THE 2005 WĀDĪ RAMM GPR SURVEY

Megan A. Perry, Geoffrey L. Jones

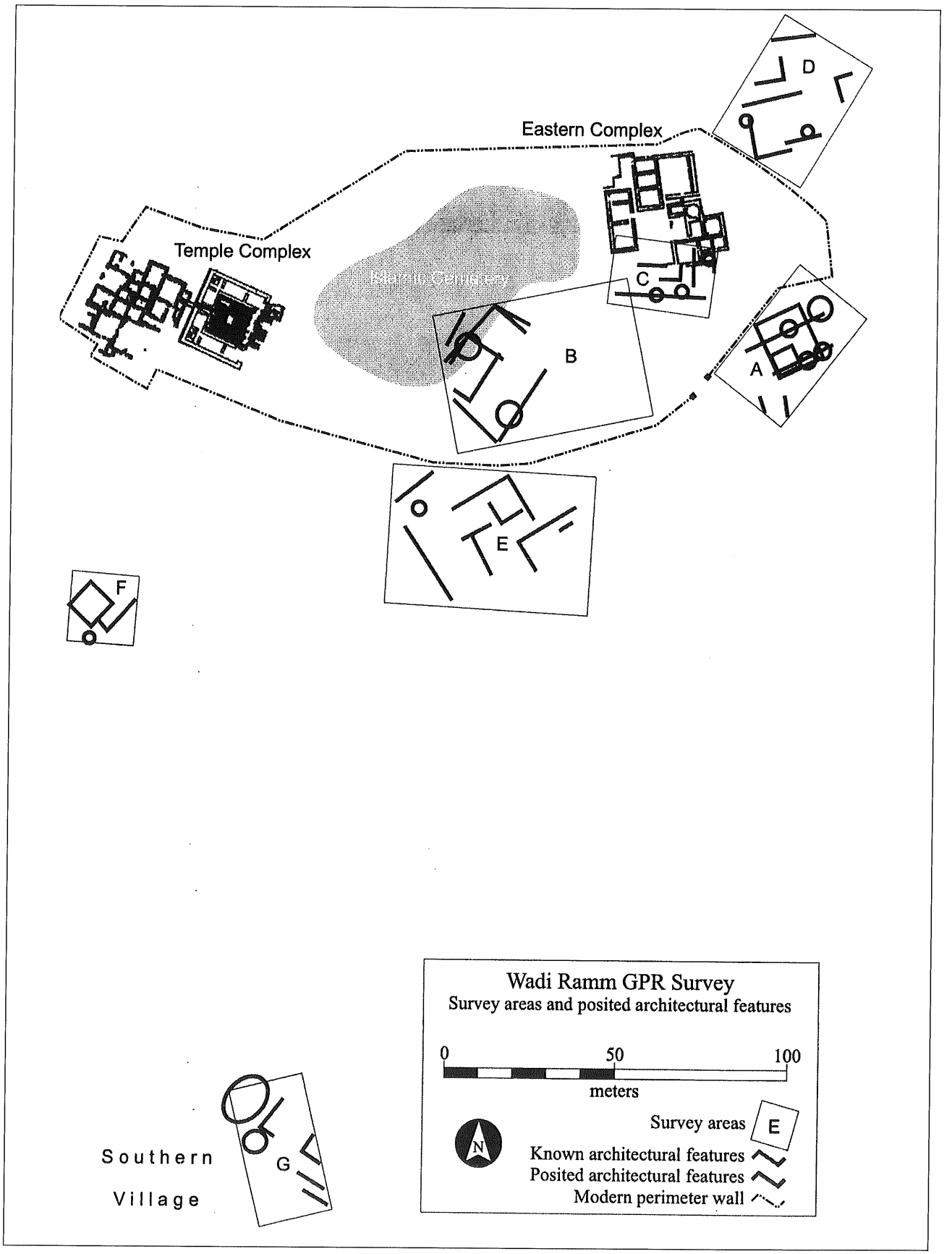
During the 1960s, the Department of Antiquities of Jordan (DoA) conducted preliminary excavations in the Nabataean temple and related structures at Wādī Ramm. During these explorations they discovered and excavated a Nabataean-period communal tomb within the vicinity of the present-day Ramm village. The records of this excavation unfortunately have been lost. In 2005, efforts to locate the cemetery associated with Nabataean and Roman period occupation at Wādī Ramm commenced using ground penetrating radar (GPR). This report details the results of the GPR survey conducted from June 25-30, 2005 and plans for future fieldwork at the site[1].

Background

Wādī Ramm (ancient *Iram*), situated in the desert Ḥismā region of southern Jordan, served as a religious and population hub, on trade and migration routes between northern Saudi Arabia and the Nabataean kingdom. Previous archaeological explorations at Wādī Ramm have focused primarily on the Nabataean temple complex (Kirkbride 1960; Savignac 1932, 1933, 1934; Sauvignac and Horsfield 1935; Tholbecq 1997, 1998), the "southern village" (Tholbecq 1998), and a hypothesized bath and domestic complex (Dudley and Reeves 1997). Numerous archaeological and epigraphic surveys in the environs of Ramm have fleshed out data provided by archaeological excavations through documenting numerous Thamudic inscriptions, shrines, water catchment systems, and other ancient structures (Farés Drappeau 1996; Farés Drappeau and Zayadine 2001, 2004; Graf 1978, 1983, 1992; Grimme 1936; Harding 1952; Jamme 1971; Kirkbride and Harding 1947; Savignac 1932; van den Branden 1950; Winnett and Reed 1970; Zayadine and Farés Drappeau 1998).

The 1960s DoA explorations of Wādī Ramm and its Nabataean temple also included excavation of a Nabataean period communal tomb somewhere in the vicinity of the site. Documentation of this excavation however was destroyed during flooding that inundated DoA records storage. No information therefore was available to pinpoint the location of the Nabataean tomb (perhaps part of a larger cemetery) beyond identifying likely locations based on site geomorphology and the location of other ancient structures. Discovery of a cemetery associated with Wādī Ramm can illuminate human migration patterns and the level of social and economic interaction among ancient communities in southern Jordan and northern Saudi Arabia. Examination of human skeletons recovered from *Iram* would address these questions through bone chemistry and population genetic analysis and assessment of health, disease, and diet. These bioarchaeological data can provide information on the interconnectedness of Nabataean communities,

1. The 2005 season of the Wādī Ramm Cemtery Survey was made possible by a permit from the Department of Antiquities of Jordan. The project staff would like to thank Dr. Fawwaz al-Khraysheh, Director-General of the Department of Antiquities of Jordan and Dr. Pierre Bikai, former director of the American Center of Oriental Research for their assistance. The 2005 project staff included: Project PI Megan A. Perry (East Carolina University), Geophysicist Geoffrey L. Jones (Archaeo-Physics, LLC), and field staff Robert Patterson, Lisa Leone, Tina Greene, and Joshua Fairchild (East Carolina University). The Department of Antiquities representative was Amer Bdour. Funding was provided by an East Carolina University Research and Development Grant, a grant from the Joukowsky Family Foundation, and a Kenneth Russell Fellowship from the American Center of Oriental Research.



1. Map of the survey areas and posited architectural and mortuary features.

population movement between Nabataea and other regions, the migration patterns of nomadic tribes, and the local impact of Roman annexation. We employed GPR as a cost-effective, time saving method for identifying ancient features at the site, including graves. In addition to identifying the location of a cemetery at Ramm, our efforts focused on exploring the possibility of other ancient architecture at the site and by including a few Islamic graves, determining the qualities of grave-related reflections at the site.

GPR Survey Methodology

Selection of survey areas addressed the goals outlined above. Site topography and layout of the visible complexes and Islamic cemetery influenced the areas selected for exploration in 2005. Seven survey areas (Blocks A-F) were chosen within the environs of the Nabataean Temple complex excavated by Tholbecq (1998) and the Department of Antiquities, the "eastern complex" (a bath and related villa) excavated by Dudley and Reeves (1997), and the "southern village" explored by Tholbecq (1998) (**Fig. 1**). Two grids were placed within open areas surrounding the Islamic cemetery and eastern complex. Block B (1800m^2) was located directly south of the main concentration of Islamic graves and within the recently constructed site perimeter wall. Block C (600m^2) was laid out in between Block B and the eastern complex. Additionally grids were established along the slopes to the north, south, and west of the main site structures. Block A (1000m^2) was placed immediately east of the modern perimeter wall surrounding the site, Block D (1200m^2) on the slope north of the eastern complex and modern perimeter wall, and Block E (2400m^2) to the south of Block B and the modern perimeter wall. Two other areas some distance from the temple and eastern complexes were also explored. Block F (400m^2) was established adjacent to two suspected tombs, on a small rise below the Jabal Ramm escarpment in between the "southern village" and the temple complex. Block G (900m^2) was placed near the "southern village".

The general survey procedure was to divide each survey area ("Block") into a series of square or rectangular survey "grids". Each grid was surveyed by taking readings at regular intervals along regularly-spaced, 1m transects. Ropes marked at regular 1m intervals were used to control transect spacing, and a trailing odometer wheel controlled the recorded position along each transect. Successive transects were surveyed in a zig-zag pattern until the grid was completed. The GPR survey method employed at Wādī Ramm involved dragging the transmitter and receiver antennae together on the ground at a fixed rate, called fixed offset reflection mode. The GPR survey was performed using a Sensors and Software pulse EKKO 1000 radar system. GPR's effective depth of investigation depends upon the matrix through which the signal travels and the GPR signal frequency. Selection of the signal frequency must compromise between depth of investigation and resolution. After staking out the seven survey blocks (Areas A-G) with a Sokkia Set 5a total station, they were surveyed in transect intervals of one meter using 450 mega Hertz (mHz) frequency antennae. Blocks A and D also were surveyed using 225mHz antennae, but these were less effective in spite of their deeper penetration. Conditions at the site were generally well suited to GPR survey and signal penetration was good. The relatively high frequency of 450mHz was found to be effective to a depth of 2 meters and provided much better resolution of subsurface reflectors than a lower 225mHz frequency. For a more complete and technical discussion of the methods see Annan and Cosway (1992) and Conyers and Goodman (1997). An overview of the geophysical approaches to archaeology can be found in Gaffney and Gater (2003).

Initial examination of the site indicated that geophysical methods, such as GPR, could be used to identify the cemetery and other features. A successful GPR survey depends largely upon soil and other field conditions. The Wādī Ramm soils were composed mainly of aeolian, colluvial, and alluvial fine sands deriving mainly from the local sandstone bedrock. The sands generally provided a good medium for propagation of the GPR signal. Rocks present at the site can result in culturally-significant anomalies (such as walls or cist tombs) in addition to non-cultural "clutter" and signal scattering. It is difficult to determine whether the majority of rock found on the site, excepting dressed local sandstone used in Nabataean and Roman architecture, is naturally-occurring or has been culturally trans-

ported. Islamic graves and other recent cultural features have employed rock from local sources, including re-used dressed sandstone. Ancient architecture primarily utilizes dressed sandstone, although foundations and rubble-and-mortar wall fill consist mainly of other undressed local rock.

All of the survey areas had varying amounts of modern metal debris on and near the surface. Metal objects near the GPR antenna array can cause a strong response known as "ringing" that can obscure phenomena of interest. Cans, wire, and other metal debris were cleared from the path of the GPR, but some instances of metal-related ringing were noted in all of the survey areas.

A field laptop computer controlled data collection and allowed real-time display of the data as a two-dimensional vertical profile. Data from multiple adjacent transects were used to construct planview maps of a surveyed area with a technique known as time slicing. Time slicing not only makes interpretation of the horizontal data much more intuitive, but also allowed for isolation of specific depths (i.e., the two-way travel times of reflected waves) for examination (see Conyers and Goodman 1997). The initial processing and time slicing of GPR data used Sensors and Software EKKO Mapper software, which utilizes Fortner Transform software to plot the data array as planview maps. Geoscan Research GEOPLOT software was used for further processing. The processing of GPR data utilized different gains and filtering techniques, such as median filtering, to increase signal strength and enhance certain data characteristics. Golden Software Surfer was used for final display of data plots.

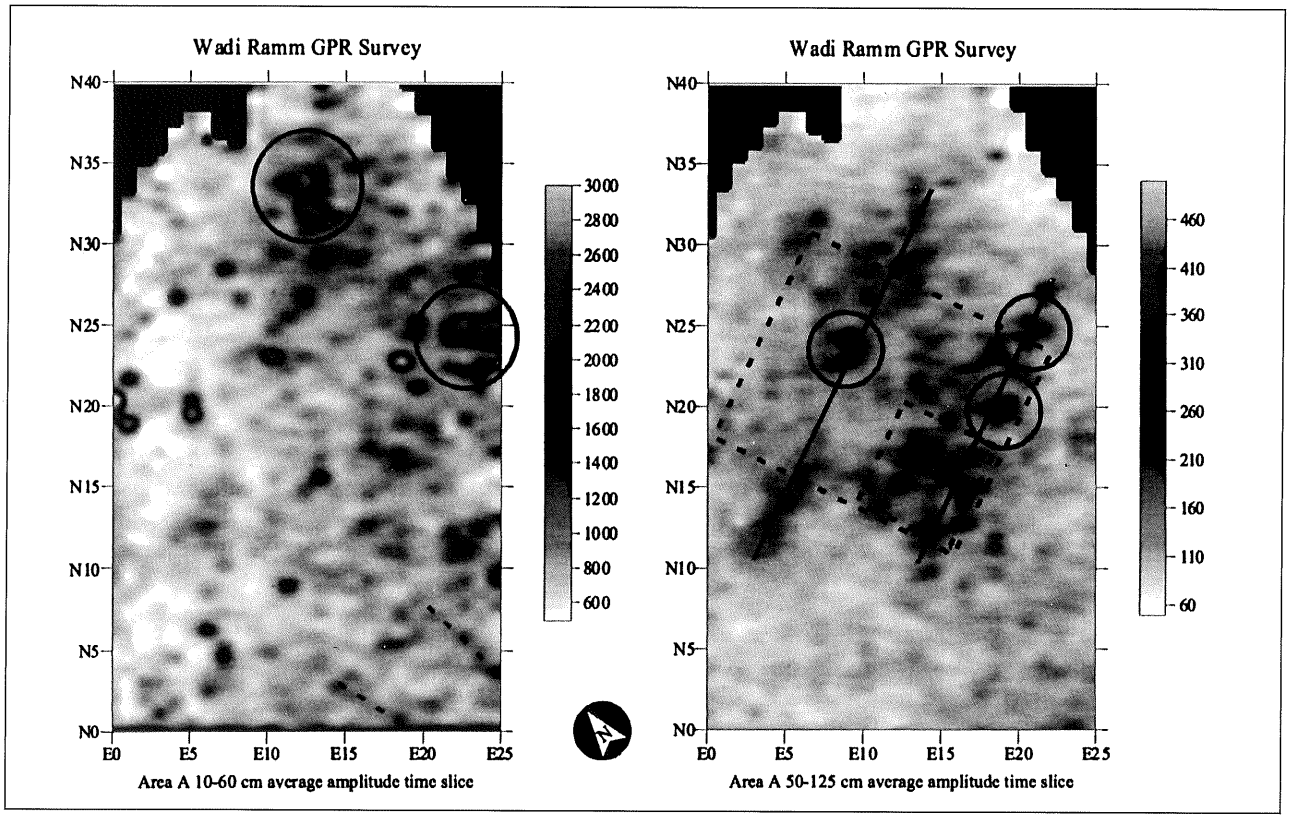
This analysis generated two planview maps of each survey area that represent two estimated depth ranges (10-60cm and 50-125cm). Sectional (profile) views also illustrate phenomena as expressed in vertical (i.e., signal travel time) dimension. The lack of detailed topographic information for the survey areas meant that data plots are presented without topographic correction. Depths in survey plots thus indicate nominal depth below the surface rather than elevation. An estimated velocity of 0.1 meters/nanosecond was used for depth calculations; actual depth however may vary from the nominal depth due to changes in topography or differences between nominal and actual signal velocities.

Results

The geophysical survey at Wādī Ramm identified many phenomena of archaeological interest, including possible ancient architecture and tombs. All seven blocks had linear patterning indicative of ancient architecture. Six out of seven blocks also contained more distinct areas of interest possibly indicating graves. Block A, located ca. 15m to the east of the eastern complex, contains fairly well defined linear/rectilinear patterning and several discrete reflectors of interest (**Fig. 2**). Block B on the other hand contained weaker indications of architecture (**Fig. 3**). This area, situated in between the temple and eastern complexes, included part of the historic/modern Islamic cemetery in order to discern the reflection pattern of these tombs and whether they could be mistaken for ancient graves. These Islamic graves tended to be expressed only in the near-surface and thus could not be misidentified as Nabataean tombs. Other discrete reflections possibly indicating non-Islamic tombs appeared in the section data views but they were generally weak, making any interpretation of patterning tenuous.

Block C, directly south of the eastern complex, contained well-defined linear/rectilinear patterning oriented slightly differently than the exposed architecture of the complex (**Fig. 4**). Block D on the other hand, ca. 20m to the north of the eastern complex, had weak linear patterning approximately paralleling walls in the complex (**Fig. 5**). Block D also contained a very strong linear anomaly in the northwest corner associated with a wall visible on the surface. The antiquity of this wall is unknown.

Block E, located on the slope to the south of the eastern complex and Block B, contains generally well-defined linear/rectilinear patterning suggestive of substantial architecture oriented slightly differently than reflections in Block B (**Fig. 6**). An area of high-amplitude response also extends across the northern portion of the survey area (roughly north of N30), apparently caused by fill on top of a horizontal stratum below the modern top of the landform. Furthermore a very well-defined anomaly appearing in isolation at approximately N27.5/E8 is consistent with the



2. Block A survey results.

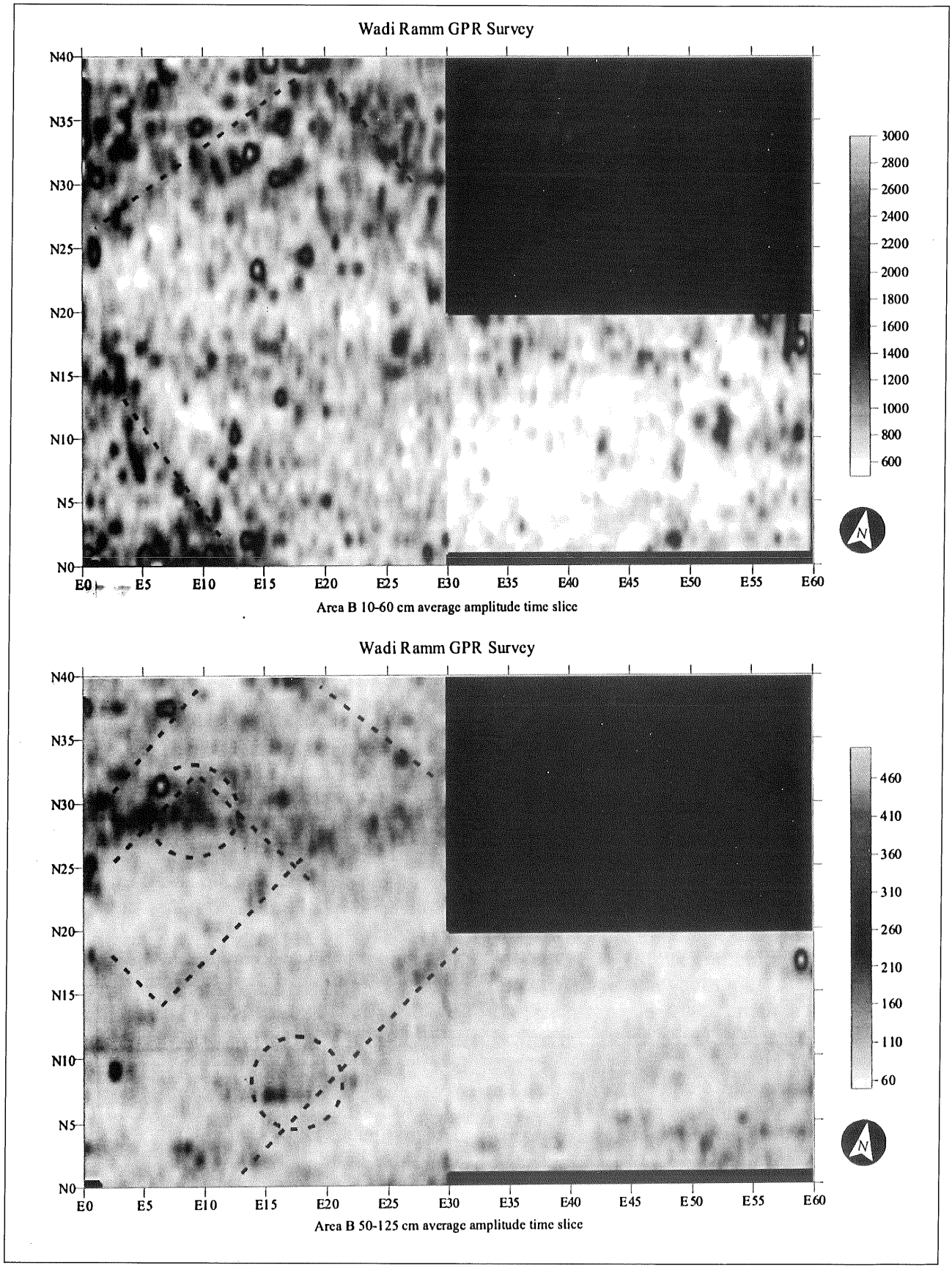
response anticipated from a Nabataean tomb.

Finally, the two southern-most areas explored contained additional areas of interest. Block F to the south of the Temple complex had strong but poorly defined rectilinear patterning in both the shallower and deeper time slices (**Fig. 7**). Area G, situated within the "southern village", contained considerable modern metal causing "ringing" responses throughout the survey area (**Fig. 8**). A number of linear/rectilinear anomalies appear despite the resulting clutter. The presence of many ancient walls visible at the surface, including the features excavated by Tholbecq (1998), suggests that these features represent ancient architecture.

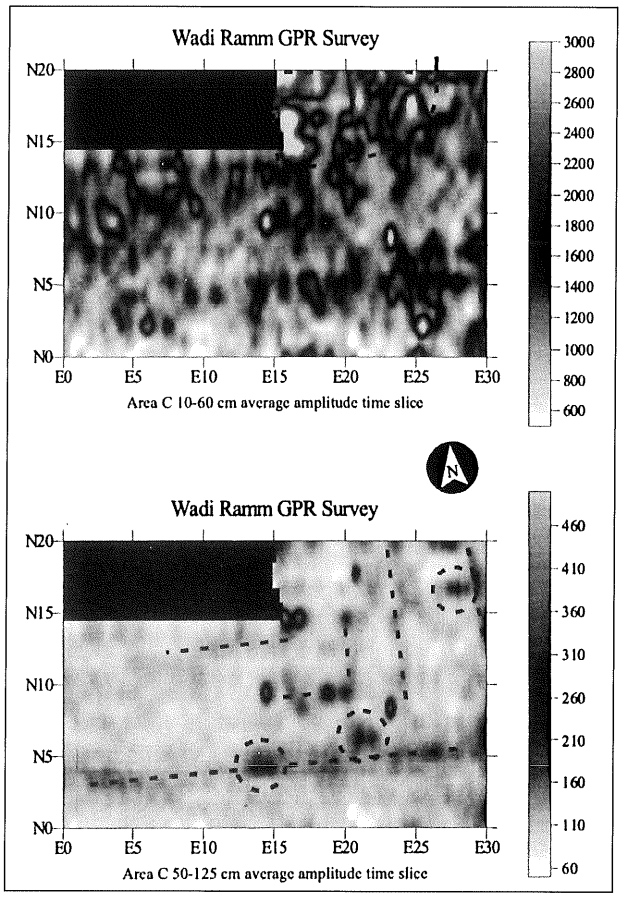
Discussion

The GPR survey at Ramm sought to identify the extent of ancient architecture and the location of the Nabataean cemetery. The patterning within the seven surveyed blocks indicates that architecture exists in the environs of the already-excavated structures. The linear/rectilinear patterning in Blocks A-E essentially displays two different orientations. Blocks A, C, D, and E share an ENE/WSW alignment similar to the eastern complex, although Block C immediately next to the complex deviates a few degrees clockwise. The orientation of possible wall features in Block B on the other hand is situated along a NE/SW axis more similar to the temple and related complexes. This deviation may stem either from variation in the site plan between different periods or from the lack of a unified grid pattern at the site during one period. Dudley and Reeves (1997:98-99) dated the bath portion of the eastern complex to the first century BC to the first century AD based on architectural and ceramic evidence. Presumably the other rooms in the complex associated with the " villa" are contemporary with the bath. Tholbecq (1998: 243) additionally dates the initial construction of the temple to the late first century BC to early first century AD and noted no changes in orientation during subsequent phases. A first century BC to first century AD date of the linear/rectilinear features identified in the GPR survey would therefore suggest the varied orientation of buildings did not result from construction during multiple time periods, but instead a lack of unified orientation during one period.

A number of possible "tomb-like" features



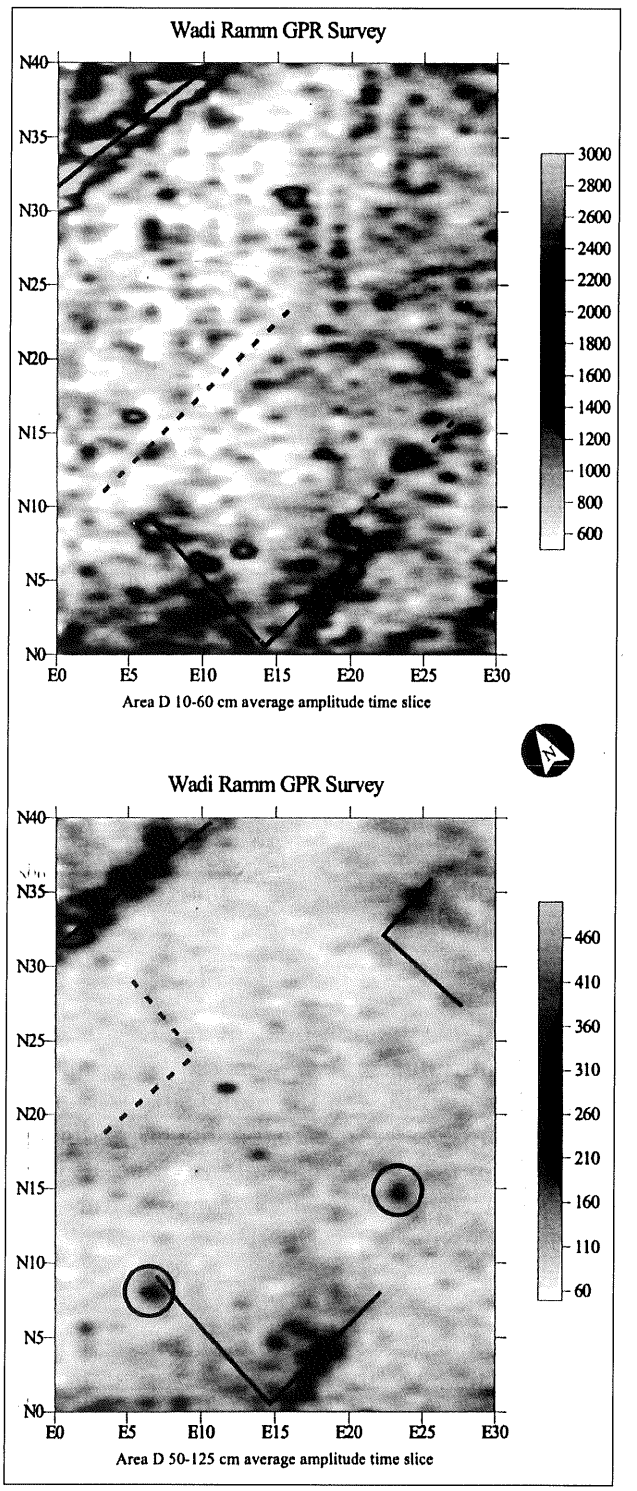
3. Block B survey results.



4. Block C survey results.

were noted during the GPR survey in all blocks surveyed. The isolated nature of these anomalies, that lack the patterning of multiple tombs more suggestive of a cemetery, makes them indistinguishable from a boulder or mass of rubble. Marked Islamic graves within the cemetery generally were expressed only in the near-surface and thus distinct from suspected Nabataean graves. The probability that these reflections, not associated with Islamic tombs, denote Nabataean tombs is weak in the absence of suggestive patterning, and thus ground truthing of these anomalies is necessary.

The presence of possible contemporary architecture in the same survey blocks as discrete "tomb-like" reflects is not unexpected. Evidence from excavated Nabataean villages, such as Khirbat adh-Dharīḥ in Jordan and Mampsis in the Israeli Negev, indicates that Nabataeans variably preferred to bury their dead near the family homestead (Lenoble *et al.* 2001; Villeneuve and al-Muheisen 2000) or outside of the main settlement (Negev 1971). Residents of Petra also built domestic and public structures near monumen-

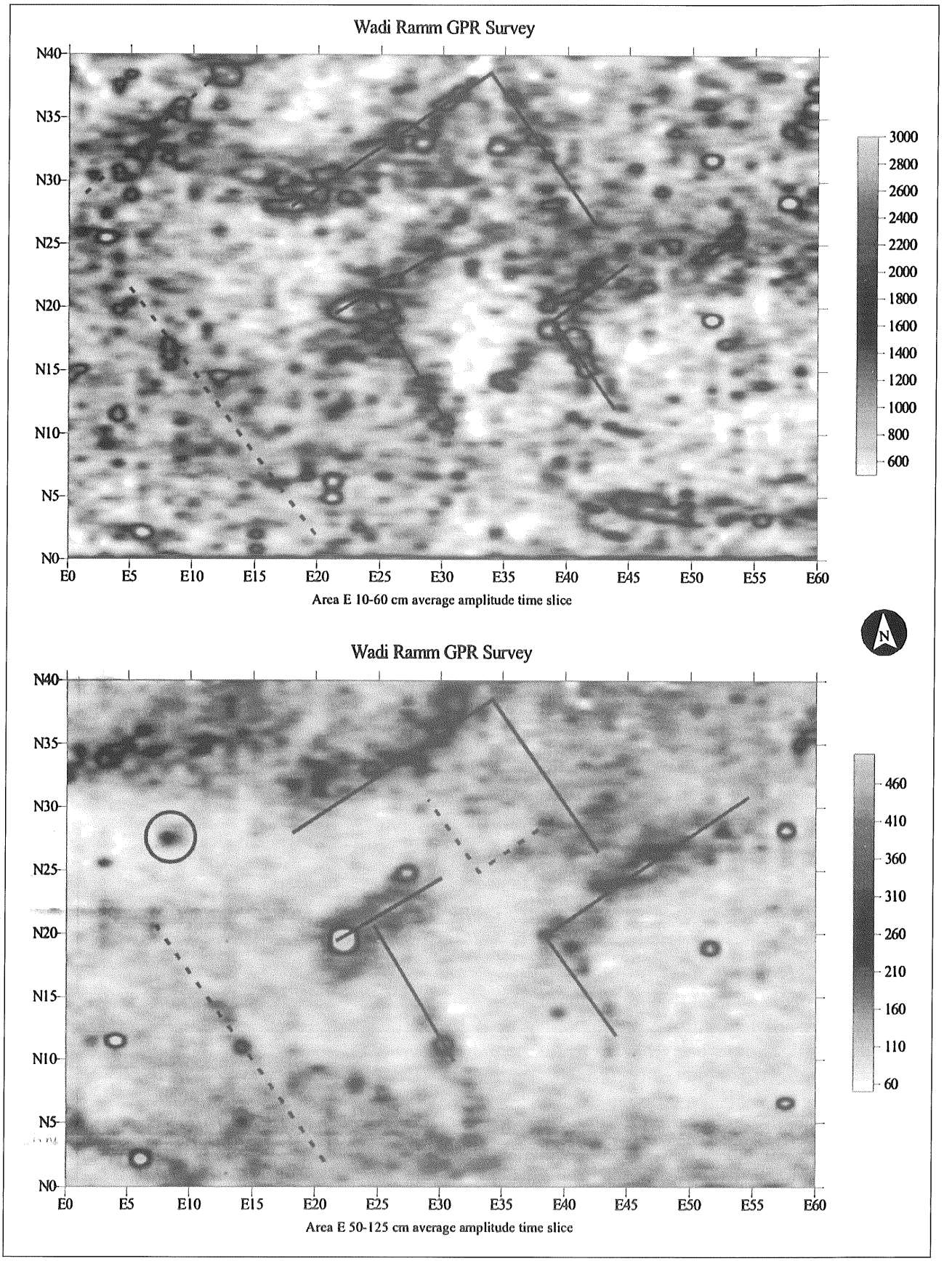


5. Block D survey results.

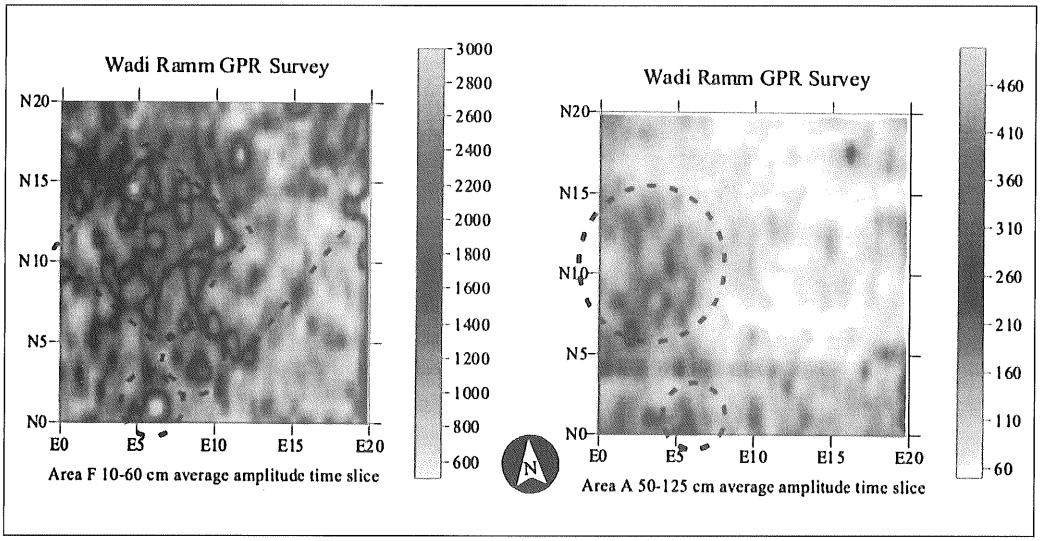
tal and rock-cut chamber tombs, although many of these tombs may have been out of use by the time the structures were constructed.

Conclusions and Further Research

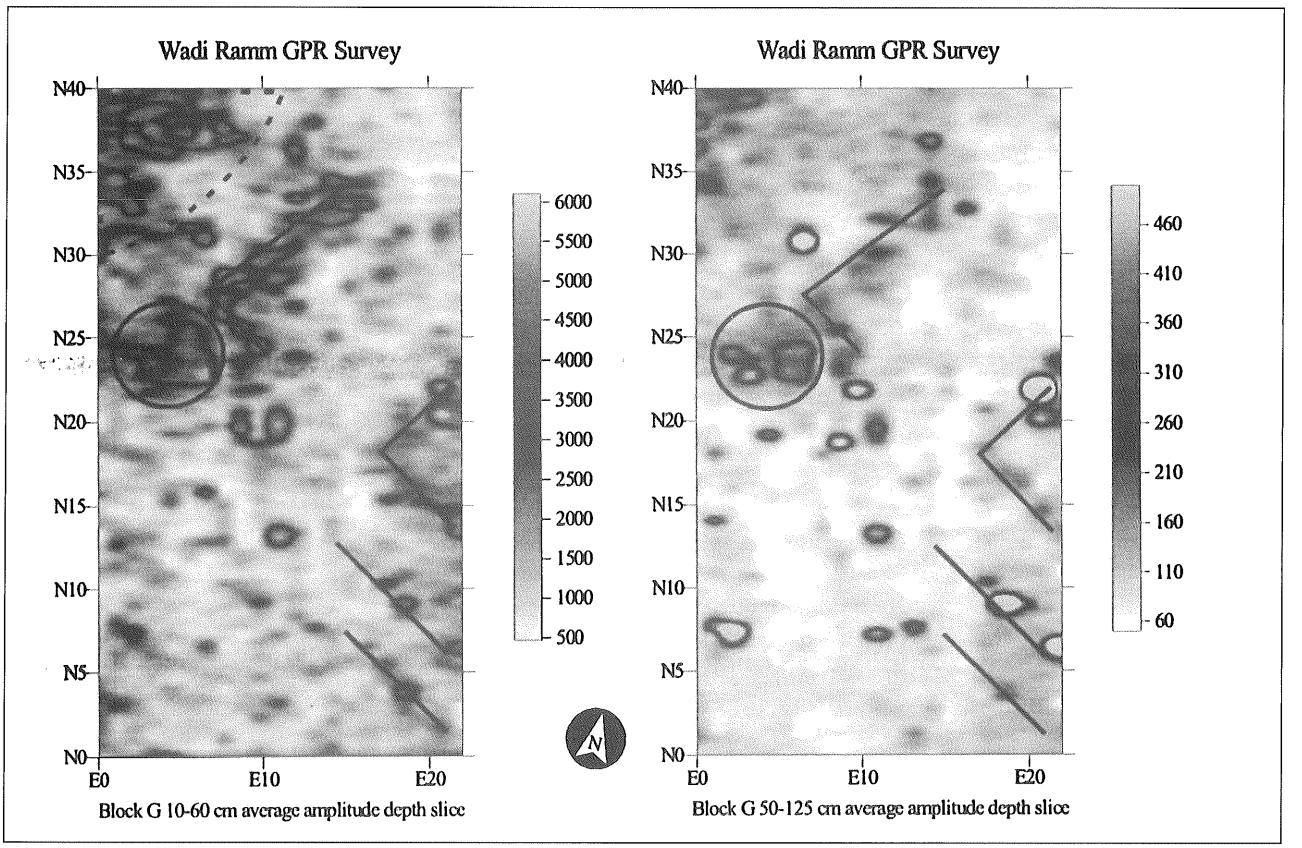
All of the survey areas explored during the 2005 season showed linear and rectilinear hori-



6. Block E survey results.



7. Block F survey results.



8. Block G survey results.

zontal patterning indicative of architectural features and discrete reflections consistent with isolated Nabataean tombs. The presence of architectural features, while not the object of this investigation, assists in our interpretation of other GPR evidence and site layout. First, GPR responses can vary dramatically under different conditions, and the reaction to stone architectural features can inform our identification of tombs or other less obviously patterned stone features. Mapping previously unknown architecture provides additional insight into intra-site patterning, providing context for the interpretation of more ambiguous anomalies.

The GPR results suggest that architectural features likely associated with the already exca-

vated Nabataean structures exist at Ramm. The presence of linear and rectilinear patterning to the north, south, and east of the Nabataean temple complex and bath/villa complex implies that built structures at the site occupy a much larger area than initially surmised. Possible walls identified in between the temple and bath/villa complexes also indicate greater occupational density than suggested by the exposed architecture. No strong evidence however exists for a large Nabataean cemetery within the surveyed areas. The scattered reflections, possibly indicating isolated Nabataean graves, on the other hand may be associated with other graves not easily detected through GPR survey, such graves lacking built architecture such as capstones or a cist.

Ground truthing through archaeological excavation of exploratory trenches would greatly increase our interpretation of these data. These test trenches will allow verification (or refutation) of preliminary interpretations and add insight into feature composition and geology. Careful spatial control kept during the GPR survey will allow accurate relocation of each anomaly and correct placement of the excavation trenches. The source of the anomaly will generally be discovered within a one meter radius in the horizontal plane, and at the same depth or shallower than the nominal depth in the data plots, which varies due to the velocity of the signal in that location.

Ground truthing scheduled for summer 2007 will focus on a sample of linear and rectilinear signals in each area to confirm the presence of architecture, the method of construction, and if possible, the date and function of the feature. A number of isolated anomalies possibly indicating graves also will be explored focusing on those in Blocks A, C, D, E, and F. Small soundings will also explore the two possible grave-related surface features associated with Block F.

Further research at Ramm also should include expanding the geophysical survey through investigating more areas via GPR and including a magnetic gradiometer survey. A GPR survey additionally should be conducted near the southern village and along the escarpment of Jabal Ramm to the west. In addition, further information on the location of the DoA's explorations at Ramm during the 1960s emerged after the 2005 field season. One of us (M. Perry) was informed by M. Barbara Reeves in June 2006 that she and Denine Dudley interviewed a local resident of Ramm village in 1996 regarding the previous DoA tomb excavation. The resident, Mohammed Abu Abdallah, noted that he witnessed excavation of a communal tomb by the DoA near the school in the Bedouin village. Mr. Abu Abdullah described the tomb as having a circular central chamber with radiating loculi, although he could not remember the date of the tomb. It is unclear whether the tomb was constructed or cut into the surrounding bedrock. Therefore further GPR survey should be employed in this area, in addition to expanding coverage near the ancient village. Finally, the magnetic gradiometer survey can map features containing igneous rock present in many of the walls and foundations observed at the site. Magnetic gradiometers can rapidly map large contiguous areas and may detect features not identified with GPR, although the "clutter" from metal debris and non-cultural igneous rock makes magnetic methods problematic at Ramm.

Megan A. Perry
Department of Anthropology
East Carolina University
Greenville, NC USA 27858

Geoffrey L. Jones
Archaeo-Physics, LLC
4150 Dight Avenue, #110
Minneapolis, MN USA 55406

Bibliography

Annan, A.P. and Cosway, S.W.
1998 *Ground Penetrating Radar Survey Design.* SAGEEP, Chicago, IL.

Conyers, L.B. and Goodman, D.
1997 *Ground Penetrating Radar: An Introduction for Archaeologists.* Walnut Creek, CA: AltaMira Press.

Dudley, D. and Reeves, B.
1997 The Wadi Ramm Recovery Project: preliminary report of the 1996 season. *Echos du Monde Classique* 41: 81-106.

Farés-Drappeau, S.
1996 Wadi Iram: un lieu du culte et de rassemblement des tribus arabe dans l'antiquité. Les premiers résultats de la mission épigraphique 1997. *ARAM* 8: 269-283.

Farés-Drappeau, S. and Zayadine, F.
2001 Preliminary report on the fourth season of the

Wadi Iram Epigraphical, Geographical and Archaeological Survey. *ADAJ* 45: 205-216.

2004 Preliminary report of the sixth archaeological and epigraphical survey at Wādī Ramm/Iram. *ADAJ* 48: 357-371.

Gaffney, C. and Gater, G.

2003 *Revealing the Buried Past: Geophysics for Archaeologists*. Stroud, U.K.: Tempus.

Graf, D.F.

1978 The Saracens and the Defense of the Arabian Frontier. *BASOR* 229: 1-26.

1983 The Nabataeans and the Hisma: in the footsteps of Glueck and beyond. Pp. 647-664 in C. Meyers and M. O'Connor (eds.), *The Word of the Lord Shall Go Forth: Essays in Honor of David Noel Freedman in Celebration of his Sixtieth Birthday*. Winona Lake, IN, Eisenbrauns.

1992 Nabataean settlements and Roman occupation in Arabia Petraea. Pp. 253-260 in M. Zaghloul, K. Amr, F. Zayadine and R. Nabeel (eds.), *SHAJ* IV. Amman, Department of Antiquities of Jordan.

Grimme, H.

1936 A propos de quelques graffites due temple de Ramm. *RB* 14: 90-95.

Harding, G.L.

1952 *Some Thamudic Inscriptions from the Hashemite Kingdom of Jordan*. Leiden: Brill.

Jamme, A.

1971 *Miscellanées d'ancient arabe, vol. 2*. Washington, DC: Allen.

Kirkbride, D. and Harding, G.L.

1947 Hasma. *PEQ* 79: 7-26.

Kirkbride, D.

1960 Region du Wadi Ramm: Communication. *RB* 67: 230-231.

Lenoble, P., al-Muheisen, Z. and Villeneuve, F.

2001 Fouilles de Khirbet edh-Dharih (Jordanie) I. Le cimetière au sud du Wadi Sharheh. *Syria* 78: 89-151.

Negev, A.

1971 The Nabataean necropolis at Mampsis (Kurnub). *IEJ* 21: 110-129.

Savignac, M.R.

1932 Notes de voyage: Le sanctuaire d'Allat à Iram. *RB* 41: 581-597.

1933 Le sanctuaire d'Allat à Iram. *RB* 42: 403-422.

1934 Le sanctuaire d'Allat à Iram (suite). *RB* 43: 573-591.

Savignac, M.R. and Horsfield, G.

1935 Le temple de Ramm. *RB* 44: 245-278.

Tholbecq, L.

1997 Les sanctuaires des Nabatéens. État de la question à la lumière de recherches archéologiques récentes. *Topoi* 2: 1069-1095.

1998 The Nabataeao-Roman site of Wadi Ramm (*Iram*): a new appraisal. *ADAJ* 42: 241-254.

van den Branden, A.

1950 *Les Inscriptions Thamoudéenes*. Louvain: Institut Orientaliste.

Villeneuve, F. and al-Muheisen, Z.

2000 Nouvelles recherches à Khirbet edh-Dharih (Jordanie), 1996-1999. *CRAI 2000*: 1526-1563.

Winnett, F.V. and Reed, W.L.

1970 *Ancient Records from North Arabia*. Toronto: University of Toronto.

Zayadine, F. and Farés-Drappeau, S.

1998 Two North-Arabian inscriptions from the Temple of Lat at Wadi Iram. *ADAJ* 42: 255-258.