Essam Nagy, EES representative, and MSA inspectors Ahmed and Ibrahim practicing with the kite at Kom ed-Dahab

FROM SPACE TO GROUND

Aerial Images and Geomagnetic Survey at Kom ed-Dahab (Menzaleh Lake, Egyptian Eastern Delta)

By Gregory Marouard

Satellite detection and remote sensing have been a credible and proven method for at least two decades – sometimes a key implement in fieldwork archeology – for the exploration of large areas or to monitor areas vulnerable to looting as was unfortunately exposed recently in the regions of Syria, Iraq, and Afghanistan. The CAMEL Lab at the Oriental Institute is a leader in this field with a long history of expertise based on a large collection of photos, some declassified and dating back to the late 1960s, such as the now-declassified intelligence satellites images collected by the Corona program.

In the specific case of Egypt, since 2005, free online programs such as Google Earth offer increasingly accurate images that are also frequently updated, which helps to detect or monitor the evolution of sites – particularly during phases of looting that have hit the country between 2011 and 2012 – but also to explore areas previously inaccessible or ignored. In recent years, however, some mass media outlets have become accustomed to relay discoveries of self-appointed "space archaeologists," but often those sensational and untimely announcements have not systematically been preceded – as should be routinely done – or followed by further verification on the ground and as a consequence the archaeological nature of those revelations have been regularly proven false and inaccurate, undermining the credibility of this approach.

After regular monitoring of ancient *tells* in the western region of Lake Menzaleh since 2006, in 2011 a new satellite picture helped to emphasize the exceptional archaeological potential of a small island of 42 hectares (103 acres) now situated 2 km (1.25 mi) from the lakeshore and less than 12 km (7.5 mi) from the modern town of Damietta.

Located in the marshes and undisturbed areas of the lake, in steady decline for more than fifty years (fig. 1), Kom ed-Dahab – the Golden Hill – is very isolated and accessible only by boat. For the first time, in September 2015, an expedition of the Oriental Institute – joined by the Egypt Exploration Society Delta Survey – reached this site and conducted the first archaeological exploration of this *terra incognita* in order to confirm on the ground the result of remote sensing.

According to the preliminary studies of the satellite images,[1] the site of Kom ed-Dahab appeared to be an early Roman town probably established in Menzaleh Lake at the very beginning of

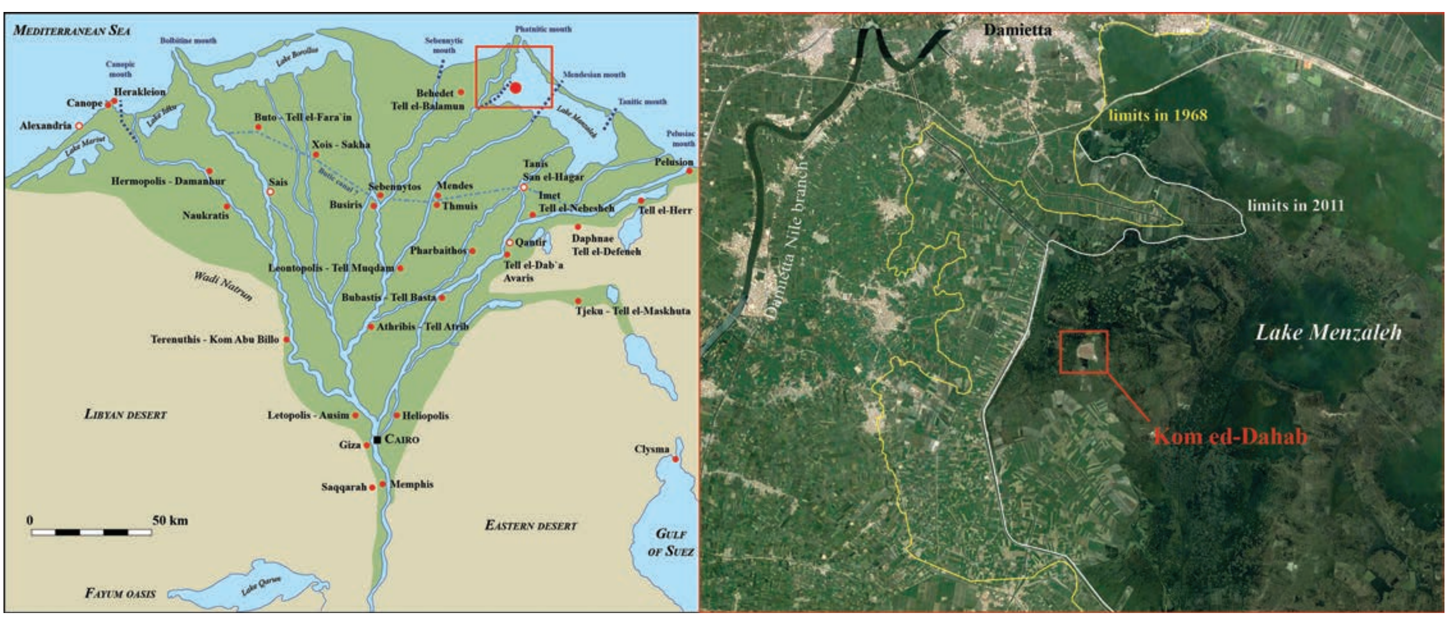

Figure 1. (left) Localization of Kom ed-Dahab in the Nile Delta and (right) in the western part of the Lake Menzaleh (image Digital Globe©)

the Roman domination over Egypt, circa the first century BC. At this time, the lake was still a lagoon, widely open to the Mediterranean Sea, and some very peculiar installations here point out a strategic harbor settlement established at the extremity of the ancient Damietta/Bucolic Branch. As a smaller version of Alexandria or Pelusion, this site was an *emporium* and an entrance gate for imported products from the Levant, Cyprus, or the Greek Islands. Acting as a transloading point, it was once connected by the Nile to some regional metropolis such as Mendes/Thmouis or Sebennytos, which lie dozens of kilometers farther into the central delta (fig. 1).

The satellite image from 2011 revealed for this town a *hippodamian* organization – a strict geometric planning of the urban grid – indicating a rare example for the Egyptian Delta of an *ex nihilo* foundation – and the existence of multiple major buildings that do not fit into the traditional Egyptian settlement pattern (fig. 2). At the eastern extremity of the main axis of the town, which extends about 450 m (490 yards) in length, a so-far unique example of a large palace with hypostyle courtyard has been discovered. Farther north two large buildings, possibly sanctuaries in stone, have been revealed perfectly included in the islets. Major installations are also visible on the southern and highest part of the site, an area where the few looting attempts are concentrated and which revealed some monumental architectural components such as columns and column bases in red granite. Long storage magazines are also visible in the northern part of the site, on a small island where the harbor remains should be located.

More exceptional, on the northern side of the town the layout of a complete Roman theater was visible on the 2011 image; it is such a vast building that it was already noticeable on the Corona image from 1968 (fig. 2). This monument measures about 56 m in length and is so far the fifth example of such a building ever discovered in Egypt, with the other theaters at Pelusion, Oxyrhynchus, and Antinopolis. According to its plan, a typical imperial pattern traditional of the Antonine period, it can be dated to the mid second century AD, like the two other contemporaneous examples discovered at Pelusion (Tell el-Farama and Tell el-Kana'is).

Since its abandonment, the site has been strongly affected by both rainwater and a probable increase in the lagoon/lake level, and even by tsunamis (as in 365 AD), which have apparently caused a leveling of the archaeological remains. The site is almost flat with a very homogeneous appearance because of the very powdery and almost untouched surface; a conventional survey was not sufficient to confirm the reality of the structures visible on satellite images. Before affecting this surface that had remained almost intact for centuries with a traditional pottery survey, the OI mission decided first to conduct non-invasive investigations by using both kite aerial pictures (KAP) (fig. facing title) and a geomagnetic survey.

The KAP method consists of a camera that captures pictures in time-lapse mode and is attached to a frameless Parafoil kite, a stronger and more stable type of kite, which is important in this area affected by strong sea winds (the Mediterranean shore is located only 20 km farther north). A systematic coverage by kite was done over the most important areas. Because of significant differences in moisture, and the highly variable salinity of the ground, which produces a salty and whitish crust on top of the ancient walls, the limits of many buildings are easily visible from above with important contrasts in the colors and density on the surface.

Back in Chicago, the aerial pictures have been reassembled using Photoscan© software in order to produce a 3D model and then an orthophotograph, a geometrically corrected vertical image of the area (fig. 3).

A team from the *Institute of Archaeology and Ethnology* at the *Polish Academy of Sciences* led by Dr. Tomasz Herbich was appointed to complete a geomagnetic survey in the area of the main buildings already recognizable from the satellite image. Tomasz Herbich's team is at the forefront of this method which they have already used on more than forty sites around Egypt during the past two decades. Considering the time and funds available for the mission at Kom ed-Dahab and the difficulties in accessing the site, our choice focused on the use of a proven technique that produces secure and immediate results. Six different areas covering 3.60 ha (ca. 9 acres) have been surveyed by using two Geoscan Research FM 256 Fluxgate Gradiometers (fig. 2).

The Geomagnetic survey is a relatively old method that emerged in the 1960s. Viable since the 1980s, it was perfected by the mid 1990s with much smaller portable tools, in addition to the introduction of high-sensitivity magnetometers characterized by short measurement times and the recording of data in the device's internal memory.

Unlike other methods such as electric resistivity or Ground-Penetrating Radar, the use of geomagnetic survey is particularly successful in Egypt especially because of the strong magnetic contrasts that some building materials can provide such as mudbricks or redbricks made with Nile silt containing iron-rich particles. This non-invasive method offers the possibility of covering large areas in a very short time and reveal the vestiges of architecture or traces of domestic or artisanal activities located about 50 cm to 2.00 m below the ground surface; these data allow us to study the urban space extensively and help the archaeologist make strategic choices about the priority areas to excavate or to protect. The Nile Delta sites have produced significant results on wide-ranging surfaces, like the exceptional work undertaken at Tell el-Dab'a / Quantir, Buto, Tell Balamun, or recently in the southern urban area of Tanis.

The method is simple and consists initially of establishing a grid with squares of 20 m by 10 m, oriented according to the cardinal points, which will be surveyed along their short side with a spacing every meter. This grid is marked on the ground with plastic cords, fixed by nonmagnetic aluminum nails. With the gradiometer instrument under measurement, the prospector walks along the axes, from south to north; he or she returns on his or her steps and then measures a new line (fig. 4). A surface of 1.0 hectare (2.47 acres) therefore requires more than a 20 km (12.4 mi) walk.

Figure 2. Satellite views of Kom ed-Dahab using Corona (1968) and Digital Globe© (2011) with repositioning of the main urban characteristics and location of the six areas covered by the geomagnetic survey (yellow)

Corona 1968
Theater
0 10 50 m
Lake Menzaleh
N
Northern Island
(Harbor installations ?)
Theater
Main street
(450 m)
Sanctuaries ?
Southern
installations
(Harbor ?)
Palace
Temple ?
0 100 200 m
Digital Globe 2011

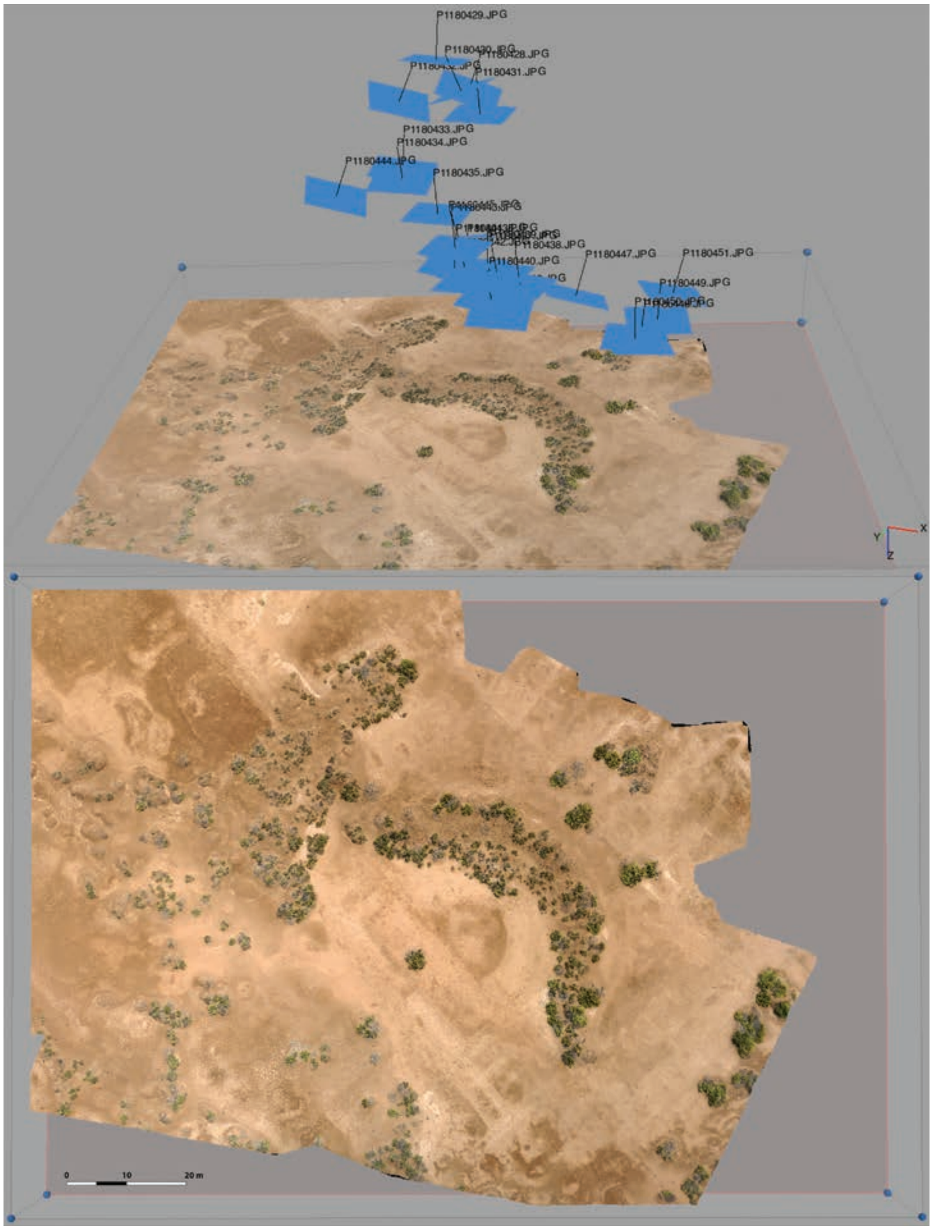

Figure 3. Reassembling of kite aerial pictures with Photoscan©

Figure 4. Gradiometer calibration and ongoing geomagnetic survey along the grid axes

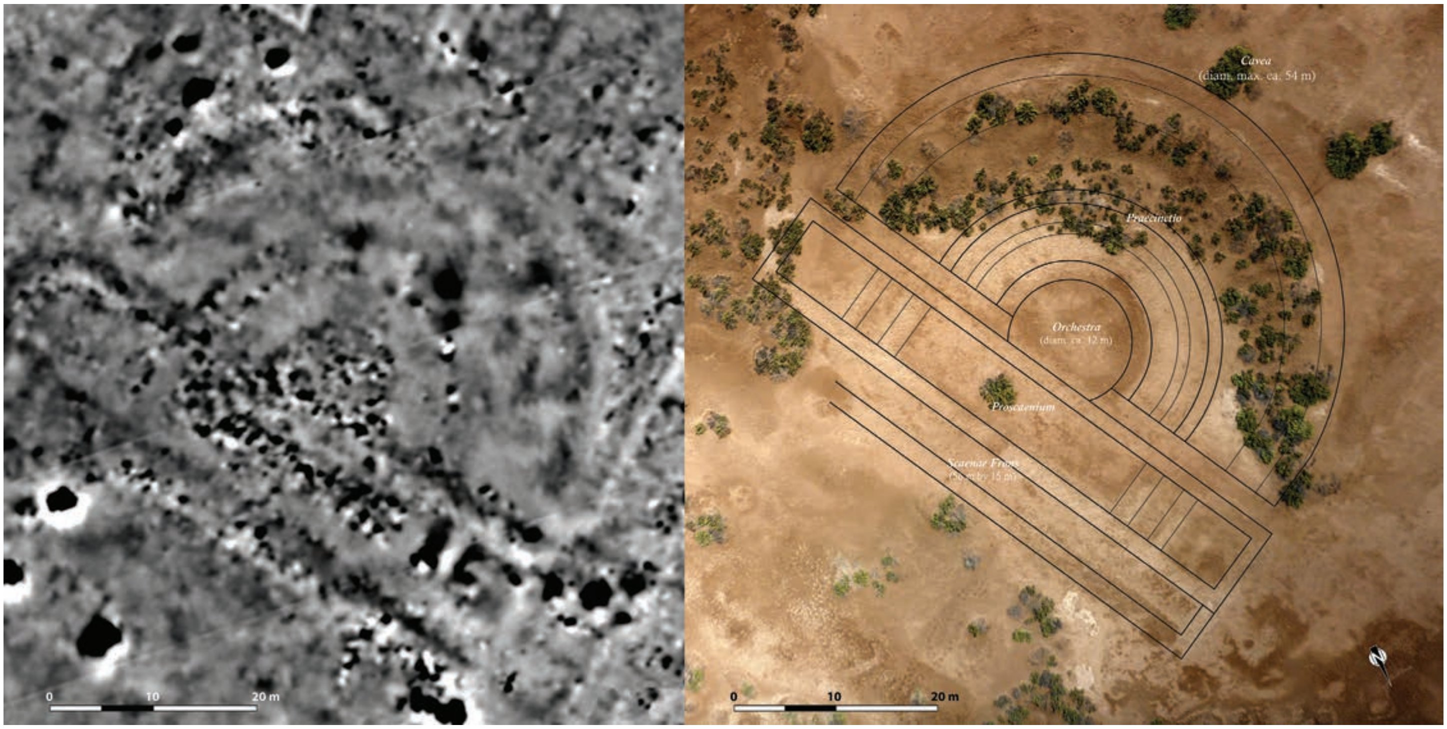

Figure 5. Magnetic map and interpreted aerial view of the theater area

Measurements are taken and stored in the device every second (about every 10 to 20 cm), so it is essential that the instrument holder walks with a very regular pace throughout the entire survey. Differences in rhythm can produce distortions and particularly a shear of the results and zigzags on the final picture. A regular calibration of the device according to the cardinal points precedes any new area (fig. 4).

After downloading the raw data and running it through a computer program, it is possible to generate a magnetic map similar to an underground picture of the area in shades of gray proportional to the measured intensity, where the black gives maximum positive magnetic charge and the white a non-magnetic charge (or the other end of the spectrum).

In addition to confirming the existence of the building, the magnetic map of the Roman theater area (Zone 5, fig. 5) has revealed many details about the construction itself: the use of the redbricks for the *praecinctio* area (which separate the upper and lower levels of the *cavea*), for the floor of the *orchestra*, and for some walls of the *proscaenium*; a massive filling under the lower (*ima*) and upper (*summa*) parts of the *cavea* with structural dividing walls; and a series of possible buttresses at the back of the main external wall of the *cavea*, as it is often observed for this type of construction.

The map also shows many surrounding constructions, such as possible pottery kilns (large black spots rimmed with white) and rows of artisanal or cooking ovens in the northeastern area, multiple domestic installations and important structures such as two peculiar square constructions (one measures 10 m on each side) located in the main axis of the theater, and a vast rectangular building (25 m by 15 m) attached on its northwestern side and connected to the western entrance (*aditus maximus*).

ENDNOTE

1. For a preliminary presentation of this work, see Gregory Marouard, "Kom el-Dahab interpreted," *Egyptian Archaeology* 45 (2014: 25–27). We would like to thank Gil Stein, Director of the Oriental Institute, for his support to start this new project, and Jeffrey Spencer and the Egypt Exploration Society Delta Survey for their enthusiastic help.