THE PETRA GARDEN FEASIBILITY STUDY, 2001

Leigh-Ann Bedal

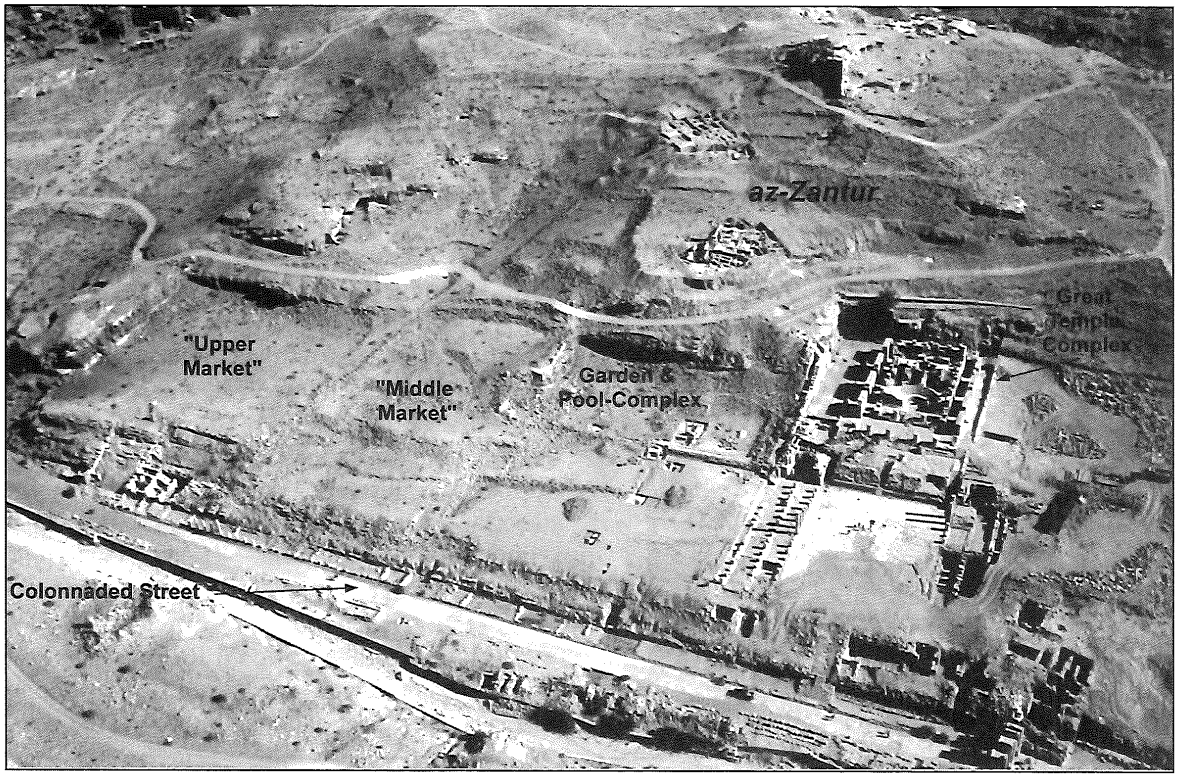
Introduction

In 1998, a preliminary survey and excavation of the so-called ''Lower Market'' in Petra revealed the remains of a monumental swimming-pool with island-pavilion. In association with the swimming-pool are the remnants of an elaborate hydraulic system – channels, pipelines, and a diversion tank (castellum) – that transported water to the pool and irrigated the large garden terrace to the north of the pool (Bedal 1999; 2000; 2001). The Petra Garden and Pool-Complex is located at the heart of Petra's city center, on an artificial terrace overlooking the Colonnaded Street, between the so-called "Middle Market" and the "Great Temple" (**Fig. 1**). Because the Petra Garden represents the only known example of a Nabataean garden in the archaeological record, and because the site is unobstructed by later (post-Classical) construction, it offers an unprecedented opportunity to conduct an intensive investigation of an ancient garden site, one of the very few to be studied archaeologically in the region.

In order to commence the investigation of the Petra Garden, a feasibility study of the garden terrace was carried out in July 2001. The primary objectives of the two-week field season was to identify the major components and layout of the garden and to determine the degree of preservation of its earthen terrace utilizing ground-penetrating radar (GPR) in combination with soil cores and strategic excavation to test the results of GPR. A team composed of specialists in geophysics, agronomy, garden archaeology, landscape architecture, and archaeological mapping, provided an interdisciplinary aspect necessary for the investigation of an ancient garden site.

Ground-Penetrating Radar

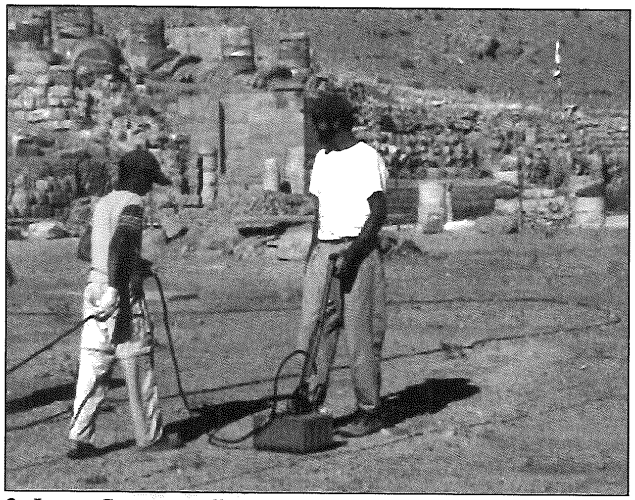
The first three days in the field were devoted



1. Aerial view, looking south, showing the relationship of the Petra Garden and Pool-Complex to other major monuments and spaces within the city center [Photo by S. Karz Reid, 2001].

primarily to the collection and processing of data using ground-penetrating radar (GPR) in order to obtain a subsurface mapping of the garden's earthen terrace which measures approximately 65 x 53m. The GPR team employed a Geophysical Survey Systems Inc (GSSI) Subsurface Interface Radar (SIR)-2000 system that is the latest version of the digital systems that control radar propagation in the ground, and record the resulting reflections.

Grid 1 was laid out over the terrace in an L-shape, avoiding a raised earthen feature (a post-Classical agricultural field boundary) that occupies the southeast portion of the study area (see **Figs. 3, 4**). As the radar antenna was moved along measuring tapes laid out in an east-west direction within the grid, data was collected in transects every 50cm for maximum illumination of subsurface features (**Fig. 2**). Optimum line spacing was based on the known energy transmission cone of a 400MHz dual antenna. Energy propagation occurred to a maximum depth of about 3.5m. A total of 103 transects of reflection data were collected. The resulting reflection data were displayed on a computer monitor in the form of vertical profiles in which we were able to immediately identify the location of major architectural features as well as unbuilt areas (**Fig. 7**). The relationship of these features was further illuminated by importing all reflection transects into an amplitude analysis program that produced horizontal slice maps, each measuring approximately 25cm in thickness. The result was a series of maps showing the overall architectural layout of the terrace at various depths. By the end of the second day, it was clear that the earthen terrace is mostly unbuilt with a series of stone structures laid out along its central north-south axis and another major stone structure along the north-eastern border. In addition, this preliminary data revealed a number of smaller, less defined features in various locations and depths across the site.[1]



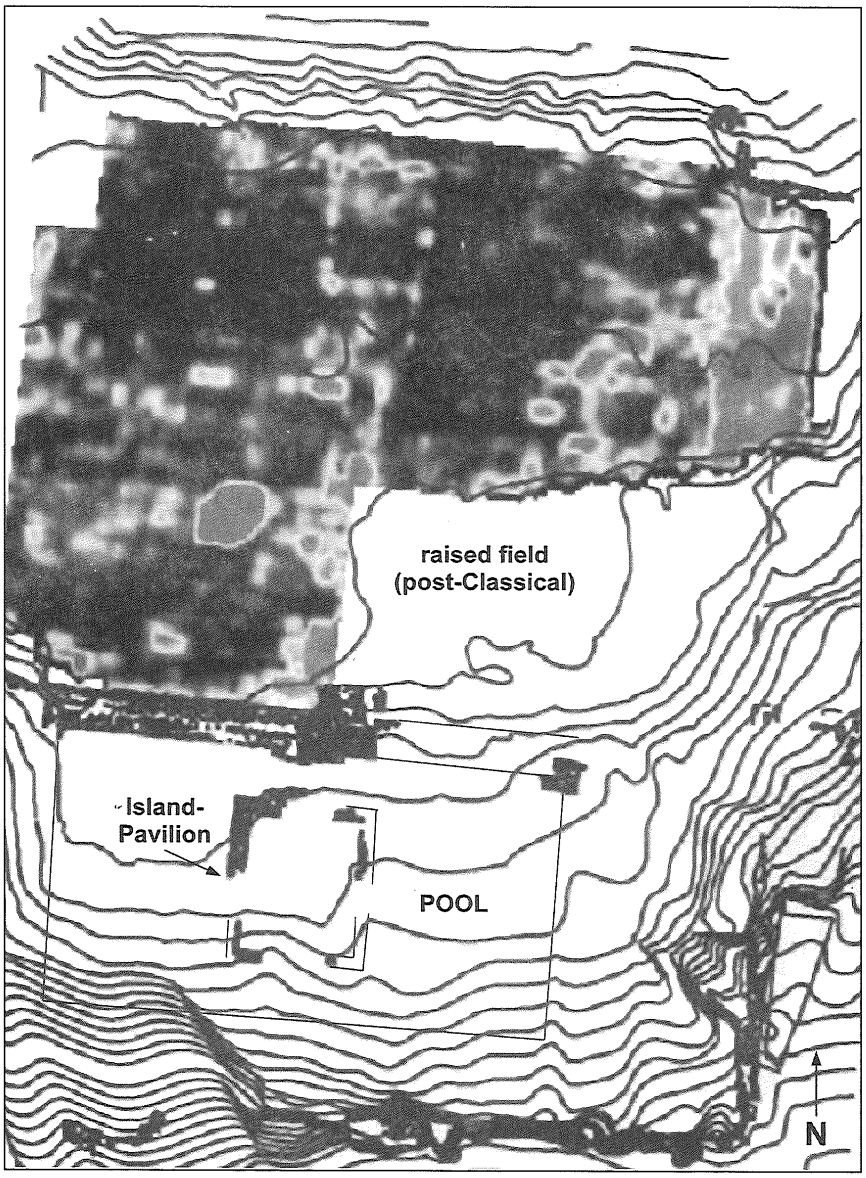
2. Larry Conyers collects data every 50cm across the garden terrace, by pulling a 400 MHz antenna along a transect. The data is immediately transmitted to a nearby computer through the cable that is handled by Ahmed al-Bedoul [Photo by E. Ernenwein, 2001].

After a preliminary examination of the horizontal amplitude slices, one feature – a rectangular structure located in the northern portion of the grid – appeared very pronounced and its segmented walls were potentially consistent with those of a colonnaded pavilion. This feature was chosen for a more detailed GPR study. To produce a detailed set of maps of this northern structure, a second grid of data (Grid 2) was collected using the same equipment, but collecting transects 25cm apart instead of 50cm (as in Grid 1), allowing for finer horizontal resolution. Since we knew from Grid 1 that the structure was aligned with the terrace's main axes, Grid 2 was laid out at an angle (**Fig. 4**) in order to disqualify any chance that the wall lines were a function of the direction the antennas had been moved along the surface, creating linear anomalies that might "look like" buried architecture. A total of 81 profiles were collected in the 18 x 20m grid, which was processed in the same manner as Grid 1 including the production of amplitude slice maps for viewing in the field. The resulting data showed a very distinct rectangular structure (the North Building), measuring 8 x 11m, at a depth of 0.25-1.00m below the surface (**Fig. 5a**). Using the three dimensional capabilities of GPR (combining horizontal slices and vertical profiles), it is possible to produce a reconstruction of the North Building as it is preserved under the ground. Based on this data, three of its walls are segmented – which may represent columns – with one solid wall on the north façade (**Fig. 6**). Extending below the level of the North Building, the GPR shows a distinct line running northeast-southwest and originating from a large, solid structure seen in the upper left corner of Grid 2 (**Fig. 5b**). It is likely that these deeper features are associated with houses date to the third-first century BC that were buried by the construction of the garden terrace, probably during the reign of Aretas IV (9 BC - 40 AD) (Parr 1970).

Strategic Excavation

With the results of the GPR immediately available, three areas were identified for further investigation as per the goals and scope of the feasibility

1. A metrological analysis of the Petra Garden and Pool-Complex revealed the application of harmonical ratios and measuring units for its construction, see C. Kanellopoulos, "The Layout of the Pool and Garden Complex in Petra. A Metrological Analysis," *LA* (forthcoming).

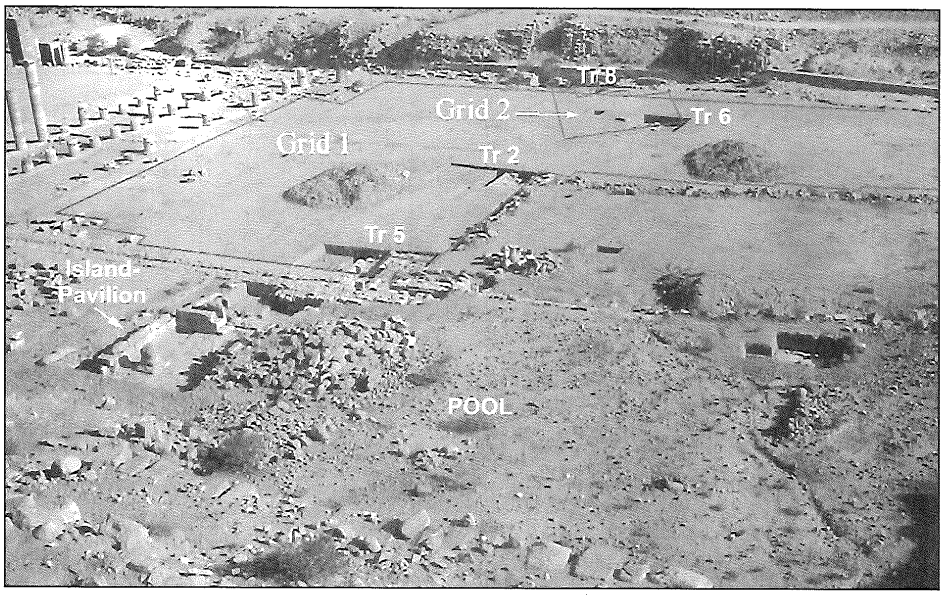


3. A horizontal amplitude slice of the garden terrace generated by GPR and superimposed on a topographic map of the site. This slice shows that there are several structures (white-gray colors) with large expanses of unbuilt space (earth = black) 25-50cm below the surface. Of note are the large stone structure along the terrace's eastern boundary (upper right) and a series of smaller structures along the terrace's central north-south axis.

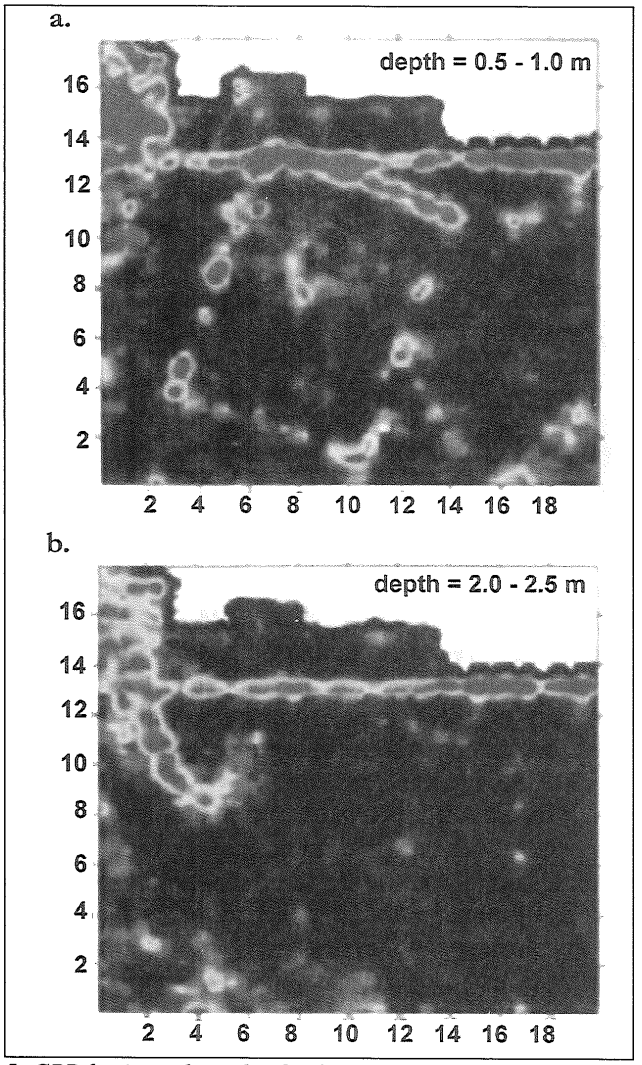
study. Excavation trenches were strategically placed to expose portions of three of the major stone structures whose presence had been revealed through GPR (**Fig. 4**). The first area chosen for excavation was located along the southern edge of the terrace, just three meters north of the pool. The GPR data showed what appeared to be a large and deeply founded stone structure (**Fig. 7**) directly north of the *castellum* (a water tank built into the pool's north wall) and stone conduits that compose a system of collection and distribution of water. Trench 5 was opened to test the GPR results and to expose a portion of this feature, which proved to be a solid stone platform packed with mortared sandstone rubble and faced with ashlars typical of Nabataean masonry. At least two phases of construction are distinguishable, with fragments of architectural elements, such as column drums and capitals, used in the rubble fill of the secondary construction phase (**Figs. 8, 9**). The stone conduits that emerge from the *castellum* lead directly underneath the stone platform in Trench 5, suggesting that the platform functioned as a hydraulic installation, perhaps a basin or fountain (**Fig. 10**).

The second area of interest was identified approximately 12m north of the southern platform (Trench 5), where GPR indicated the presence of another large stone-built feature at the center of the terrace. A small area of this feature was exposed on the surface and investigated during the 1998 field season. Trench 2 uncovered a second platform (3.67 x 3.85m), constructed of a core of mortared sandstone rubble faced with well-hewn sandstone ashlars (**Fig. 11**). A small limestone basin with a small drainage hole was found resting against the platform's southern face, just east of center.

The third feature investigated through excava-



4. View of the garden site, looking northwest, showing the location of the two GPR grids (outlined in gray) and excavation trenches of the 2001 season.

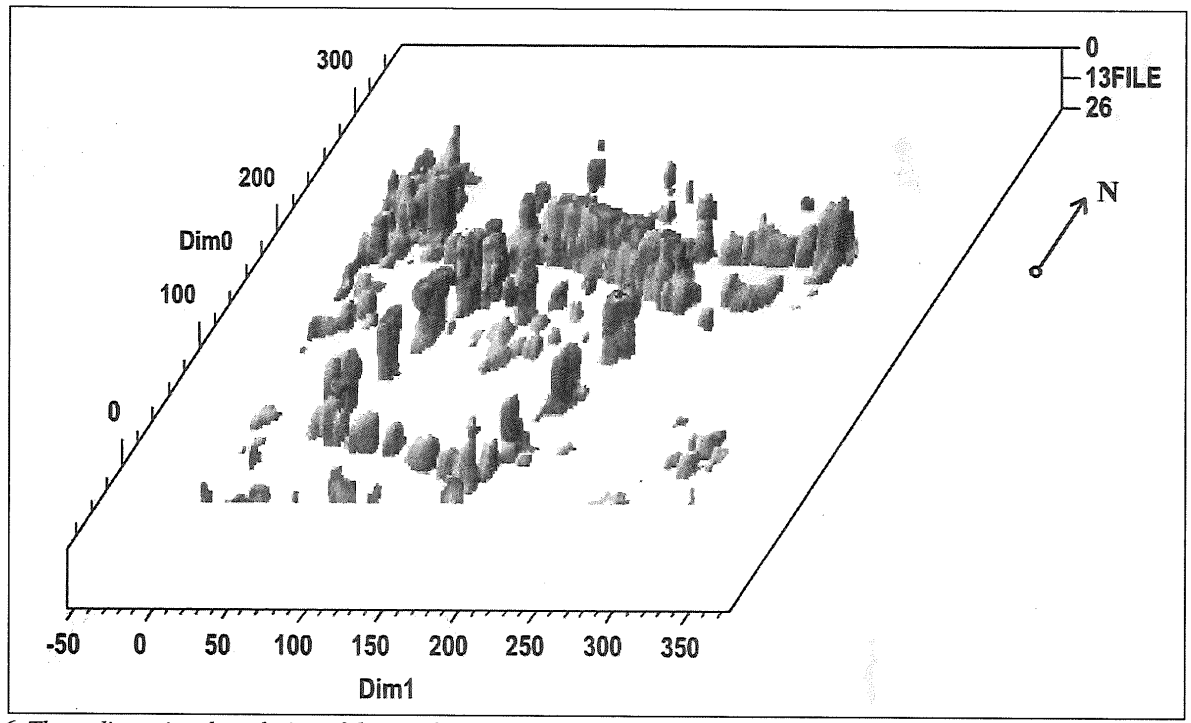


5. GPR horizontal amplitude slices of Grid 2 at two different depths. The outlines of the North Building are clearly visible less than 1m below the surface: (a). a solid structure, located to the west of the North Building, is founded more than 1.5m deeper and appears to be crescent-shaped at the bottom; (b). a distinct line runs southwest-northeast, underneath the northwest corner of the North Building.

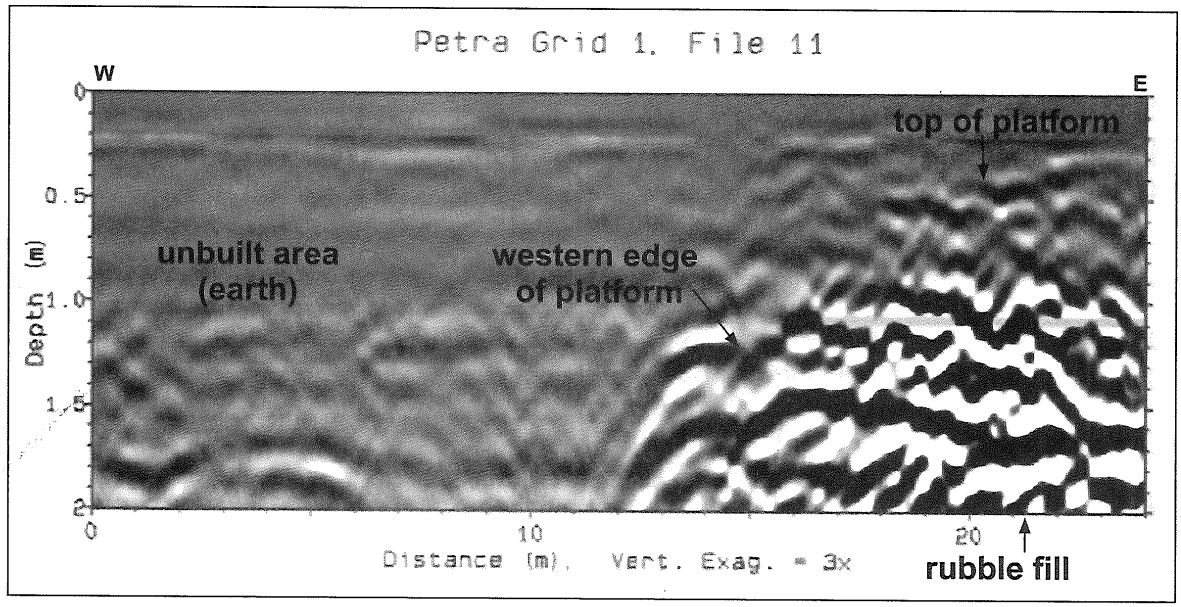
tion was the North Building, located 14m north of the central platform (Trench 2) and 5m south of the terrace's northern retaining wall. Two test trenches (6 and 8) exposed the southeastern and northwestern corners of the North Building, located immediately below the surface **(Fig. 12)**. The rough construction of the walls suggests that only the foundations (two courses high) are preserved. It is unclear from the limited exposure what the function of this building is, but its stratigraphic association suggests that it is post-Nabataean-Roman, possibly Byzantine. That the building is well aligned and centrally oriented with the site's other major architectural elements may suggest, however, some continuity in the use of the garden terrace in this later period. Below the level of the foundations an oval stone-line pit (1.5 x 1m) was uncovered **(Fig. 12)**. The discovery of the pit came as a complete surprise because its presence had not been detected in the GPR data. The pit is oriented perpendicular to the bold oblique line that the GPR data locates ten meters to the north **(Fig. 5a-b)**. Pottery sherds found within the pit are consistent with a first century BC date. The exact function of the pit is currently unclear, but the discovery of a feature that apparently belongs to the site's pre-garden phase offers promise for future clarification of the chronological development of the center of Petra.

Soil Studies

In addition to aiding in locating and excavating architectural elements, the application of GPR proved useful for the investigation of the garden soils. In addition to providing a map of the stone structures on the terrace, GPR indicated where there were no structures and thus where we might search for remnants of the garden soils which



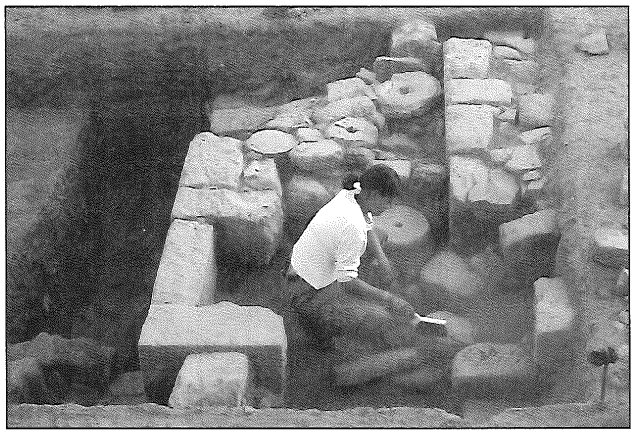
6. Three-dimensional rendering of the North Building in Grid 2, composed of GPR data from horizontal slices and vertical profiles for levels 25-95cm below the surface.



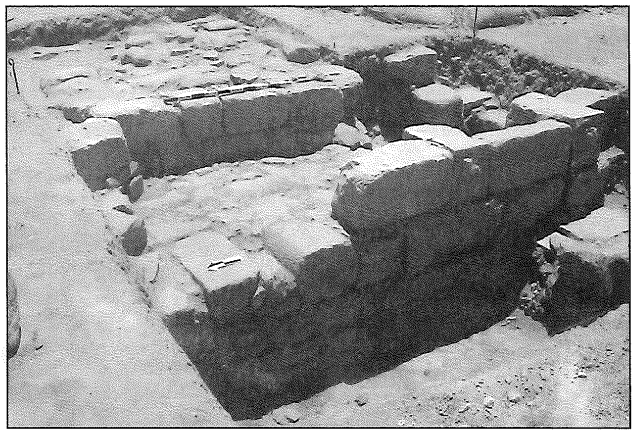
7. GPR profile of the southern platform (right) that was partially excavated in Trench 5. The unbuilt, earthen area immediately to the west of the platform may represent part of the garden's cultivated area.

might provide information on the nature of the garden itself. Vertical profiles of the subsurface provided by the GPR, showed what appeared to represent several laminated surfaces or stratigraphic layers to the east of the North Building. A total of 16 auger tests at various locations on the garden terrace provided a preview of the stratigraphic sequence that would be encountered in excavation (**Fig. 13**). Samples of the major soils at the site will be subjected to characterization analyses which will aid in establishing the morphology of soil units.[2] In Trench 6, three surfaces were detected to the east exterior of the North Building that have the characteristics consistent with cultivated soils — mottling and a high content of charcoal bits and pottery sherds. The uppermost cultivated soil is

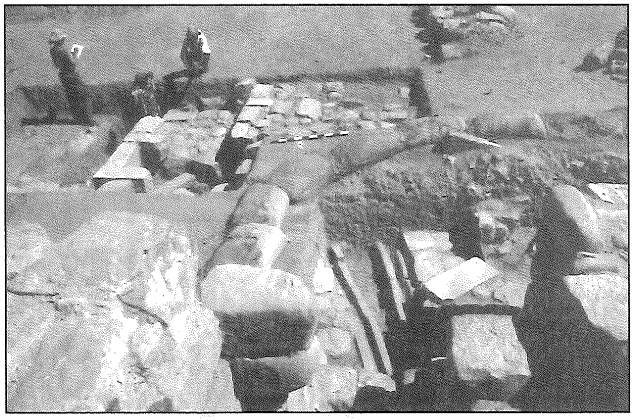
2. The analyses of soil samples were not completed by the time of publication of this preliminary report. The results will be included in future publications on the Petra Garden.



8. The southern platform (Trench 5), looking north. Kelly Cook sweeps off architectural elements used as fill between two construction phases.



9. The southern platform (Trench 5), looking southeast, after the removal of fill composed of architectural elements, exposing a rough surface of tightly packed rubble. Only the top preserved course of the exterior wall would have been exposed above the ancient ground level.



10. The southern platform (Trench 5), looking north. In the foreground is the castellum in the pool wall, with emerging stone conduits that lead directly toward the platform.

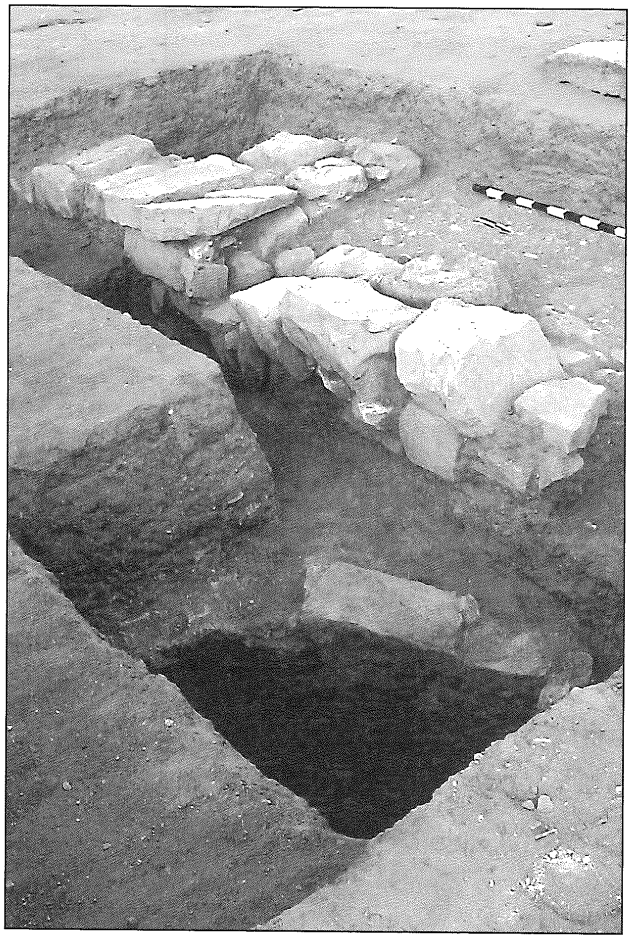
11. The central platform (Trench 2), looking northwest, with stone basin (lower left) found resting against the platform's southern face. The large hole in the northern part of the platform may represent ancient stone-robbing activity. The eastern face of the platform was preserved one course higher than the rest and was the only stone construction exposed on the surface of the garden terrace.

gray in color and represents the modern use of the terrace as an agricultural field by the modern Bedouin inhabitants of Petra. The two lower cultivated soil strata are each likely candidates for the garden surface of the classical period. A coin of Aretas IV was discovered at the bottom of the earliest soil layer, providing a *terminus post quem* for its cultivation **(Fig. 14)**. Future excavations will involve large horizontal exposure of each of these strata with the hope of identifying subtle features such as tree pits, root cavities, and earthen irrigation channels that cannot be easily detected in vertical soundings, and to determine their relative relationship to the architecture.

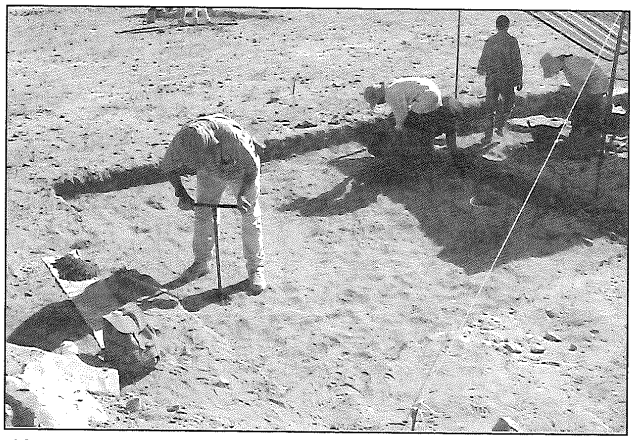
Summary

With one short feasibility study, valuable information has already been acquired about Petra's ancient garden through the combination of GPR, strategic placement of excavation trenches, and soil cores. After only three days of data collection, processing, and interpretation of the GPR data, it was possible to determine the locations for strategically placed test excavations. Using color images of horizontal GPR reflection amplitude slices, a map of the prominent archaeological features buried under the surface was created. The GPR-generated maps proved useful for placing excavation trenches in areas where the most valuable or desirable information could be obtained while avoiding areas that appear less promising for serving the goals and objectives of the feasibility study.

The combination of geophysical mapping and strategically placed archaeological tests prevented an unnecessary waste of time and expense on randomly placed trenches. Due to the nature of garden sites with their large expanses of unbuilt areas, randomly placed test trenches are unlikely to produce a significant amount of contextual information. By starting with a geophysical study, valuable maps of the terrace's subsurface were produced in only a

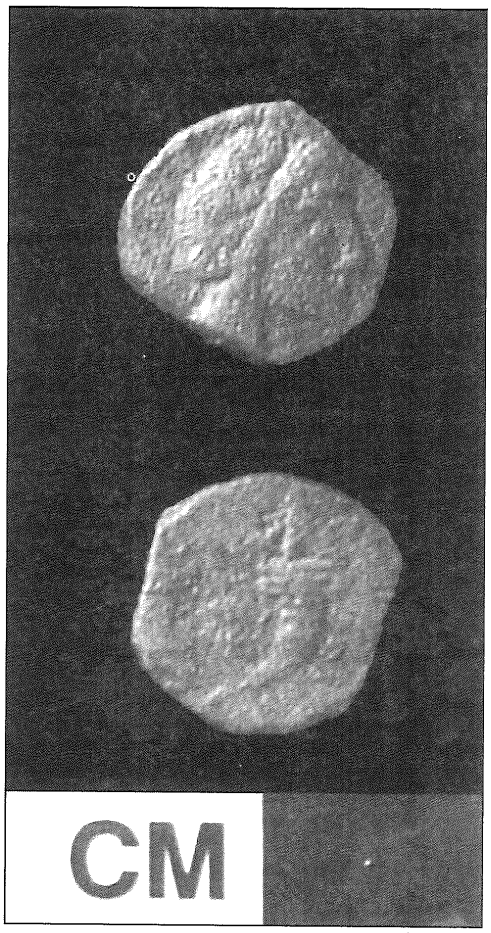


12. *The southeastern corner of the North Building foundations (Trench 6), looking southwest. In the foreground is a stone-lined pit that pre-dates the North Building, and possibly the garden terrace.*



13. *John Foss uses an auger to collect a soil sample from Trench 2.*

few days. Future excavations at the site will make use of the GPR maps produced from the feasibility study for more strategically placed excavation trenches. A combination of GPR and excavation results are integrated into an overall site map (**Fig. 15**) and cross-section (**Fig. 16**). Ultimately, a fusion of data from GPR, excavation, soil cores, and



14. *A coin of the Nabataean king, Aretas IV (9 BC-40 AD) found in the lowest stratum of cultivated soil in Trench 6, above the stone-lined pit (#01-C-03). On the obverse is the bust of Aretas IV; on the reverse is a pair of crossed cornucopias (the one on the left is badly eroded).*

other methods of site analysis will yield a comprehensive three-dimensional reconstruction of the site that will enhance upon the usual information represented in two-dimensional site maps.

Acknowledgments

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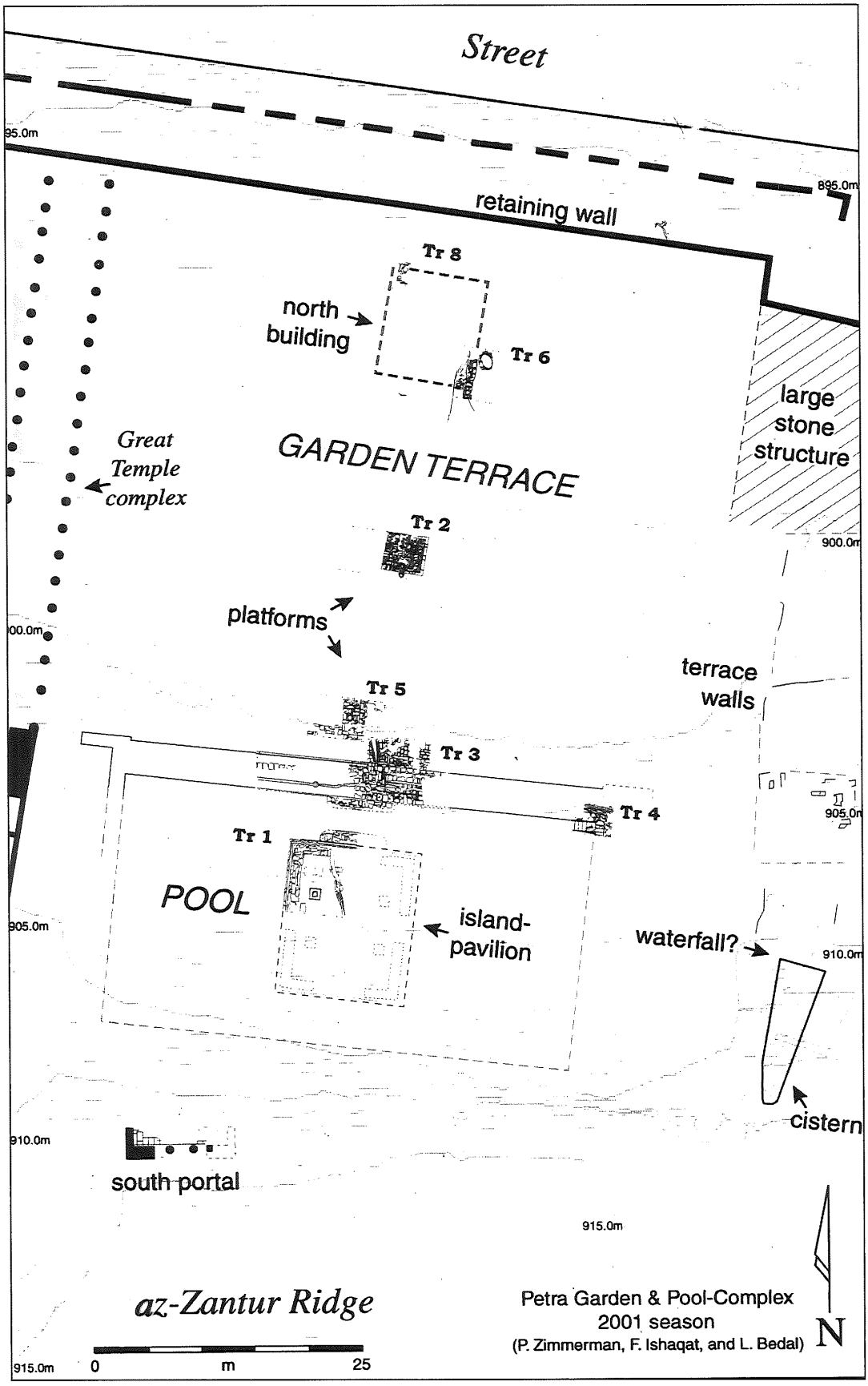
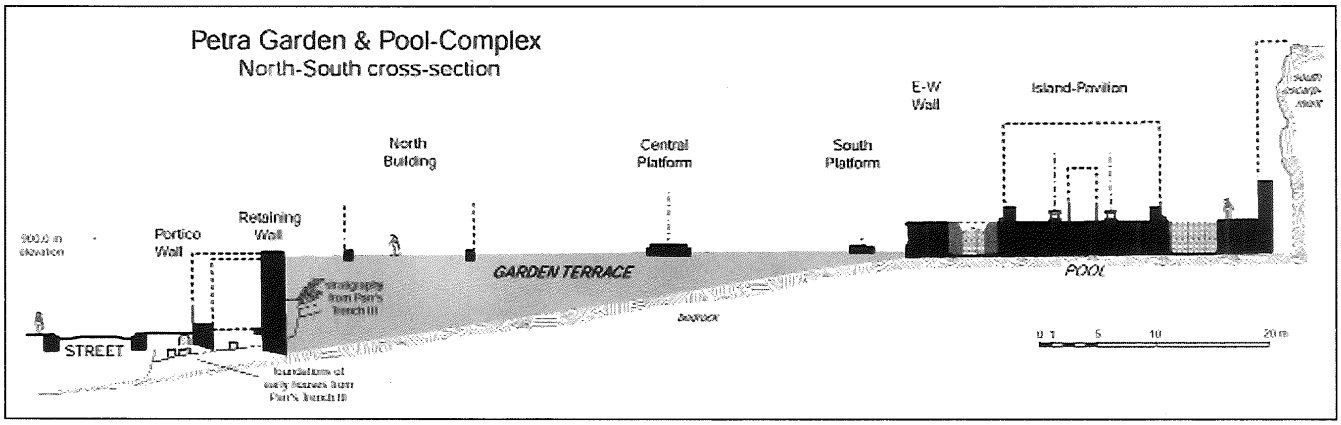


15. Map of the Petra Garden and Pool-Complex combining the results of the 1998 and 2001 field seasons.



16. Reconstructed cross-section of the Petra Garden and Pool-Complex facing east. The slope of the bedrock, which has yet to be determined, is presented here as an even grade between the level of the pool floor and under the street. Important information on the northern part of the terrace and the street was obtained from the section drawing for Trench III as presented in figure 1 of Parr 1970 [Drawing by C. Kanellopoulos; digitized by L.-A. Bedal].

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All photographs were taken by the author unless otherwise indicated. The GPR-produced images were provided by Larry Conyers and Eileen Ernenwein.

L.-A. Bedal
Division of Humanities and Social Sciences
Pennsylvania State University, Erie
5091 Station Rd.
Erie, PA 16563-1501
USA

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