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# GEOPHYSICAL SURVEY AT TELL EL-GHABA, 2010

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**Abstract:** The article presents the results of geophysical prospection carried out in 2010 on the site of Tell el-Ghaba in northern Sinai where an Argentinian archaeological project working in 1995–2002 uncovered architectural remains from the Twenty-sixth Dynasty. The aim was to trace the limits of occupation and the settlement layout. An area of 6.5 ha in the southeastern part of the site was surveyed, applying the magnetic method (FM256 gradiometer by Geoscan Research) in a sampling grid of 0.50 m by 0.25 m. A ground survey recording surface pottery scatter determined the area of the site at approximately 12 ha. The magnetic prospection indicated that architectural remains extended only in a zone approximately 100 m wide, running alongside the eastern shore of a lagoon. The magnetic map also indicated the position and inner layout of individual buildings. The results of geophysical research have confirmed the usefulness of the magnetic method in reconstructing the layout of urban architecture made of Nile silt brick.

**Keywords:** archaeological geophysics, magnetic prospection, mud-brick architecture, Sinai

## THE SITE

Tell el-Ghaba in the northern Sinai was one of the localities on the ancient “Ways of Horus”, a land bridge between the eastern Nile Delta and the Levant. It is located at 30°58’ North and 32°25’ East, between Tell Hebua to the west and Tell Keduā to the east, at the edge of the eastern part of a lagoon, near the former Pelusiac branch of the Nile.

The Argentinian Archaeological Mission undertook research at the site within the frame of a salvage project under the auspices of UNESCO, aimed at investigating the antiquities of northern Sinai threatened by advanced irrigation works in the region. Archaeological

exploration in 1995–2002 led to the identification of an early Saite settlement, dated to the early Twenty-sixth Dynasty (pottery dates point to the reigns of Psamtik I and Psamtik II). The architecture lies no deeper than 1.80 m below ground surface and only the foundations of the mud-brick structures remain. The overall site surface has been calculated at approximately 12 ha (Fuscaldo 2005: 8–9).

The work, which was suspended in 2002, was taken up again in 2010. Reopening the project, the current mission director Sylvia Lupo opted for a repeated program of geophysical research to aid in planning future fieldwork.

## GEOPHYSICAL SURVEY IN 1998–1999

The original exploration program had included magnetic and electrical resistivity surveys, which were carried out by Jorge Trench (2006).<sup>1</sup> A Geoscan Research FM18 fluxgate gradiometer was used for the magnetic part of the prospection. In 1998, the survey covered three areas (IV, V and VI), totaling 1.7 ha [Fig. 1]. Archaeological testing verified that the anomalies discovered in Area V corresponded to furnaces. The building designated as F was located in Area VI and was also verified by archaeological exploration (Crivelli Montero, Fuscaldo 2005: 345, 358–359). In 1999, the prospection focused on Areas VII and VIII, covering an area of 1.6 ha. Based on the magnetic survey results, Jorge Trench

identified the remains of eight structures in Areas VII and VIII. The most distinct of the anomalies corresponding to buildings were mapped on the site plan and designated as H, I, J, K. The location of the remaining buildings was not discussed in the publication of the survey. Anomalies H, I and J were tested archaeologically. Remains of mud-brick architecture were found very close to the surface. The sampling grid used in the 1998 prospection was limited to two measurements per square meter, exceptionally reaching four measurements in the vicinity of the anomaly corresponding to Building F. All the measurements in 1999 were made in a 0.50 m by 0.50 m grid (four measurements per square meter), in parallel mode.

### Team

*Dates of work:* 30 April–10 May 2010

*Director of the geophysical project:* Tomasz Herbich (Institute of Archaeology and Ethnology, Polish Academy of Sciences)

*SCA representative:* Ahmed Abdel Latif

*Geophysical team members:* Dawid Świąch, Robert Ryndziewicz, archaeologists (independent)

*Student-trainee:* Krzysztof Kiersnowski (Institute of Archaeology, University of Warsaw)

### Acknowledgments

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<sup>1</sup> The publication covers only the magnetic prospection results; the electrical resistivity survey conducted in 1998 was of secondary importance, used to verify small sections of the areas distinguished based on the magnetic survey results.

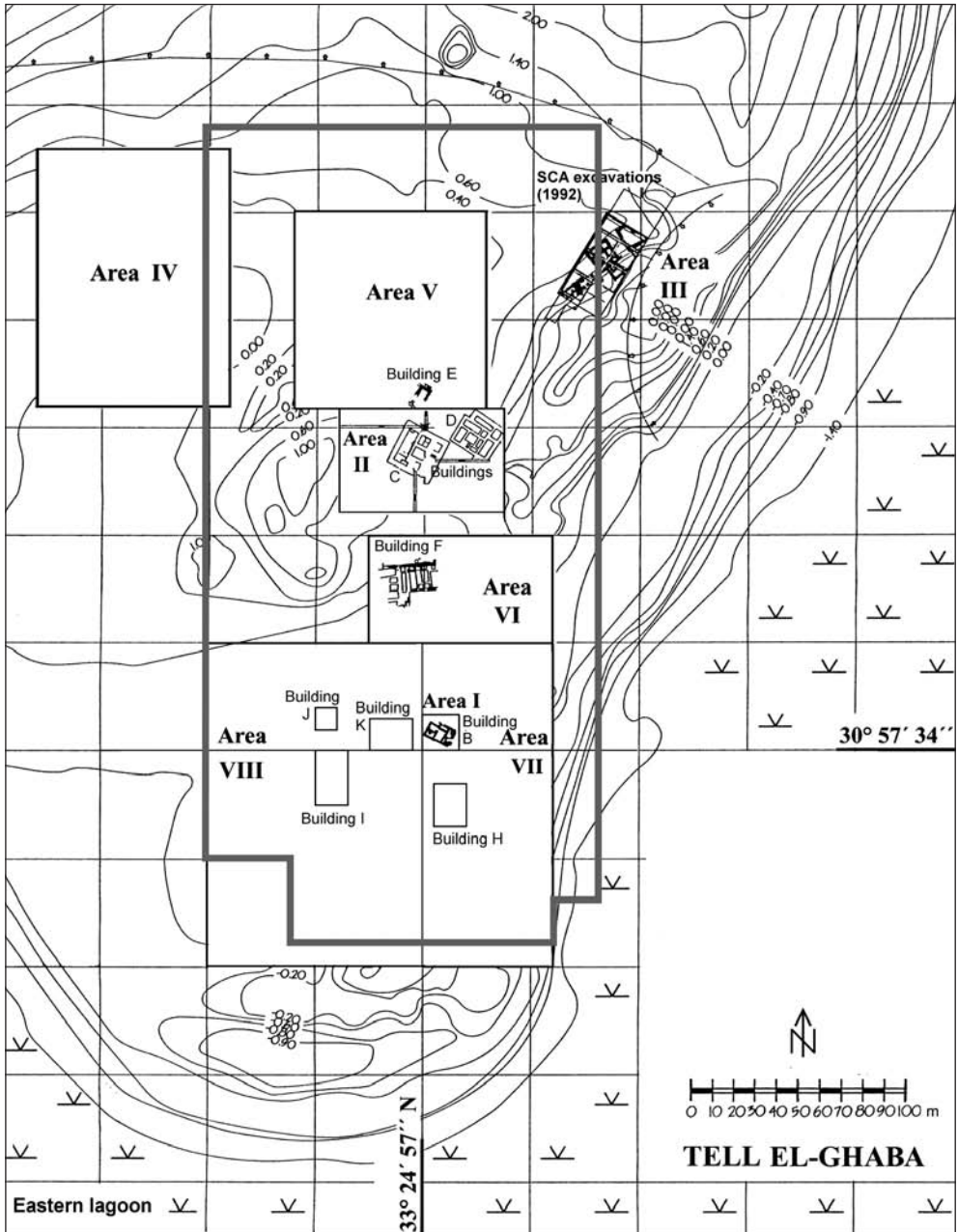


Fig. 1. Site map prepared by the Argentine Archaeological Mission (1999); area of the magnetic survey in bold gray line

## MAGNETIC SURVEY IN 2010: METHOD AND PRESENTATION OF RESULTS

A comparison of magnetic maps obtained for Tell el-Ghaba in 1998–1999 with maps of other sites from the region featuring architecture raised of analogous building material (that is, bricks made of Nile silt) and investigated with the same kind of apparatus, but in a denser measurement grid (Hebua II, see Herbich 2009: 74 and Tell Abyad, see Valbelle, Leclère 2008), indicated that the method should bring much more information than had been the case in the earlier Ghaba survey. Therefore, a repeated program of geophysical prospection was planned by the Argentinian Mission as a priority in planning further fieldwork once the project resumed excavations in 2010.

The prospection was carried out with two fluxgate type gradiometers measuring the vertical component of the Earth's magnetic field intensity with up to 0.1 nT accuracy. Measurements were taken along lines spaced 0.50 m, every 0.25 m, within a 20-m grid, in parallel mode. The instruments were adjusted at a reference point after completing each square of the grid.<sup>2</sup>

The results are mapped as changes of magnetic field intensity. The map is presented in a positive scale where extreme negative values come up as white and extreme positive ones as black.

### MAGNETIC SURVEY RESULTS

The prospection covered an area of 6.56 ha, in a rectangle 180 m wide and 380 m long, in the central and eastern part of the site

[see *Fig. 1*]. In the northern part of the area, this is mostly flat ground, in the southern part there are small mounds usually no more than several dozen square meters, covered with vegetation [*Figs 2, 3*]. At the eastern edge of the area the ground rises to about 2 m in height. This mound is covered with sand, which also covers the northeastern part of the surveyed area. No traces of architecture of any kind can be observed on the surface. Archaeological dumps can be seen in area VIII. In the southeastern part there are earth embankments dating from the time of the military occupation of the site during the Arab–Israeli conflict.

Area IV was the only area previously surveyed that was not included in the present project. Otherwise, the repeated survey covered all the places previously tested archaeologically by the Argentinian mission (buildings B, C, D, E, F). In the northeastern part, the measurements also encompassed an area excavated by the SCA in 1992.

The map demonstrates a belt of anomalies distinguished from a less disturbed surrounding [*Fig. 4*]. This belt is about 100 m wide at the southern end and narrows toward the north. Walls were shown up mostly as negative anomalies; positive anomalies occurred in just a few cases. The orientation was heterogeneous but still approximately the same: NNE–SSW/SEE–NW/W. Architectural plans came up as mainly square, typical of Saite architecture, the sides of buildings reaching

<sup>2</sup> On methods of surveying with a magnetometer, see Aspinall, Gaffney, Schmidt 2008: 91–113.



*Fig. 2. Northern part of the prospected area, view from the north  
(Photo T. Herbich)*



*Fig. 3. Southeastern part of the prospected area, view from the south  
(Photo T. Herbich)*

up to 20 m in length showing up at magnetic maps in a similar way as those registered at several sites in the Delta (eg., in Buto and Balamun, Hartung *et alii* 2007: 160–161; Herbich, Spencer 2008: 106). Structures identified during previous research were outlined quite clearly: excavated buildings C (squares H5, western part of H6, by the southern edge of G5) and D (squares H6 and H7, southeastern corner of G6 and southern part of G7), building E (northeastern part of G5), building F (squares K4, K5 and K6), building B (northern part of O6). Buildings, which were only tested before, were mapped with greater distinctness than on the 1999 map: building J (at the intersection of squares N3, N4, O3, O4), building I (squares O3 and P3), building H (square P6 and the northern and adjacent parts of P5 and R6) and building K (squares O4 and O5), unverified on archaeological grounds.

More buildings could be discerned in areas VII and VIII. These should be the structures Trench noted without describing their location. Architecture was mapped around the intersection of squares R3, R4, S3 and S4 (the northern part of the building was covered by the 1999 survey). A faintly discernible structure can be seen around the intersection of squares P2, P3, R2 and R3. Other mapped structures included one west of building I (squares O2 and P2) and a distinctly rectangular double-unit structure, aligned precisely north–south in the northern part of M3. At the southern end of area VIII a building was mapped around the intersection of squares S3 and T3.

The outlines of building F, discovered by Trench in Area VI and largely excavated, were marked clearly on the magnetic map. The present survey indicated the

presence of more structures in the vicinity: a fragment of a structure to the south of building F (square L4), a building in square I7, J7 and in the northeastern corner of J6, two buildings in K6 and K7. Anomalies in these places were mapped in 1998, but their low distinctness precluded their identification as images of architectural features.

Moving northward, one observes anomalies corresponding to excavated buildings C, D and E and more structures north of them, in square F7, northern part of G7 and adjacent margins of F6 and F8. The highly distinct image on the current map suggests that the building was excavated and this is confirmed by evidence on the ground surface in the form of dark soil from mud bricks and the remains of archaeological dumps. Egyptian archaeologists may have conducted excavations in this area.

The present magnetic survey traced the western border of architecture in squares R2 in the south, through G5 and on to D9 in the northeast. Anomalies observed in D9 reflected the edges of trenches excavated by the SCA in 1992 [see *Fig. 1*]. The eastern border of ancient architecture runs from T5 to L8, where it turns a right angle and continues eastward. The narrowing of the belt of anomalies corresponding to settlement architecture, observed north of squares J8 and J9, appears to be due to a thicker layer of overlying sand concealing the remains. Wherever the ground dips in this area, that is, the overlying deposits are thinner — as in K8 and K9 — a distinct image of architectural traces was mapped. Anomalies reflecting architecture are present also in the area with lower distinctness of the magnetic image, e.g., squares I8 and G8. The settlement appears

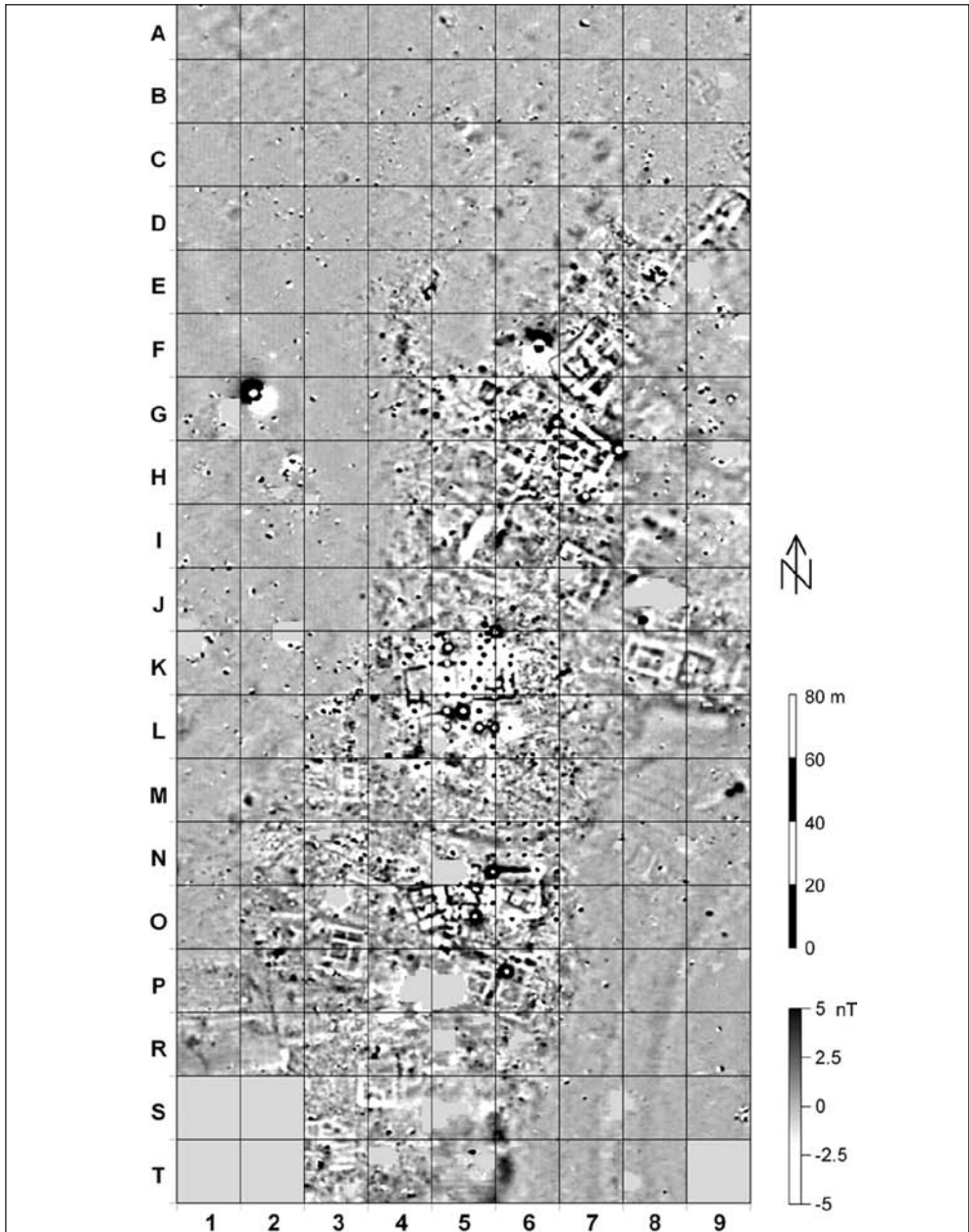


Fig. 4. Magnetic map. Geoscan Research FM256 gradiometers. Sampling grid 0.25 m x 0.50 m, interpolated to 0.25 m x 0.25 m. Low pass filter. Dynamics -3.4/+5 nT (white/black) (Processing T. Herbich)



to have lined the shore of a lagoon, which is reflected by an anomaly curving slightly from the center of T8 to the southeastern part of N9. It would appear that in the southern part of the surveyed area the architecture was located some 40 m away from the shore.

A series of anomalies of oval shape and diameter from 1 m to 2 m, characterized by a high amplitude of values ranging  $-10/+30$  nT, was mapped in squares E8, around the intersection of G5 and G6, J8, by the western border of K7, in N3 and N4, at the northern end of P6, in R4. Some of these (as in E8, J8, N3 and P6) were mapped in sections of the map reflecting architectural remains. These anomalies should be interpreted as images of furnaces or open hearths.

Anomalies of irregular outline, characterized by raised magnetic-field intensity values, run along the western border of the

settlement (for example, in squares C7–E7, C6–E6, F4, I4–J4). They are thought to correspond to concentrations of mud or ashes. Those of more regular shape could reflect the fill of pits of some kind.

The magnetic image is heavily disturbed by the presence of a large number of high amplitude anomalies (ranging  $-50/+200$  nT), undoubtedly caused by iron survey rods left in the ground during the archaeological excavations or when originally tracing the areas for prospection in 1998. Such a regular grid of anomalies 5 m by 5 m is observable, for example, in squares N6–O6 (north of building B and around it), H6, H7 and G7 (traces of excavations in building D) and K5, K6, L5 (traces of excavations in building F).

The unsurveyed areas on the present map correspond to mounds covered with vegetation or archaeological dumps from the earlier excavations.

## CONCLUSIONS

The results of geophysical research in Tell el-Ghaba have confirmed yet again the usefulness of the magnetic method, when properly applied, for a reconstruction of plans of brick architecture made of Nile silt. Taking into consideration the results of magnetic mapping, one can revise the tentative plan of the settlement proposed previously on the basis of a ground survey of the site. The magnetic prospection shows beyond all doubt that architectural remains can be found in a belt approximately 100 m wide lining the eastern shore of a lagoon. Area V, which is located about 150 m from the shore of the lagoon and which was believed to be part of the settlement based on an abundant scattering of ceramics

on the surface, appears to be devoid of any architectural substance, judging by the magnetic results. The survey has also excluded the presence of any kind of architecture in area IV (at least at the eastern edge covered by the present prospection). These observations are based on an analysis of the magnetic map, which is sufficiently clear in terms of the plotted image to permit verification by a simple program of drillings. The magnetic map will help to plan future research by the Argentinian mission to supplement the previous work. It will also facilitate a reconstruction of the urban layout, modeled on settlement plans from Buto, traced from magnetic maps by Ulrich Hartung (Hartung *et alii* 2009: 186).

Moreover, it should be reiterated that iron rods used for topographic surveying cause serious disturbances of the magnetic image. For the good of future geophysical

research, it should become part of standard archaeological practice to use for such purposes only magnetically non-sensitive materials.

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