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Project Gallery

The Rajajil Columns: employing multi-method geophysical survey to investigate monument construction and use

Bryan Hanks[1] & Mesfer Hamad Alqahtani[1,2]

[1] Department of Anthropology, University of Pittsburgh, USA
[2] Heritage Commission, Ministry of Culture, Kingdom of Saudi Arabia
Author for correspondence: Bryan Hanks ✉ bkh5@pitt.edu

Ancient stone monuments may have marked the locations of key ritual activities for pastoralist communities. This project is the first to employ multi-method geophysical survey to identify additional features of construction and use at the Chalcolithic-period Rajajil Columns site in northern Saudi Arabia.

Keywords: Southwest Asia, Chalcolithic, ground penetrating radar, magnetometry, pastoralism, stone monument

Introduction

The Rajajil Columns site is situated in the Al Jouf Province of Saudi Arabia (Figure 1). The main site covers nearly 6ha and consists of 54 separate groups of standing sandstone pillars and other stone features (Figure 2). Many of the pillars, originally standing up to 3m in height, are now broken and displaced. Stone-lined features at the base of the pillars may represent burial cairns and a large group of small stone cairns are situated on a hill to the south (Zarins 1979). The site is believed to have extended over a wider zone, but modern agricultural activities have impacted some areas. Previous field studies include site surveys, planning and small excavations at the base of two column groups and a stone feature near the southern periphery (Gebel *et al.* 2016) (Figure 2). Analysis of recovered stone tools suggests activities dating to the Chalcolithic period (fifth millennium BC) with possible traces of both earlier and later activity (Gebel & Wellbrock 2019). This aligns with the mid-Holocene period, when environmental conditions in the Arabian Peninsula favoured the expansion of mobile pastoralism. Interpretations of Rajajil vary, suggesting it may have served different purposes: as a collective burial ground for dispersed herding communities, a site for astronomical functions, a special location for sociopolitical gatherings and a domestic settlement area (Zarins 1979; Almushawh 2018; Gebel & Wellbrock 2019; Kacem 2022). Archaeological research thus far has concentrated on exploring the stone pillar clusters, and a

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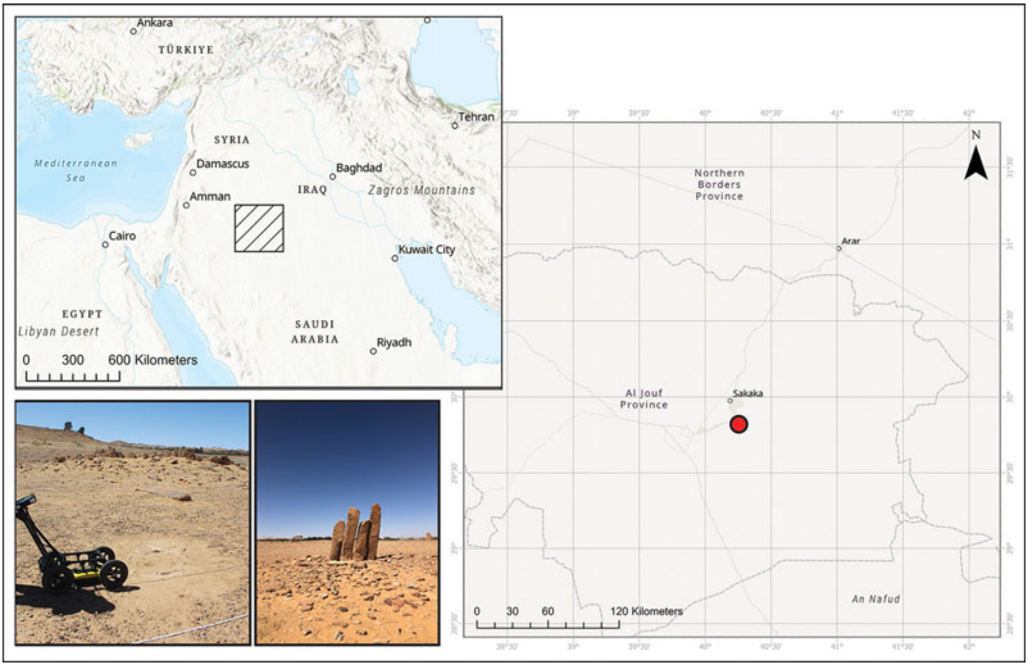

Figure 1. Location of the Rajajil Columns site. Inset left) GPR survey near RJ-27 complex; inset right) RJ-24 stone complex near site entrance (figure by authors using Esri:ArcGIS).

more comprehensive understanding of the function and use of the site through time has remained elusive. Our project extends on previous studies, using geophysical survey to identify associated zones of human activity that may then be validated through ground-truthing, environmental studies and absolute dating. This will contribute to a fuller understanding of this important monumental site across time and through the changing social, economic and environmental conditions that contributed to developing pastoralism in the region. Positioned along an ancient trade route connecting the Red Sea, Levant and northern Arabian Peninsula, this site represents one of the earliest standing-stone monuments associated with pastoralist communities in the region, likely playing a crucial role in emerging social stratification and territorial demarcation.

Multi-method geophysical survey

In March 2024, we conducted the first exploratory multi-method geophysical survey at Rajajil. A drone provided digital elevation modelling and high-resolution imagery. Subsurface geophysical methods included fluxgate gradiometry (Bartington 601-2), ground penetrating radar (GPR) (Sensors and Software SmartCart, 500 MHz antenna) and a low-frequency multi-depth electromagnetic apparent conductivity/susceptibility meter (GF Industries, CMD-mini Explorer). Five 20 × 20m grid blocks were aligned on a 324°

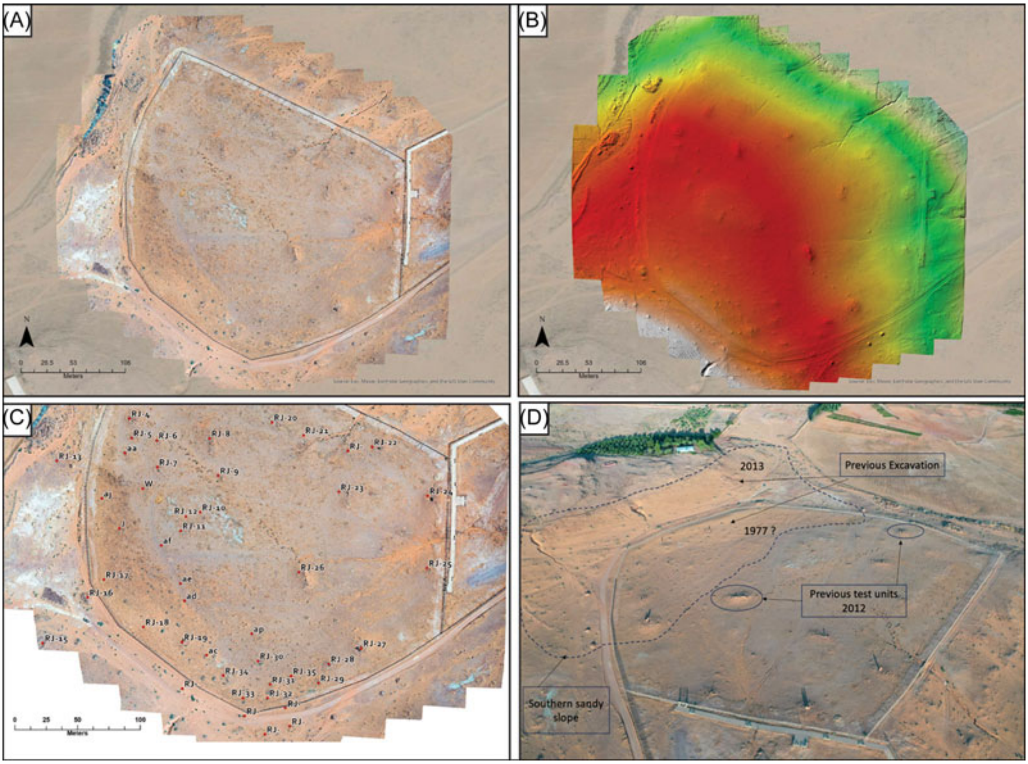

Figure 2. Images of the Rajajil site: A) drone photograph; B) digital elevation model; C) identified surface features; D) previous archaeological research locations (figure by authors).

magnetic baseline to encompass two standing-stone clusters (RJ-26 & RJ-27) and an area between them (Figures 3 & 4). Another 10 × 10m grid (4b) was added to the north-east of grid 4a following the identification of two potential stone fire-pit features (Figure 5). Fluxgate gradiometry was conducted in all grids, while GPR was conducted in grids 1, 2 and 4b, and low frequency electromagnetic apparent conductivity/susceptibility in grids 1 and 4b.

Results

Our research identified several promising anomalies within all surveyed grids. The local sandstone geology is magnetically 'quiet' and many monopolar positive responses were recorded in the +1 to +10nT range (fluxgate gradiometry). Such responses may represent infilled pit features and/or low-temperature burning. A strong contrast in such responses characterises the areas surrounding the RJ-26 and RJ-27 columns, with RJ-26 being substantially more magnetically active (Figure 3, grids 4a & 5). Fluxgate gradiometry survey

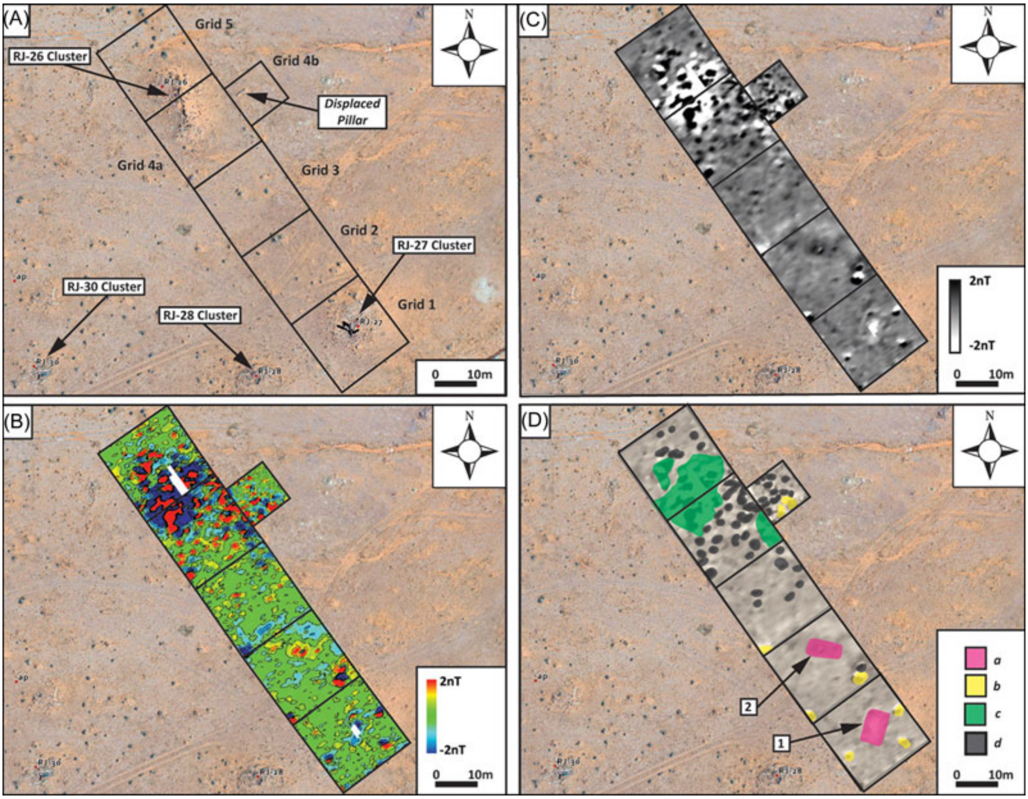

Figure 3. A) Geophysical survey grid and identified stone column clusters; B) fluxgate gradiometry results; C) colour contour plot of fluxgate gradiometry results; D) interpretation of fluxgate magnetic responses showing unique responses (a) (1 – rectangular anomaly; 2 –rectangular feature); simple dipolar responses (b) (modern metal debris); complex dipolar responses (c) (modern metal debris and/or burned soil); and monopolar positive responses (d) (figure by authors).

in grid 1 produced intriguing results indicating a rectangular magnetic feature surrounding the RJ-27 stone cluster (Figure 3B & D). The apparent conductive responses achieved through low-frequency electromagnetic survey (both low and high responses) suggest zones where subsurface stone may have been removed during construction activities and subsequently infilled with more conductive soils (Figure 4D & E). Grid 4b produced several geophysical responses in combination with the identification of two probable surface-level fire-pit features (Figures 5 & 6). These included several monopolar positive responses (fluxgate gradiometry) in the range of +1 to +10nT and associated apparent magnetic susceptibility (low frequency electromagnetics). GPR survey in grid 4b also revealed strong subsurface reflections, including a possible curvilinear shape (Figure 6C & F) that may represent a subsurface anthropogenic feature. Two-dimensional GPR radar profiles further indicate substantial modification to the natural geological strata in this grid area (Figure 6D & E), also possibly relating to construction activities.

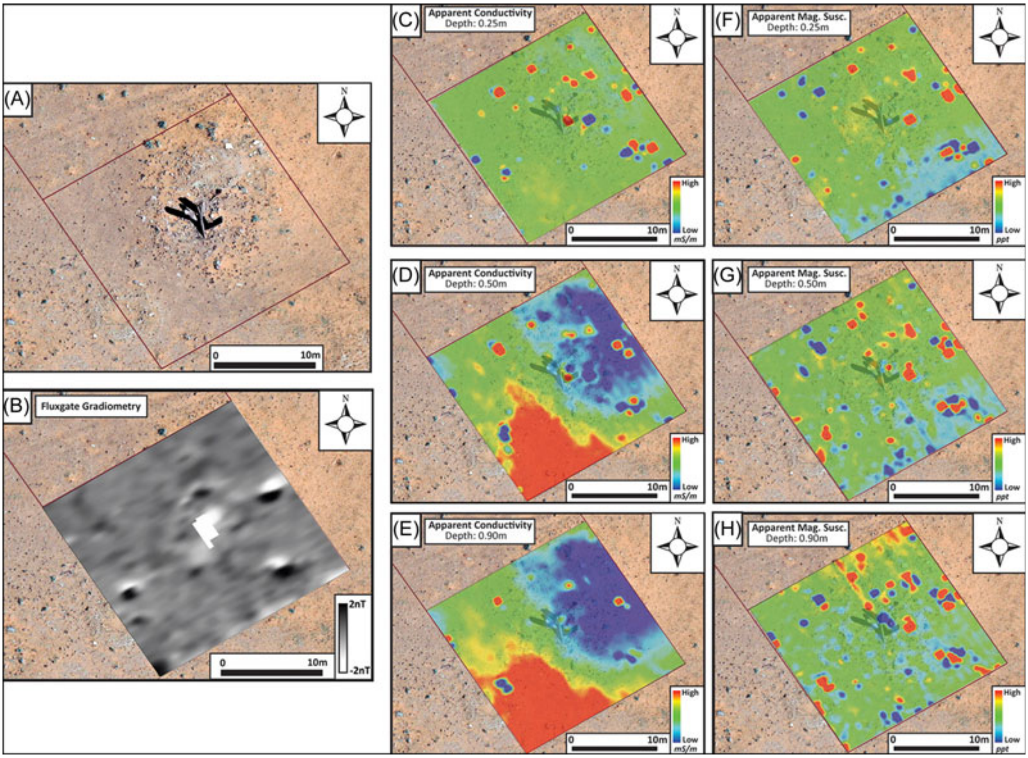

Figure 4. A) Grid 1 location over the RJ-27 column complex; B) fluxgate gradiometry greyscale plot; C–E) apparent conductivity responses, note the large zones of high and low readings, possibly relating to the removal of stone and subsequent infilling with more conductive soils; F–H) apparent magnetic susceptibility responses, note small positive responses likely representing modern metal debris across the site (figure by authors).

Conclusion

Application of multi-method geophysical survey at the Rajajil Columns site has yielded new data relating to underlying geological conditions as well as complex human activities likely connected with construction and use of the site. The variety of subsurface and geophysical responses achieved, and the identification of probable fire-pit features in grid 4b, support the need for more detailed surveys across the site in future. Such surveys, in conjunction with targeted ground-truthing, excavation, artefact and ecofact analyses and radiocarbon dating, may offer a more robust analytical framework for interpreting the nature of human activities associated with this important monumental site and how these may have changed through time.

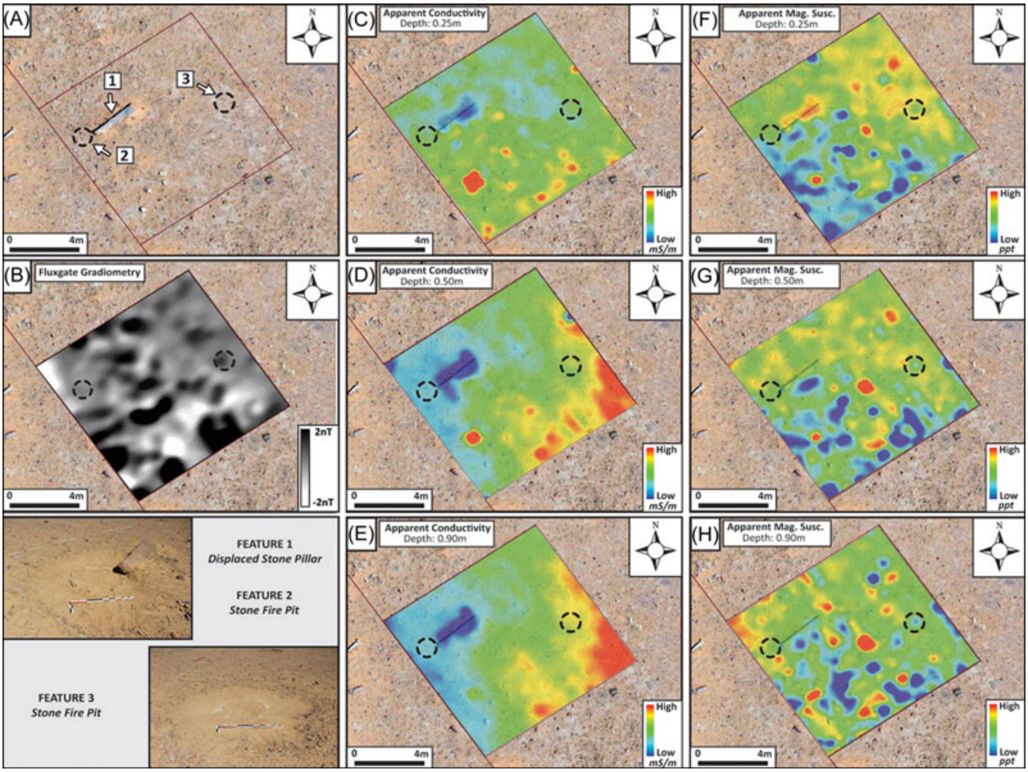

Figure 5. A) Drone photograph of grid 4b showing a displaced sandstone pillar (1) and two probable stone fire pits (2 & 3); B) fluxgate gradiometry greyscale plot; C–E) apparent conductivity responses; F–H) apparent magnetic susceptibility responses (figure by authors).

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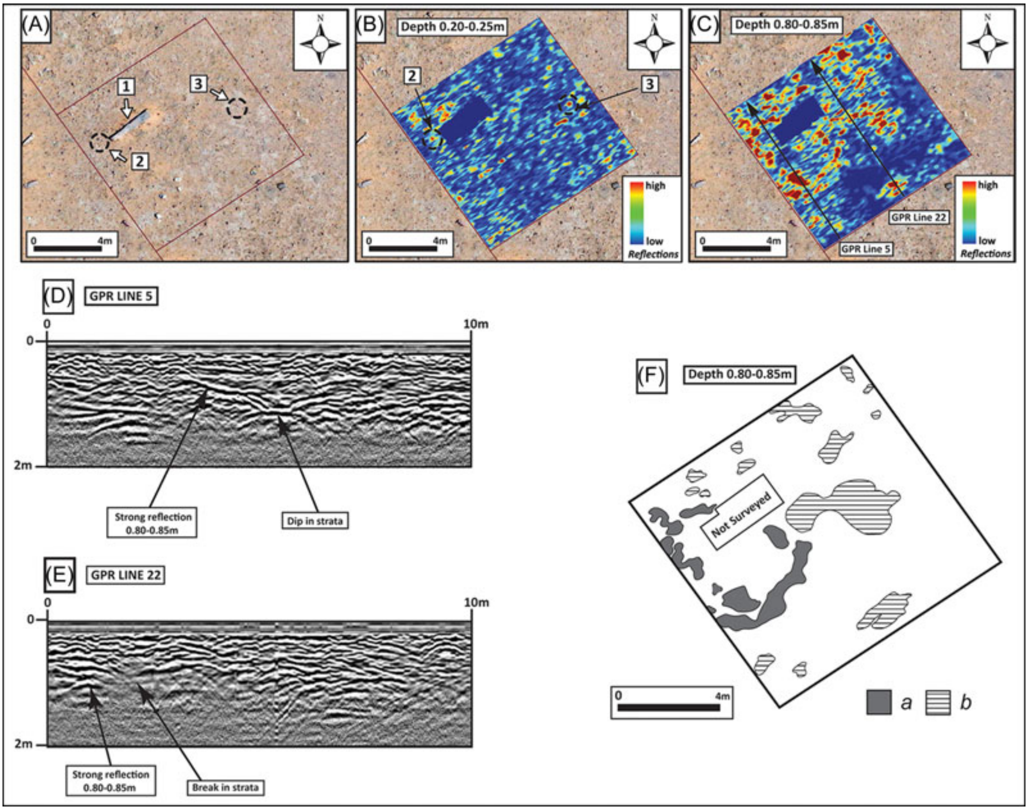

Figure 6. A) Drone photograph of grid 4b; B) GPR slice view showing locations of strong responses at 0.20–0.25m below surface (2 & 3); C) GPR slice view showing strong reflections at 0.80–0.85m below surface including a possible curvilinear anomaly; D) reflection profile of GPR traverse Line 5; E) reflection profile of GPR traverse Line 22; F) interpretation of curvilinear (a) and other strong GPR reflections (b) at 0.80–0.85m below surface (figure by authors).

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