard work and effort during field acquisition this 2013 summer season. It was a pleasure to work with them.