



## **GEOPHYSICAL INVESTIGATION AT TELL EL-DABAA "AVARIS" ARCHAEOLOGICAL SITE**

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### **ABSTRACT**

Tell El -Dabaa is one of the important archaeological sites in the Eastern part of the Nile Delta. It is located at about 7 km north of Faqous city, Sharqiya governorate, Egypt. The ancient name of El-Dabaa area was Avaris, which had been considered as the main capital of Hyksos (Dynasty XV) from 1650 to 1542 B.C. The whole area was covered by the deltaic deposits during the successive flood events along Nile Delta. Geomagnetic and geoelectric surveys have been carried out in order to outline the subsurface archaeological remains in this area. The target area, which is about 10000 m<sup>2</sup>, was surveyed in grid pattern each of 20x 10 m for magnetic survey and 20 × 20 m for geoelectrical resistance survey. Integrated results of the magnetic and geoelectric data analysis have succeeded in delineating a clear subsurface picture of archaeological remains. The results show many linear anomalies, which may represent buried walls, as well as some small archaeological remains detached from the main walls. Also, we could notice some rectangular features with different sizes, which might be described as remains of different archaeological buildings. Besides, some circular structures with small size obtained and could be interpreted as columns foundations.

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**KEYWORDS:** Tell El-Dabaa (Avaris), magnetic, resistivity, geophysical, archaeology, Hyksos, Egypt

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## HISTORICAL BACKGROUND

Tell El-Dabaa is one of the famous and important archeological sites in the eastern part of the Nile Delta, Egypt. It is located at about 7 km north of Faqous city, Sharqiya Governorate (Fig.1).

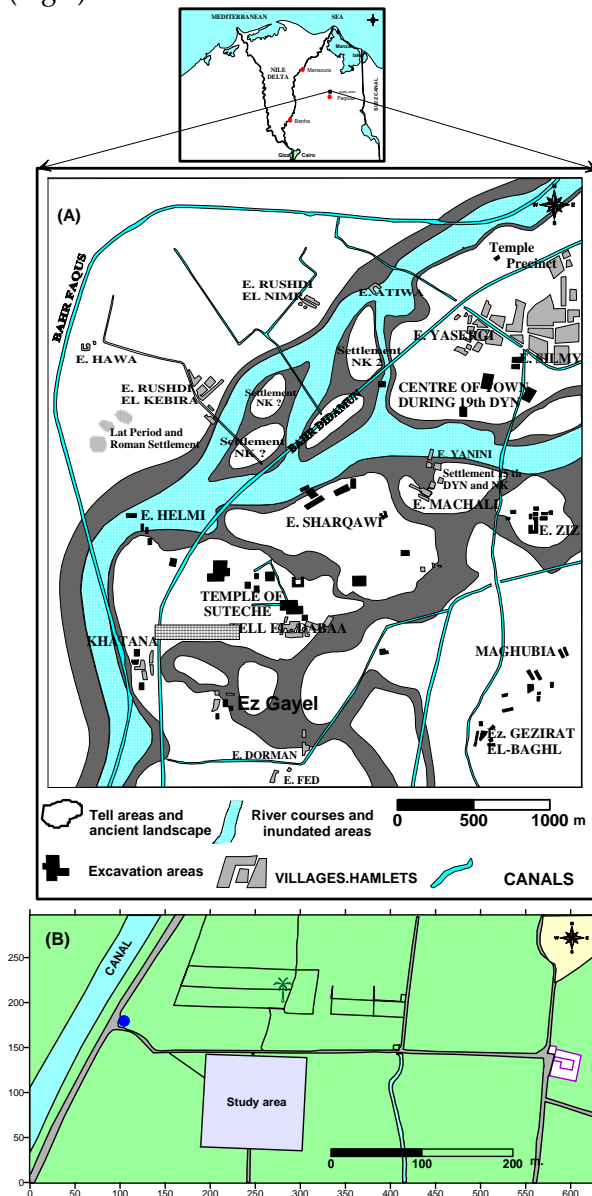


Fig. (1): (A) Reconstruction of the historical landscape of Tell El-Dabaa and Qantir (Modified after Bietak, 1996). (B) Location of the study area in cultivated land.

The earliest evidence of occupation in this area dates back to the first intermediate period, when royal estate was found in the region. During the middle kingdom, it was a flourishing settlement area known as Rawaty, “mouth of the two roads”. During the turbulent second intermediate period it was the capital city of Hyksos (Dynasty XV), with both economic and

military roles. During the XVIII<sup>th</sup> Dynasty, the area was known by the name Peru-nefer (Bietak 1979 and 1996). In the XIX<sup>th</sup> Dynasty, it became a part of Piramesse the northern residence of Ramesses II (EAIS, 2005).

Excavations at Tell El-Dabaa have been conducted by the Austrian Archaeological Institute in Cairo and the Institute of Egyptology, University of Vienna from 1966 to 1969 and from 1975 to the present (Bietak 1991). The results of the excavations were published in many reports and papers (e.g. Bietak 1975; 1986 and 1996; Bietak et al., 1994; El-Qady et al., 2003).

The majority of Egyptologists however followed the theory of Pierre Monter, which states that Avaris and Piramesse were located at Tanis (Monter, 1957). It is the overwhelming evidence from many seasons of excavations that has finally changed the general opinion of scholars. Today Avaris and Piramesse are identified as Tell El-Dabaa and Qantir respectively. Together they cover an area of approximately 12 sq. km from Qantir in the north to Ezbet Gayel and Ezbet Gezirat El-Baghl in the south (Bietak, 1996).

Today a mound, with approximately 500 m diameter represents the remains of this vast town-site. At the end of the last century the site was spread out more than 1Km westward, as far as the village of Khata’na and Ezbet Helmy on the eastern bank of Bahr Faqous, which follows the bed of the old Pelusiac branch of the River Nile (Fig. 1-A) (Bietak, 1996). The current study is one step forward to discover and complete the overview subsurface pictures of the Tell El Dabaa area. To achieve this target, geophysical surveys using magnetic gradient and resistance measurements have been conducted using “FM36 Gradiometer and RM15 resistance meter” respectively. Results of the geophysical survey will help for planning the future excavation activities in the area based on scientific research work.

## GEOPHYSICAL INVESTIGATION

Most of the ancient architectural features in Egypt were made of mud bricks and granite. Therefore, magnetic and electrical resistivity are the most effective archaeo-geophysical tools for detecting such structures and the associated

fired remains, such as pottery, fire bricks and kilns, (Breiner, 1973; Abdallatif et al., 2003, Bates et al., 2007, ). In this work, the study area is surveyed using magnetic gradient and electrical resistance scanning techniques to confirm the subsurface features.

**1. Magnetic gradient survey**

The magnetic gradient survey has been applied in this study as the gradient of the vertical components of the magnetic field or the difference between the readings of two sensors separated by specified short vertical distance was recorded. The survey was conducted using

FM36 fluxgate gradiometer with sensitivity of 0.1 nT (Geoscan Research, 1987). The gradiometer emphasizes the near surface features and tends to cancel response of deeper of longer range features.

The area of investigation is 100 m × 100 m, and divided into 50 individual grids each of them was 20 × 10 m, as shown in Fig. (2-A). The area has been surveyed along lines using parallel traverse mode with a sampling rate of 0.5 m (2 samples/meter) and the line traverse spacing is 0.5 m. The whole area is flat leveled and has different kinds of cultivation activities without any evidences about the subsurface features.

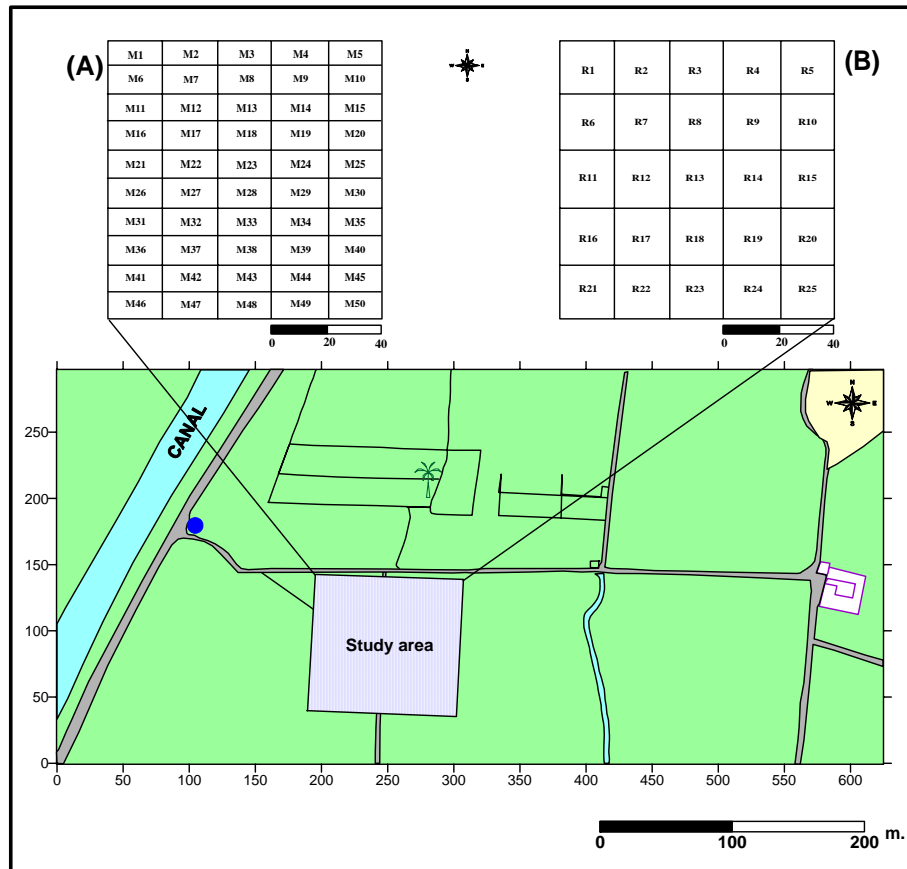


Fig. (2): Surveyed area and the individual grids applied the FM36 gradiometer (A), RM 15 resistance meter (B).

**2. Electrical Resistance Scanning**

Surface and subsurface electrical resistance is largely dependent on water and ionic content in the different subsurface rock materials such as stone, clay, wet soil, dug soil, sand, etc. Buried walls; building foundations; roads and ditches can be shown up clearly with this technique as well as tombs, bits and underground

cavities due to the significant contrast between resistance values of these structures and the host material (Aitken, 1974), Tsokas, and Liritzis, (1990). Clay and soil may have resistivities of 1-10 Ohm.m and porous rocks may have 100-1000 Ohm.m., while non-porous rocks have values between 10<sup>3</sup> -10<sup>6</sup> Ohm.m. These differences may be distinguished by measurements

of resistivity of the ground, enabling archaeological remains to be discovered and planned.

The study area has been surveyed throughout 25 grids each of them was 20 x 20 m, as shown in Fig. (2-B). The distance between the measuring points is 1 m along a line, and the traverses spacing was 1 m, while the mobile electrodes spacing was 0.5 m. In the present study the Geoscan Resistance Meter (RM-15) has been used, with the twin-array of electrodes configuration.

The twin electrode array was especially designed for near surface investigations and particularly for the archaeological Prospection (Geoscan Research, 1993.). The system is quick, where up to 6000 readings can be acquired per day (Evan, 2003).

## DATA PROCESSING

### 1. Geomagnetic data

The gradiometer survey is normally accompanied by some noise owing to the relatively high sensitivity of the instrument, weather conditions at the survey time, and also the experience of the operator. Removal of these errors and noise are significant in order to enhance the presentation of the data obtained as well as facilitate the interpretation process in proper way.

The errors and noise in the current field data are mainly summarized as tilting of the FM36, discontinuities at grid edges, striping of traverses and displacement of the obtained features. However, enhancement of the field data obtained has also been extended to removing the effects of scattered iron objects at the surface and hidden high-frequency clutters like cans, nails, iron sticks, and cables. Also using Geoplot program (Geoscan, 1994) was essential, which has many functions for remove noise and reduce errors effect, such as zero mean grid, zero mean traverse, despiking, destaggering, and multiply. The details of processing scheme were as follow:

1- The grid edge discontinuities are treated by the application of Zero Mean Grid (ZMG) with a threshold value of 2.5.

2- The stripes between traverses are removed by the application of Zero Mean Traverse (ZMT) with least mean square fit.

3- The data were clipped initially at  $-9/9nT$  to remove the high frequencies resulting from any expected surface iron spikes. Also, the despiking function (K) is applied for more enhancement and good presentation.

Finally, the Gaussian Low-Pass Filter (L) is applied to remove the high frequencies as well as to smooth and enhance the weak anomalies of deep archaeological features. The Low-Pass Filter parameters are set to X and Y radii = 2.

The processed magnetic data is illustrated in figure (3). It is obvious that the scattering effects of local high magnetic anomalies in different sites are essential specially, whereas there are linear features. The relatively high magnetic anomalies can be interpreted as ovens and/or parts of columns from rocks such as granite, firebrick and/or mud-brick walls. The other linear features with relatively low magnetic anomalies are related to the non magnetic materials which used for building of these features.

### 2. Geoelectrical resistance data

Using the Geoplot software (Geoscan Research, 1994), some processing steps had been conducted on the raw data (Zero Mean Grid (ZMG), despiking function (K), Gaussian Low-Pass Filter (L) with parameters are set to X and Y radii = 2 and the data are clipped initially to  $-6/6$  Ohm.m. Figure (4) represent the resistance image constructed from the processed data in terms of shadow plot. The inspection of the image indicates presence of high and low resistant anomalies taking different kinds of regular shapes. There is a sharp contrast between high resistance anomalies and surrounding deposits. From resistance measurements we can notice that the study area very rich with different types of subsurface structures. Some are characterized by high resistance features like those at grids 5-A, B, C, D, E; 4-A, B and 2-B, E. Other features have relatively intermediate electrical resistance anomalies and scattered in all surveyed grids. Moreover, there is low electric resistance anomalies with regular characters concentrated in North-West part of surveyed area. The background resistance of the soil is relatively low (Fig. 4).

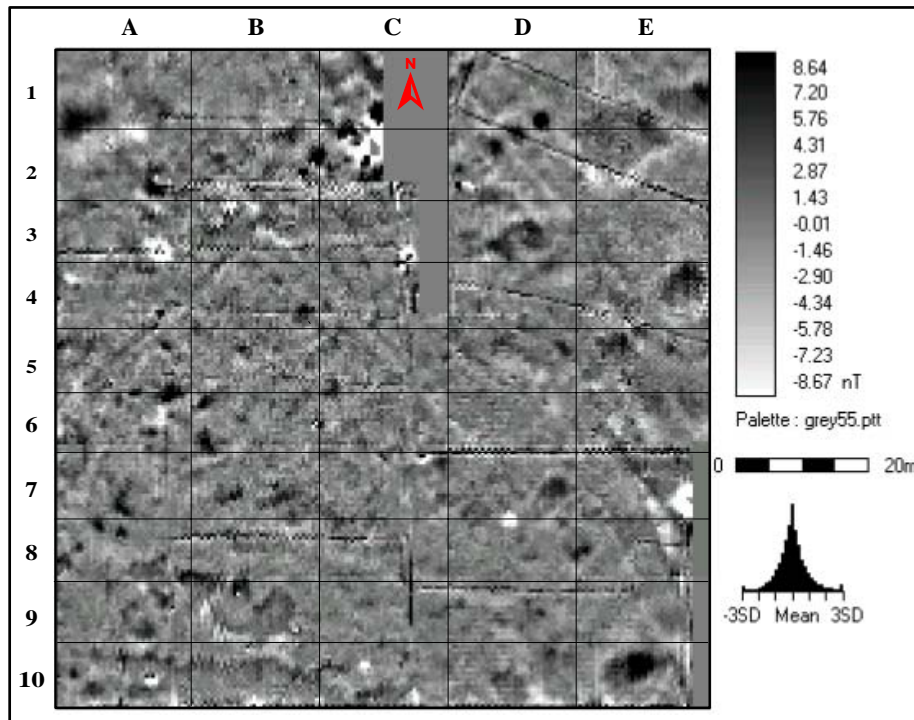


Fig. (3): processed image for magnetic data collected by FM36-Gradiometer with following parameter, Vertical Gradient, Grid 10/20m, Units Absolute, Range -19/17 nT/m and Color clipping -9/9 nT/m.

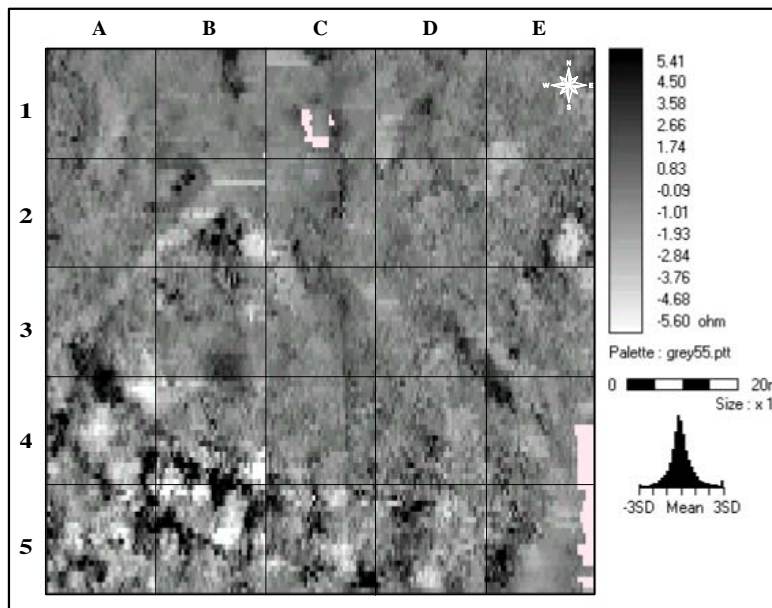


Fig. (4): processed image for resistance data collected by RM15 Resistance Meter with following parameters: Grid 20/20m, Zigzag traverses, Twin array, Range -35/45 Ohm.m and Color clipping -6/6 Ohm.m.

**DISCUSSION**

Figure (5) represents the sketch for magnetic anomalies and its distribution in study area. The comparison between magnetic and electric results revealed that, there are some archaeological features appear clearly in the two images (electrical and magnetic images) these features have magnetic and electrical resistivity

signatures different than host sediments. However, there are some remains have anomalies appear only in electric resistance images, which mean that these objects have significant resistance signatures, whereas its magnetic effects are close to the host sediments. Conversely, there are other features have significant magnetic anomalies whereas; its resistivity signatures are similar to the surrounding sediments.

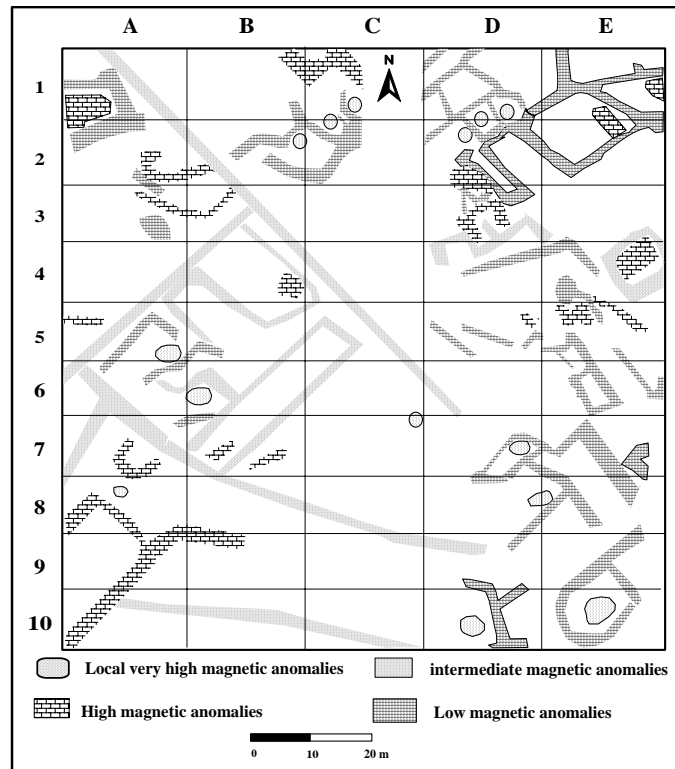


Fig. (5) Sketch of magnetic anomalies distribution in study area.

Figure (6) shows the final interpretation results of electrical resistance image. In the southern east part of study area there are many linear

features of high electrical resistance anomalies, which can be interpreted as a fire break wall or walls made of limestone.

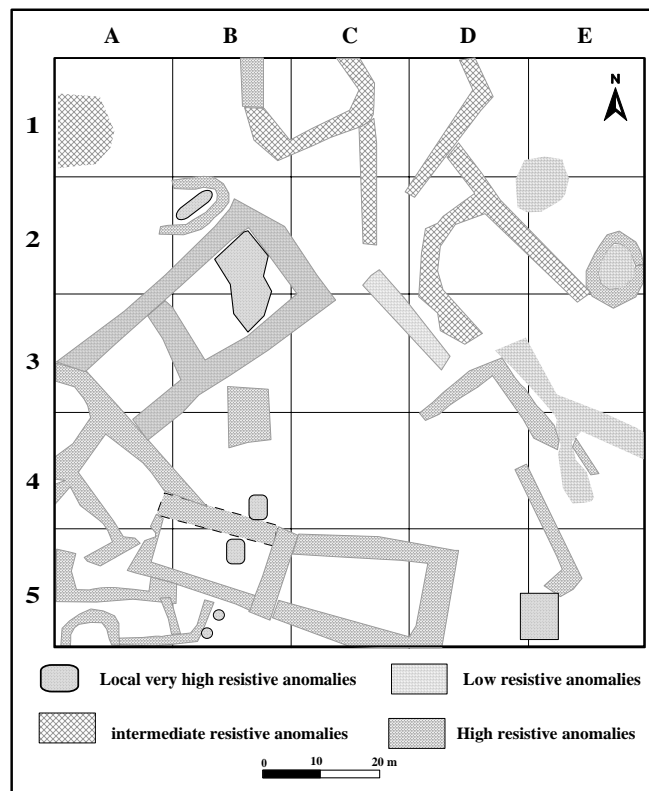


Fig. (6) Sketch for final interpretation of the resistance image.

The northern and western parts have many mud-brick walls of regular shapes. This can be interpreted as part of big building; however, the increasing of the overburden clay content attenuates its anomaly signature. In addition there are circular bodies that interpreted as some patches and pits distrusted along the surveyed site. At the junction of each two wall sides, there is a relatively high resistivity values. This high resistivity value could be interpreted as columns connecting the wall systems in the expected palace. However, we can notice that, the effective anomaly size of the interpreted structure (wall and columns) is affected by the type of the host sediments and almost its dimensions are larger than the real size that appears at some excavation sites near to the study area.

Correlating the archaeological features resulted from geomagnetic gradient and resistance measurements showed a good consistence between them at many sites. Contrarily, some features only appear in magnetic results and other only notice in electrical resistance results. So, it is generally essential to carry out the archaeological survey using more than one geophysical technique.

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## REFERENCES

- Abdallatif, T.F; Mousa, S. E.; and Elbassiony, A. (2003) Geophysical Investigation for Mapping the Archaeological Features at Qantir, Sharqya, Egypt., *Archaeological Prospection* 10, 27–42.
- Aitken, M.J., (1974) *Physics and archaeology*, 2<sup>nd</sup> edn. London: Oxford University Press, Oxford.
- Bates R. Martin, C. Richard Bates, John E. Whittaker (2007) Mixed method approaches to the investigation and mapping of buried Quaternary deposits: examples from southern England. *Archaeological Prospection* V. 14, Issue 2, 104-129
- Bietak M., (1986) Avaris and Piramesse: archaeological exploration in the eastern Nile Delta. Revised reprint from the proceedings of the British Academy 65 (1979), 225-296
- Bietak M., (1991) Tell el-Dab'a V: Ein Friedhofsbezirk der Mittleren Bronzezeitkultur mit Totentempel und Siedlungsschichten. *Untersuchungen der Zweigstelle Kairo des Österreichischen Archäologischen Institutes VIII*. Vienna.
- Bietak M., (1996) Avaris, the capital of the Hyksos, recent excavations at Tell El-Dabaa. *British Museum Press*. 99 p.

## CONCLUSION

The aim of the present study was to detect the ancient remains located underneath the cultivated land close to Tell El-Dabaa archaeological site using the magnetic and electrical resistance surveys. The archaeological sites of tell El-Dabaa and surrounding area has many different types of archaeological remains such as tombs, palaces, houses and temples. These archaeological remains constructed from different types of materials such as fire-brick, mud-brick and/or stones.

Technically, the resistance and magnetic imaging surveys are powerful and sensitive tools for exploring the archaeological site at Tell El-Dabaa area, which is believed to be the capital of the Hyksos, AVARIS. We could recommend a future planning to excavate this site. Additionally, further geophysical surveys are recommended in many parts of Tell El-Dabaa like GPR and frequency domain electromagnetic. Applying many geophysical methods for Archeo-geophysical Prospection help to detect all features in the area and reinforce the results of different tools.



- Bietak M., Dorner, J., Hein, I. and Jánosi, P., (1994) Neue Grabungsergebnisse aus Tell El-Dabaa und Ezbet Helmi im Östlichen Nildelta (1981-1991). *Ägypten und Levante* 4, 9-58.
- Bietak, M. (1979) Urban Archaeology and the "Town Problem". In Weeks, K. (ed.) *Egyptology and the Social Sciences*. Cairo: American University in Cairo Press, 95-144.
- Bietak, M., (1975) Tell El-Dabaa II. Der fundort im Rahmen einer archäologischen-geographischen Untersuchung über das ägyptische Ostdelta. *Untersuchungen der Zweigstelle Kairo des Österreichischen Archäologischen Institut I*. Vienna.
- Breiner, S., (1973) *Applications manual for portable magnetometer*, Geometrics California, U.S.A. 58p.
- Egyptian Antiquities Information System Project (EAIS) (2005) Geographical Information System cahiers of Sharqiya Governorate, In *Antiquities, Egypt*, 65p
- El-Qady G., Soliman, N., Taha, A. and Dorner, J., (2003) Archaeological prospection in AVARIS, the capital of Hyksos using geoelectrical resistance imaging. *Journal of Geophysics of the National Research Institute of astronomy and geophysics (NRIAG)*, 2, 103-113.
- Evan G. Gurrison, (2003): *Techniques in Archaeological Geology*, Springer, 304p.
- Geoscan Research Resistance Meter RM-15, (1993) *Instruction Manual*. Bradford: Geoscan Research.
- Geoscan Research. (1987) *Instruction Manual Version 1.0* (Fluxgate Gradiometer FM9, FM18, FM36). Geoscan Research: Bradford.
- Geoscan Research. (1994) *Instruction Manual 1.01 (Geoplot 2.01)*. Geoscan Research: Bradford.
- Hesse, A., Jolivet, A., and Tabbagh, A., (1986) New prospects in shallow depth electrical surveying for archaeological and pedological Applications. *Geophysics*, Vol. 51, 585-594.
- Monter P, (1957) *Géographie de l'Égypte Ancienne*, Première Partie. To-Mehou, La Basse Égypte. Paris.
- Tsokas, G and Liritzis, I (1990) Resistivity prospecting in the centre of Athens for the detection of buried antiquities. *Prospezione Archeologica, Quaderni* 1, 133-143.