

# REMOTE SENSING IN THE NILE DELTA: SPATIO-TEMPORAL ANALYSIS OF BUBASTIS / TELL BASTA

*Eva Lange, Tobias Ullmann, Roland Baumhauer*

*Abstract: The paper describes the latest results of geographic and geophysical investigations at the site of Tell Basta, the ancient city Bubastis, in the south-eastern Nile Delta. Given the obvious impact of the local geomorphology and hydrogeography on the evolution of the city, the addition of such methods to the ongoing archaeological studies at the site is all the more important. Special emphasis lies on the analysis of remote sensing imagery and historic cartographic information, provided by the maps of early travellers in order to generate information about the north-western part of the tell which is nowadays completely overbuilt and not accessible anymore for further archaeological research.*

*Keywords: Archaeology of the Nile Delta, Cemetery, Geomorphology, Historic Cartography, Hydrogeography, Remote Sensing Imagery, Settlement, Temple*

## Introduction

Bubastis, situated in the southern part of the eastern Delta, where the Pelusiac branch of the Nile once ran close to the Tanitic branch, played a major role amongst the cities of Ancient Egypt. Today, only a part of the remains (approximately 52 ha) of the former metropolis is preserved. The archaeological site, called Tell Basta, is located at the south-eastern edge of the modern city of Zagazig, the capital of the province Sharqiya.

In general, the importance of the Nile branches for the vitality of a city can be observed throughout the history of Delta settlements. Obviously, the settlements' importance depended on the condition of the Nile branches on which they were situated: a continuous, consistent flow of water had a positive impact on the development of those cities<sup>1</sup>. As Bietak has shown, the favourable geographical location of Bubastis with access to two Nile

branches is clearly the major reason for its outstanding position amongst the ancient cities of the Nile Delta.<sup>2</sup>

According to the developing understanding of the important role of the hydrogeography on the history of Bubastis, ongoing research at the site is not confined to archaeological investigations but includes now geographical and geophysical studies in an interdisciplinary project. Besides the reconstruction of the main features and dynamics of the local hydrogeography, geophysical research is also investigating the geomorphology of the settlement and its environment, in order to assess the natural conditions which would have had a direct impact on the dynamics and direction of the process of the formation of the settlement.

Also, it is a matter of fact that the rapidly increasing modern population has led to a sprawl of urban areas in Egypt, which has negatively affected many ancient sites, especially in the Nile Delta. This is also true for Bubastis; the north-western tell is inaccessible today as it is now part of the city of Zagazig. Modern settlement dynamics have changed the outline of the tell and reduced or destroyed many natural features and ancient remains over time. Therefore, the use of early maps and remote sensing imagery has become a key element in our investigations, as they have the potential to reveal ancient landscape features now hidden under modern agricultural areas and buildings.

The following paper presents the first results of the combined analysis of historic cartographic information and remote sensing imagery; from the maps of early travellers to WW-II aerial imagery and contemporary satellite data. The integration of these data sets in a geo-database has provided vital information about the above mentioned parts of the tell which are nowadays completely overbuilt. In a wider sense, such a GIS approach pre-

<sup>1</sup> Mendes and Tell Timai present impressive examples where the peaks of the extension of the settlement coincide with the times of the highest volume of water carried by the Mendesian Nile branch: BIETAK 1975, 99, 110–111.

<sup>2</sup> As the Pelusiac branch became silted up over the course of time, the Tanitic branch took on the role of the main traffic artery: BIETAK 1975, 77–88, 99–105.

sents an interesting and important tool to the archaeology of settlements in general and a method that could be applied to other sites.

After an introduction to the archaeology of the site, the methodology of remote sensing and the building of the geodatabase will be presented, together with the analysis of the imagery, combined with information coming from earlier excavations.

### Archaeology of Bubastis /Tell Basta

The vast site of Tell Basta contains the remains of the various urban zones of the city, dating from the Old Kingdom until the time of Roman emperors, and bears witness to the enduring importance of the city. Since Bubastis served as the dynastic city of the Libyan kings of the 22<sup>nd</sup> dynasty, it reached its peak of importance in the Third Intermediate Period, at that time competing for prominence with the capital of Egypt, Tanis.<sup>3</sup>

Ancient Egyptian texts concerning the topography of the city and its environment are rare. Sometimes labels to the depictions of gods of Bubastis include the designation *sh.t ntr* “Field of the Gods“ for this location. This may refer to the fertile agricultural *environments* of Bubastis.<sup>4</sup> Names of certain mounds and other topographical features in the vicinity of the city appear in mythological manuals, but no further details can be deduced from those short attestations<sup>5</sup>.

Written records from the time of the 5<sup>th</sup> dynasty show that, at that time, the area of Bubastis belonged to the 13<sup>th</sup> nome of Lower Egypt, the Heliopolitan nome. In the late New Kingdom, the lists of Egyptian nomes of the Delta name Bubastis as the capital of a new district, the 18<sup>th</sup> nome of Lower Egypt.<sup>6</sup> The district consisted of the city itself and its *hinterland*, its borders defined by the Pelusiac Nile branch in the west of its area and a smaller channel to the east, a territorial division which had already become apparent in the lists of the Old Kingdom.<sup>7</sup> The establishment of a special

Bubastide nome hints at the increasing importance of the city, a development which may date back farther than the actual mentions of the city in the lists of nomes actually suggest.

The origins of the city as an important regional centre may have started already in the Predynastic Period. Possible evidence for this assumption derives from cemetery U at Abydos, where the German Archaeological Institute discovered the tomb (U-j) of a Predynastic ruler, dating to the end of the 4<sup>th</sup> millennium BC. Here, a large amount of small inscribed labels came to light, mentioning the origin of certain goods, which had been sent from different towns and institutions to the funeral provision of the king. Amongst them, labels naming a place called *b3s.t* were found, most probably referring to the later city of that name in the eastern Delta<sup>8</sup>. This early settlement could have functioned as a main distribution centre of trading goods coming from the Levant and from the Nile valley.

No remains of the pre- and early dynastic settlement of Bubastis have come to light thus far. However, in 1970, Ahmed el-Sawi discovered a comparatively large tomb built of mud bricks at the north-eastern part of the tell, most probably dating to the beginning of the 1<sup>st</sup> dynasty, based on the type of the stone vessels found amongst the funerary equipment.<sup>9</sup> (Fig. 4).

In the later Old Kingdom, the archaic city had become a major cult centre of the lioness goddess Bastet, enticing the kings of the 6<sup>th</sup> dynasty to erect enclosures for the veneration of the royal *Ka* and to connect those buildings with the temple and cult of the main deity of Bubastis.<sup>10</sup> Nowadays, the *Ka*-temple of Pepi I, roughly 100m northwest of the temple of Bastet (Fig. 4), represents the only preserved example of its kind, otherwise known to us only through written sources.<sup>11</sup> The temple has the remains of a massive mud brick enclosure wall, encompassing an area of 64.0m by 87.50m and oriented on a north-south axis. The sanctuary consisted of three chambers, possibly for the cult

<sup>3</sup> KITCHEN 1996, 130, 285; LANGE 2008, 131; LANGE 2010.

<sup>4</sup> GAUTHIER 1928, 54; HABACHI 1957, 88, 121; MEEKS 2006, 21 §23 [IX.8]; LEITZ 2014, 344–348.

<sup>5</sup> PETRIE and GRIFFITH 1889, pl. X–XII; OSING 1998, 253–254; RONDOT 1989; LEITZ 2014, 341, 344–348.

<sup>6</sup> HELCK 1974, 183–184, 195–196; BIETAK 1975, 157, 166–169.

<sup>7</sup> BIETAK 1975, 157. Cf. also the slightly different interpretation of HELCK 1974, 183.

<sup>8</sup> DREYER 1998, 125–126, Abb. 78, 103, 104, 136, 139; Taf. 31, 103–105; LANGE 2016, 310.

<sup>9</sup> Dating basing on the published drawings by: EL-SAWI 1979, 63, Fig. 102, 104–109; KROEPER 1988, 18–19, Fig. 210–213. Cf. also ASTON 1994, 97 no. 19, 123, no. 84, 130, no.107. A more precise dating would require a new documentation of the finds.

<sup>10</sup> HABACHI 1957, 11–36; LANGE 2006.

<sup>11</sup> LANGE 2006, 127–131.

of the king in connection with Bastet and Hathor, and a double row of decorated limestone pillars.<sup>12</sup> There was most likely another Ka-temple, commissioned by the first king of the 6<sup>th</sup> dynasty, Teti, to the north of the temple of his successor Pepi, but only a few traces have survived in this now overbuilt area<sup>13</sup>. The existence of the royal enclosures and the appearance of Bastet on the relief decoration of the temple of Pepi I prove the existence of a temple of the goddess at this time. This early temple was most probably situated at the same location of the later temple of Bastet to the southeast of the Ka-temple of Pepi I.<sup>14</sup>

The main cemetery area of the Old Kingdom town stretches from the northwest to the northeast of the tell (Fig. 4). Depending on the social status of the deceased, the tomb architecture ranges from simple, brick-lined pits for lesser burials to vaulted tombs for the members of the provincial elite, sometimes even equipped with one- or two-storeyed decorated limestone chambers. So far, three distinct elite cemeteries have been excavated<sup>15</sup>. After the Old Kingdom, the cemetery area was intensively re-used as a burial place throughout Ancient Egyptian history until the Roman Period, both for simple burials and for elaborate tombs.<sup>16</sup>

However, as the construction of the spacious palace building of the Middle Kingdom in the core of the cemetery area illustrates<sup>17</sup>, functional assignments to areas were subject to change (Fig. 4). The palace, being the centre of administration of the city and the residence of the highest-ranking officials of Bubastis, was also intended to be used by the king on his travels through the Delta which required overnight stays in the most important cities in an adequate building.<sup>18</sup> First results of the reconstruction of the building history of the Middle Kingdom palace point to the existence of at least two phases: one in the earlier 12<sup>th</sup>

dynasty and the second dating into the reign of Amenemhet III, proven by the discovery of a decorated door jamb showing him in an iconic Sed-festival episode.<sup>19</sup> An earlier palace building of the Old Kingdom might have existed at the same site, around which the elite cemeteries of the later Old Kingdom would then have been clustered.<sup>20</sup>

Directly east of the palace the cemetery of the governors of Bubastis is situated, most likely dating from the reign of Amenemhet II to the time of Amenemhet III or IV.<sup>21</sup> It seems reasonable to assume that the tomb owners of this cemetery spent their working life in this building. Although the installation of cemeteries within settlements is not unknown for Ancient Egypt, the arrangement of burials of officials in such close proximity to their seats of office is nevertheless unique and might represent a special Delta tradition. A comparable cemetery installation in the broader sense is known from Tell Daba.<sup>22</sup>

The temple and settlement zone of Bubastis are situated to the south and southeast of the area described above (Fig. 3–5). Most notable is the temple of the local main goddess Bastet. The remains now visible on the surface date back to the first millennium BC, i.e. the reigns of Osorkon I and Osorkon II and Nectanebo II in particular.<sup>23</sup> Although the loss of a large percentage of its architecture hinders the reconstruction of its ground plan, the existence of a sequence of two columned courtyards and a hypostyle hall followed by the sanctuary is obvious.<sup>24</sup> The exact location of the first pylon at the entrance and the enclosure wall remains unknown to this day as excavations have not yet produced clear evidence for them.<sup>25</sup> Attached to the north-western corner of the temple of Bastet was a smaller building, dedicated to the cult of Mahes, the son of the goddess Bastet.<sup>26</sup> Further temples or chapels for the cult of deities of the divine pantheon of Bubastis (for

<sup>12</sup> LANGE 2006, 121–124, Taf. XXVIII–XXX.

<sup>13</sup> EL-SAWI 1979, 75–76; Fig. 164–167.

<sup>14</sup> LANGE 2006, 122–123.

<sup>15</sup> EL-SAWI 1979; BAKR 1992; LANGE 2013; BAKR and LANGE 2016.

<sup>16</sup> HABACHI 1957, 97–102; EL-SAWI 1979; BAKR 1982; LANGE 2015.

<sup>17</sup> FARID 1964, 94–95; VAN SICLEN 1996; BIETAK and LANGE 2014, BIETAK 2015; BIETAK 2016.

<sup>18</sup> LANGE, forthcoming 1.

<sup>19</sup> FARID 1964, 92–94; VAN SICLEN 1996, 245 Fig. 11.

<sup>20</sup> BIETAK and LANGE 2014, 7. BIETAK 2016.

<sup>21</sup> FARID 1964, 85–90; LANGE 2015. Cemetery C of the later Old Kingdom with VAN SICLEN 1991 burials of high officials just to the south of the cemetery of the governors of the Middle Kingdom may mirror a similar situation for the 6<sup>th</sup> dynasty: LANGE 2015, 188; BAKR and LANGE 2016.

<sup>22</sup> BIETAK 1994; SCHIESTL 2009; LANGE, forthcoming 2.

<sup>23</sup> NAVILLE 1891.

<sup>24</sup> NAVILLE 1891, Pl. LIV; HABACHI 1957, 45–91; ARNOLD 1996, 42, 45–47, 51 Fig. 2; KITCHEN 1996, 318 Fig. 3; LANGE 2009, 203.

<sup>25</sup> LANGE 2011.

<sup>26</sup> NAVILLE 1891, 49, 54–55; HABACHI 1957, 46–55.

example Atum and Hor-hekenu)<sup>27</sup> certainly existed in the adjacent area but have not been excavated so far. In his description of the city Herodotus interestingly mentions a temple of a god he refers to with the Greek name “Hermes”, who is normally equivalent to the Egyptian god Thoth, at the other end of the dromos leading from the temple of Bastet to the east (Hd., Hist. II, 138, cf. below)<sup>28</sup>.

In the same passage, Herodotus informs us that the temple of Bastet had been surrounded by two canals emerging from the Pelusiac Nile branch and thus creating the impression that the temple rested on an “island”. Papyrus Brooklyn 47.218.84, a compendium of local traditions of the Nile Delta that dates into the second half of the seventh century BC, contains fascinating paragraphs about Bubastis.<sup>29</sup> It describes the *isheru* (i.e. the sacred lake of a special, horseshoe shape)<sup>30</sup> of the temple of Bastet where the goddess travels in her barque on festival occasions, thus in a way supporting the tales of Herodotus, although the actual nature of those waters (canals or lake?) still remains unclear.<sup>31</sup> An inscription in the second register on the eastern wall of the Ptolemaic temple enclosure of Horus at Edfu refers to the goddess Bastet of Bubastis as “Bastet, the Great One, lady of Bubastis (...) under (whose temple) the Nile flows”.<sup>32</sup>

This picture not only fits in very well with the Ancient Egyptian idea of each temple representing the site of creation on the first island emerging from the chaos of the primeval waters<sup>33</sup>, but geophysical investigations of the Tell Basta-Project in 2008 and rescue excavations of the Egyptian Supreme Council of Antiquities in the following year may have brought to light a part of the southern canal of the above described waters surrounding the temple of Bastet<sup>34</sup>.

To the east of the temple of Bastet lies a vast area, which is still mostly unexplored. Visible

architectural remains as well as the pottery on the surface clearly point to a Ptolemaic and Roman era settlement, correlating with the above mentioned writings of Herodotus, who claims the temple was “in the midst” of the city and its dromos ran east in the direction of the temple of Hermes, thereby crossing the market place. Whether this area was the city centre of Bubastis also in earlier periods remains an open question in the light of current knowledge. The location of the offering places on the eastern walls of the tombs of the Old Kingdom in Cemetery A<sup>35</sup> point to a possible location of the Old Kingdom city to the east, however.<sup>36</sup> This would roughly be identical with what is now the agricultural area directly to the north of the surviving eastern tell (Fig. 3–5).

### Methodology of Remote Sensing and Database

In order to map the changes of the tell in modern times we have investigated the available archives for early maps and remote sensing imagery of Bubastis. The useful data span the period from the early 19th century and today. The following sections introduce the data sets and briefly discuss the methods that were used to spatially align the data sets in a Geographic Information System (GIS). The overall goal of the GIS approach was to spatially overlay and store all of the records, maps and images in one database in order to enable a comprehensive spatio-temporal view on the development of the archaeological site, specifically in the last two hundred years to provide new information about the ancient settlement.

Tab. 1 lists the maps and remote sensing data that were available for this analysis. The high resolution true colour imagery of ESRI’s basemap served as georeferenced basis for all of the following work. It was acquired by the satellite World-

<sup>27</sup> Cf. HABACHI 1957, 117–122.

<sup>28</sup> NAVILLE 1891, 60–62. However, as the relief decoration of the blocks coming from the probable location of this temple show Atum, HABACHI assigned this building to Atum, and not to Thoth, followed by other authors: cf. HABACHI 1957, 119–120; KITCHEN 1996, 304; JANSSEN-WINKELN 2007, 38; RITNER 2009, 249.

<sup>29</sup> MEEKS 2006, 19–25.

<sup>30</sup> GESSLER-LÖHR 1983, 404–408.

<sup>31</sup> MEEKS 2006, 20 § 22 [IX.6-IX.8]; LANGE and ULLMANN, 2015. Cf. also LEITZ 2014, 341.

<sup>32</sup> CHASSINAT 1932, 263.18–264.2; KURTH 2004, 495; LANGE and ULLMANN 2015, 18–19.

<sup>33</sup> FRANKFORT, 1948, 151–152; ARNOLD, 1992, 40–41; EATON 2013, 15 (with further literature). In addition, the *isheru* of the temple of lioness goddesses also served the function of cooling the dangerous heat and fire connected with those deities, at the same time also shielding humans from the emission of the negative aspects of their fiery powers, which was assumed to create plagues and diseases. I would like to thank A. von Lieven for pointing out this double effect to me. Cf. also PERDU 1998; KURTH 2004, 495.10.

<sup>34</sup> LANGE and ULLMANN 2015, 19.

<sup>35</sup> BAKR 1992, 58.

<sup>36</sup> Cf. SEIDLMAYER 1990, 414.

View-2 and provided a spatial resolution of about 0.5 m. The dataset was visually evaluated and compared to in situ collected GPS data prior to the analyses. As far as we could judge from the reference data, it showed no noticeable anomalies, but satisfying location accuracy instead. The basemap image shows the location of Bubastis and its surroundings in the year 2012.

Imagery of the CORONA mission was available for the year 1969 for the entire region of Zagazig, including Bubastis. The data were made available by the U.S. National Archives. The dataset is of good quality and cloud free. The horizontal resolution is approximately four meters and thus the detection of small-scale features and details is limited.

The earliest aerial image available was recorded by the German Forces during the WW-II. The German “air scouts” systematically recorded the Nile Delta and the Nile Valley with photographs taken while flying at different heights and from different viewing positions. The film negatives were stored in an office in Germany and were then taken by the US Allies at the end of the war. Since then, the film reels have been stored in the American archives. Today the ‘Luftbilddatenbank Estenfeld’<sup>37</sup> has access to the data and provides high resolution digital scans that were taken over Zagazig/Bubastis in the year 1943. The imagery is cloud free, sharp, and provides a spatial resolution of about one meter. Thus small-scale surface structures and details are clearly visible in the imagery.

The earliest systematic record of the topographic situation of Zagazig/Bubastis was available via the Survey of Egypt Maps (SoE) that were recorded in the 1930s.<sup>38</sup> The datasets display the location of channels, rivers and streets along with the contour lines and points for the ground elevation above sea level.

One of the earliest maps of Bubastis was produced by J. G. Wilkinson in the 1820s (cf. below)<sup>39</sup>. As it is not clear from his drawing whether or not he truly finished it, the map must be considered a sketch, even though a compass point and a scale bar were provided. Nevertheless,

his map displays some interesting annotations and drawings for the former extent of Bubastis.<sup>40</sup>

None of the older images or maps contains a digital spatial reference or metadata on image location and coverage. Thus the images themselves do not hold the information that is necessary to spatially overlay the datasets or to assign the image information to real world locations. The aforementioned datasets were therefore georeferenced to make them usable in a Geographic Information System (GIS). Prior to this operation the data were visually inspected in order to confirm that they did not show strong blurring or image artefacts that may result from the scanning of the slides. The data were further processed in the GIS, e.g. the generation of suited image subsets and contrast/brightness enhancements were performed. The georeferencing approach used was then the image-to-image registration and the WorldView-2 data of ESRI’s Basemap served as the reference image. All data were projected and registered to the Universal Transverse Mercator System (UTM Zone 36 North) using the WGS1984 ellipsoid.

The image-to-image operation aligns two datasets according to geometric location, whether the data were acquired with different viewing geometry or mapped in different coordinate systems. The aim is to map the so-called ‘warp image’ in the same coordinate system as the base image so that the image information, the pixels of both datasets, respectively, represents the same objects. The referencing includes manually locating and matching distinct point features on the earth’s surface. These points have to be detectable in both images. Also it is essential that the real world locations remained unchanged between the acquisition dates. It is necessary, for example, to find ground features that are visible in the year 2012 (WorldView-2) and the year 1969 (CORONA Imagery). The so called ‘tie points’, or ‘ground control points (GCPs)’ are then used to calculate a geometric transformation function between the base and the warp image. The model-function used in this analysis was the ‘rotation, scaling, and translation

<sup>37</sup> LUFTBILDDATENBANK DR. CARLS GMBH: [www.luftbilddatenbank.de](http://www.luftbilddatenbank.de).

<sup>38</sup> We would like to thank R. Schiestl (Ludwig-Maximilians-University Munich, Germany) and S. Seidlmayer (DAI – German Archaeological Institute) for providing us with the map of Zagazig of the SoE.

<sup>39</sup> LECLÉRE 2008, 364, pl. 8.1.

<sup>40</sup> The sketch of the site of Tell Basta, printed as part of the map of the Nile Delta in the *Description de l’Égypte*, Vol. 6, 1828, Pl. 30, could not be used for our imagery database, as it lacks accurate information about spatial reference and the most basic details on the site itself.

(RST)' approach and all data were resampled to the common UTM grid with a spatial resolution of one meter and using bilinear interpolation.

Fig. 1 provides two examples for the image-to-image registration and shows the situation near Zagazig in the year 2012 (fig. 1a) and in the year 1969 (fig. 1b). The two bridges crossing the channel were already present in 1969 and the location of the piers did not change over time, as can be seen in the imagery. Thus the tops of the piers were marked in the base and the warp image, which is illustrated with the red and green circle. The centre of the eastern bridge was used as another tie point and is marked in yellow. Such distinct infrastructural features generally served as good and reliable point features to select GCPs. Fig. 1c and fig. 1d show the same datasets for a location in the south of Zagazig, which has remained agricultural land over the last forty years. It can be seen in the imagery that the field boundaries and pathways have not changed and thus serve as reliable GCPs.

All of the data were investigated in this way and the location of field boundaries, bridges, streets and railways were used to identify tie points in the imagery and maps. Tab. 2 lists the number of points that were used for the registration and refers to the estimated root mean square error in the unit meter as well. The error can be interpreted as the average deviation between the predicted locations (model output) and the true location of ground control points (manually selected).

The image-to-image registration was most difficult for Wilkinson's map of Bubastis. No features were drawn by Wilkinson that were still identifiable without doubt in the modern aerial imagery, except for the generalized outline of the temple of Bastet. The compass direction and the scale, which were both drawn by Wilkinson, were taken into account and the registration was based on the scaling and rotation of a digitized version of Wilkinson's Map. The sketched outline of the temple was matched with today's extent, as well as it possibly could be.

## Results and Discussion

Fig. 2 shows the final results of the image-to-image registration (left column) and the manually

digitized land cover maps based on visual image interpretation (right column). Fig. 2a-b shows the situation in the year 2012. Only the south-eastern part of the site and the small area of the temple of Pepi I are archaeologically accessible. Looking back, one can observe that the border areas of Zagazig had already covered the north-western part of the tell in 1969 (fig. 2c-d). Furthermore, the southern industrial area was already established and a sharp line cuts the site in its south. The industrial area partially existed in 1943 (fig. 2e-f) and it was already planned in 1935, as it can be seen in the land survey map (fig. 2g-h). However, the modern city of Zagazig and ancient Bubastis were not connected before the 1940s. Only some buildings close to the Coptic cemetery and the hospital were already established on the site (isolated buildings in the north of the tell; fig. 2h). When comparing the map from the SoE and the WW-II imagery, two facts can be established. Firstly, the map already shows the street that crossed the site from south-west to north-east in 1943. Secondly, the map indicates a small railway that was built in the north-western part of the tell (solid line in fig. 2f running south-south-east to north-north-west). However, the rails cutting Tell Basta were not drawn on the 1930s' map.

Before the north-western area of Tell Basta, still visible on the maps of Wilkinson, the WW-II imagery and the Corona imagery, became overbuilt by the expanding modern city of Zagazig, only a few excavations had been conducted there. In 1889, Edouard Naville excavated the so-called Cat's Cemetery, the necropolis of the sacred animals of the goddess Bastet, in a place described as the "western part of the mounds of tell Basta"<sup>41</sup>. Naville's work brought to light large pit-like burials filled with bones of cats, mixed with ashes and charcoal as well as bronze statuettes of the goddess Bastet. The find of numerous kilns near those tombs led him to the conclusion that the bodies of the animals had been burned just beside their final resting place.<sup>42</sup>

Due to the lack of a detailed description of the find-place in Naville's publication, its exact location is no longer identifiable. Ahmed el-Sawi, however, published a map of his own excavations at the north-western tell from 1968–1971, where he labelled an area that lay around 50m west of the Coptic cemetery and measured roughly

<sup>41</sup> NAVILLE 1891, 53.

<sup>42</sup> *ibid.*

200 × 150 m as “Cemetery of Cats” (Fig. 4), most probably referring to the earlier works of Naville’s. He himself discovered a further, but smaller cemetery of the same kind in the vicinity, just south of the Coptic Cemetery.<sup>43</sup> Whether this was just an extension of the Cat Cemetery discovered by Naville or actually a separate resting place of the sacred animals of Bastet is hard to say. Nevertheless, an indication of a different characteristic of the smaller cemetery excavated by El-Sawi is the presence of jar burials, while Naville only mentions brick-lined pit burials. This difference, however, might be caused by the fact that Naville was forced to dig considerably deeper than El-Sawi, as the upper layers of “his” Cat Cemetery had been completely destroyed by fellahin.<sup>44</sup> Therefore, it could be that Naville excavated cat burials dating to an earlier period than those found by Ahmed el-Sawi.

Fig. 3 shows the georeferenced WW-II imagery of the north-western and the central part of the tell. Surface structures that were visible in the image were manually digitized and were overlaid as black lines. Fig. 3a further shows the extent of the tell in 1943 and 2012. As can be seen in the imagery, the Old Kingdom Cemetery, the Middle Kingdom Palace and the New Kingdom Cemetery were not excavated in 1943, which is in accordance with the known research history at Tell Basta. No surface structures were visible but the shadow of higher mounds, presumably remains of the brick walls, can be seen. The northern Cat Cemetery, excavated by Naville more than 50 years earlier was covered again by vegetation in 1943. As mentioned above, in 1939 and again in 1943–1944, Labib Habachi excavated the southern part of the north-western tell where he revealed the Ka-temple of Pepi I<sup>45</sup> and nearby a, perhaps similar, building of Amenhotep III<sup>46</sup>. Interestingly, the outlines of the temple of Bastet are recognizable in the 1943 imagery, as well as the beginnings of the excavations in the surroundings of the temple of Pepi I by Habachi. Most remarkable are the dense and parallel structures in the north-western part of the site that are situated between the Coptic Ceme-

tery and the Hospital. These structures were not detectable in any of the other imagery. As we do not have any records of archaeological activity here, their nature remains unclear and as this area is covered by modern buildings nowadays, a future investigation here seems unfeasible (Fig. 3c).

To the immediate north of the temple of Pepi I, a similar temple of Teti (see above) was located by El-Sawi in 1970, attesting to the royal interest of the 6<sup>th</sup> dynasty kings in the early provincial temple of Bastet.<sup>47</sup> Generally speaking, the excavations conducted by el-Sawi from 1968–1971 shed light on the intense use of the north-western tell from the early Dynastic Period until Ptolemaic times. Besides the already mentioned royal Ka-enclosures and the Cat Cemetery, he revealed an elite cemetery, probably from the earlier 6<sup>th</sup> dynasty<sup>48</sup>, a large administrative building (el-Sawi’s so-called “Great Building”) of the 3<sup>rd</sup> or 4<sup>th</sup> dynasty<sup>49</sup> and extensive cemeteries with burials from the earlier Middle Kingdom to the Ptolemaic Period.<sup>50</sup> Another palatial structure east of the Coptic Cemetery seems to date to the Middle Kingdom.<sup>51</sup> Fig. 4 shows the same imagery with an overlay of El-Sawi’s map published in 1979<sup>52</sup>, slightly altered by the authors of this paper<sup>53</sup> and georeferenced using the location of the mapped street and power-lines. None of the structures revealed by El-Sawi can be detected on the 1943 imagery (Fig. 4a-b), due to the fact that those buildings and tombs were not visible on the surface before the actual excavation took place. The extent of the modern buildings of the growing city of Zagazig, which covers most of the ancient structures on the north-western tell, can be seen in Fig. 4c.

Fig. 5a shows the extents of the tell in the years 1935, 1943, 1969 and 2012. It is evident from the pictures that the eastern border of the site remained nearly unchanged over the years, while its northern and southern parts were gradually reduced and covered by urban area and buildings. The figure further shows “surface structures” that were digitized as vectors in the GIS for the years 1943, 1969 and 2012. These structures display – in

<sup>43</sup> EL-SAWI 1977, 128 fig. 1, 129; EL-SAWI 1979, 76.

<sup>44</sup> NAVILLE 1891, 53.

<sup>45</sup> HABACHI 1957, 11–36; LANGE 2006, 121–122.

<sup>46</sup> HABACHI 1957, 102–106.

<sup>47</sup> EL-SAWI 1979, 75–76, Fig. 164–167.

<sup>48</sup> EL-SAWI 1979, 63, 72–74.

<sup>49</sup> EL-SAWI 1979, 74–75; LANGE 2013, 9.

<sup>50</sup> EL-SAWI 1979, *passim*.

<sup>51</sup> EL-SAWI 1979, 76–77.

<sup>52</sup> EL-SAWI 1979, Fig. 4.

<sup>53</sup> Addition of the location of Cemetery A and C, excavated by Mohammed Ibrahim Bakr in 1984–1989 on the north eastern tell: cf. BAKR 1992, LANGE 2013; BAKR and LANGE 2016.

the widest sense – linear irregularities and linear features that were visually detectable in the imagery of the remote sensing data sets. Therefore, the mapped line-features not only contain ancient surface remains, but also excavation grids, pathways, or the shadows of mounds and hills. Nevertheless, such mapping is essential to obtain meaningful results about the history of older excavations, their spatial dimensions and to distinguish between old and new features.

For example, the excavation grids close to the temple of Bastet and the palace of the Middle Kingdom were clearly recognizable in the imagery of 2012, as well as remains of the southwestern city of Bubastis (Late Dynastic to Roman Period). The 1943 and 1969 images show – for this mostly unexplored area – a couple of surface remains that run from north-west to south-east. Presumably, these line-features can be associated with the dromos, which connected the temple of Bastet in the west and the temple of Hermes (Thoth) in the east, according to Herodotus (Hd. II, 138, see above). These two localities were also drawn by John Gardner Wilkinson in 1822–1827<sup>54</sup>. Fig. 5b shows the digitized and transformed map of Wilkinson's and today's land cover. According to Wilkinson's map, the tell was stretched to the northwest and it continued towards the Nile Channel, "Canal of Muezz". It seems that Wilkinson could identify the dromos and the "Marketplace"; however, it is not clear whether he had adapted his drawing in order to match the descriptions of Herodotus. Wilkinson's "Mounds of the Walls" and "Ruins of Bubastis Tell Basta" northeast of the dromos are of great interest, as they are covered by cultivated land nowadays. Also, the orientation of the modern street seemed to correlate to the orientation of the "Mounds of the Walls". Furthermore, it seemed that Wilkinson was able to identify the location of the "temple of Hermes" described by Herodotus (see above) at the eastern end of the dromos, that is his "Temple of Mercury". Naville had also been searching for this building in 1889 by measuring the distance given in Herodotus' description starting from the ruins of the temple of Bastet and following the traces of the Dromos to the east. He finished at a spot in the cultivated area, just at the

border of the tell, a topographical situation which is surprisingly identical to the modern situation. Here, he detected decorated blocks of red granite from the time of Osorkon I.<sup>55</sup> These blocks show depictions of the king offering to Heliopolitan deities (Atum, Shu and Tefnut), Bastet in the sacred barque, as well as parts of a long dedicatory inscription of Osorkon I that recounts the dedications of the most valuable objects to the temples in all of Egypt.<sup>56</sup> Unfortunately, Naville was not able to excavate this findspot any further or to obtain further information about the building. Still, the decorated blocks corroborated his assumption that he had discovered the remains and the location of the temple of Hermes/Thoth<sup>57</sup> that was mentioned by Herodotus. However, none of the early images show any hints about the aforementioned localities.

### Conclusion and Outlook

The analyses of the remote sensing imagery lead to the following results:

(1) The extent of the site was much larger than it is visible today. This is especially true for the northern and southern parts, which are covered by urban building today. It seems that the eastern side remained nearly unchanged over the last 150 years. Moreover, given that the referencing of Wilkinson's Map is correct, the remains of the ancient city to the north of the south-eastern tell, which were marked by Wilkinson as "Ruins of Bubastis" and "Mounds of the Walls", are still accessible today. These areas are nowadays mostly covered by cultivated fields. Thus it could be possible to investigate these localities first of all by the means of geophysical survey. The same applies for the presumptive location of the "Temple of Mercury".

(2) The analysis of the 1943 and 1969 remote sensing imagery indicated structures in the so far mostly unexplored south-eastern part of the tell, running in SE direction. These structures may be traces of the Dromos. Using the imagery as a starting point, it will be possible to further investigate these areas which might form the centre of the city of Bubastis in the Late Dynastic Period up

<sup>54</sup> WILKINSON 1843, 427–430; LECLÈRE 2008, 364 with further literature and pl. 8.1. Cf. also THOMPSON 1992, 273–274.

<sup>55</sup> NAVILLE 1891, 60–62.

<sup>56</sup> NAVILLE 1891, pl. L–LII. A comparable inscription appears on another decorated block of Osorkon I discovered in 2003 in the northern part of the entrance hall of the temple of Bastet: LANGE 2008, 131–141, esp. 134–136.

<sup>57</sup> NAVILLE 1891, 60.



to the times of the Roman emperors and to identify the location of the temple of Hermes / Thoth.

(3) The study of the former extents of Tell Basta showed an overall shape of the tell as a mound stretching from the northwest to the southeast. It might be possible that Tell Basta was surrounded by a northern and a southern branch of the Nile. This is supported by “in-field” sediment analysis which was carried in a borehole survey using hand augering in spring 2016 by Tobias Ullmann from the Department of Physical Geography of the University Wuerzburg.

The preliminary results indicate fluvial regimes towards the western and eastern side (west of the temple of Bastet and east of the New Kingdom Cemetery) and – most likely – a high-sand Gezira in the now central part of the site (New Kingdom Cemetery and temple of Bastet). Furthermore, the excavations of el-Sawi and Bakr clearly show a significant concentration of Old Kingdom structures in the north-western and northern areas of the tell. The variety of the remains is remarkable here. Administrative buildings, temples and extensive burial grounds with a high concentration of elite tombs have been excavated, proving the intensive use of the northern tell from the time of the first dynasties. While those discoveries open up an entirely new set of questions which can only

be answered by a fresh study of the excavated material, this pattern may already reveal specific dynamics of the occupation of the natural tell in the early periods of the evolution of the settlement. However, intense geophysical and archaeological investigations will be necessary to verify this hypothesis.

Given the increasing threats to archaeological sites and the amount of information already lost, remote sensing imagery delivers a very welcome methodological tool to the archaeological investigations in the Nile Delta. The remotely sensed imagery does not only document the historic and present state of the sites but also helps to detect geomorphological and archaeological features that are otherwise not recognizable due to modern building activities. As an additional tool to on-ground investigations, such as geomagnetic survey and drill augering, remote sensing substantially enhances all geophysical efforts to reconstruct the palaeo-landscape of the Nile Delta, the most important determining factor of all processes of ancient human habitation. In this respect, the authors hope that the, so far mostly untouched, image archive of the WW-II German Scouts will be useful for other researchers, since it provides a nearly area wide coverage of the Delta and the Nile Valley.

Table 1 Maps and remote sensing datasets of Bubastis.

Name	Acquisition Date	Type	Resolution/Scale	Source
ESRI Basemap (WorldView-2)	2012	digital true colour imagery	approx. 0.5 m	ESRI Basemap Imagery; provided in ESRI ArcMap 10.3
<b>CORONA Imagery</b>	1969	panchromatic imagery; high resolution scan of bw-film; Mission 1052-1 (KH-4A)	approx. 4 m	provided by the U.S. National Archives in 2015
<b>WW-II Imagery</b>	1943	panchromatic imagery; high resolution scan of b/w-film	approx. 1 m	German Forces WW-II; provided by Luftbilddatenbank Estenfeld in 2015
<b>Survey of Egypt Map (SoE)</b>	1935	topographic map	1:25,000	Survey of Egypt 1935; provided by R. Schiestl (LMU) and S. Seidl-mayer (DAI) in 2015
<b>Wilkinson's Map of Bubastis</b>	1822-27	hand drawn sketch	n/a	LÉCLERE 2008; redrawn by the authors.

Table 2 Root Mean Square Errors of the image-to-image referencing based on the RST method (rotation, scaling, and translation). The ESRI Basemap was used as reference. All data were resampled to a common grid with a spatial resolution of one meter using bilinear interpolation.

Warp Image	Number of tie points	Coverage	Root Mean Square Error
CORONA Imagery	194	City of Zagazig and surroundings	9.9 m
WW-II Imagery	65	Southern Zagazig and Bubastis	10.4 m
Egypt Land Survey Map	64	Southern Zagazig and Bubastis	5.8 m

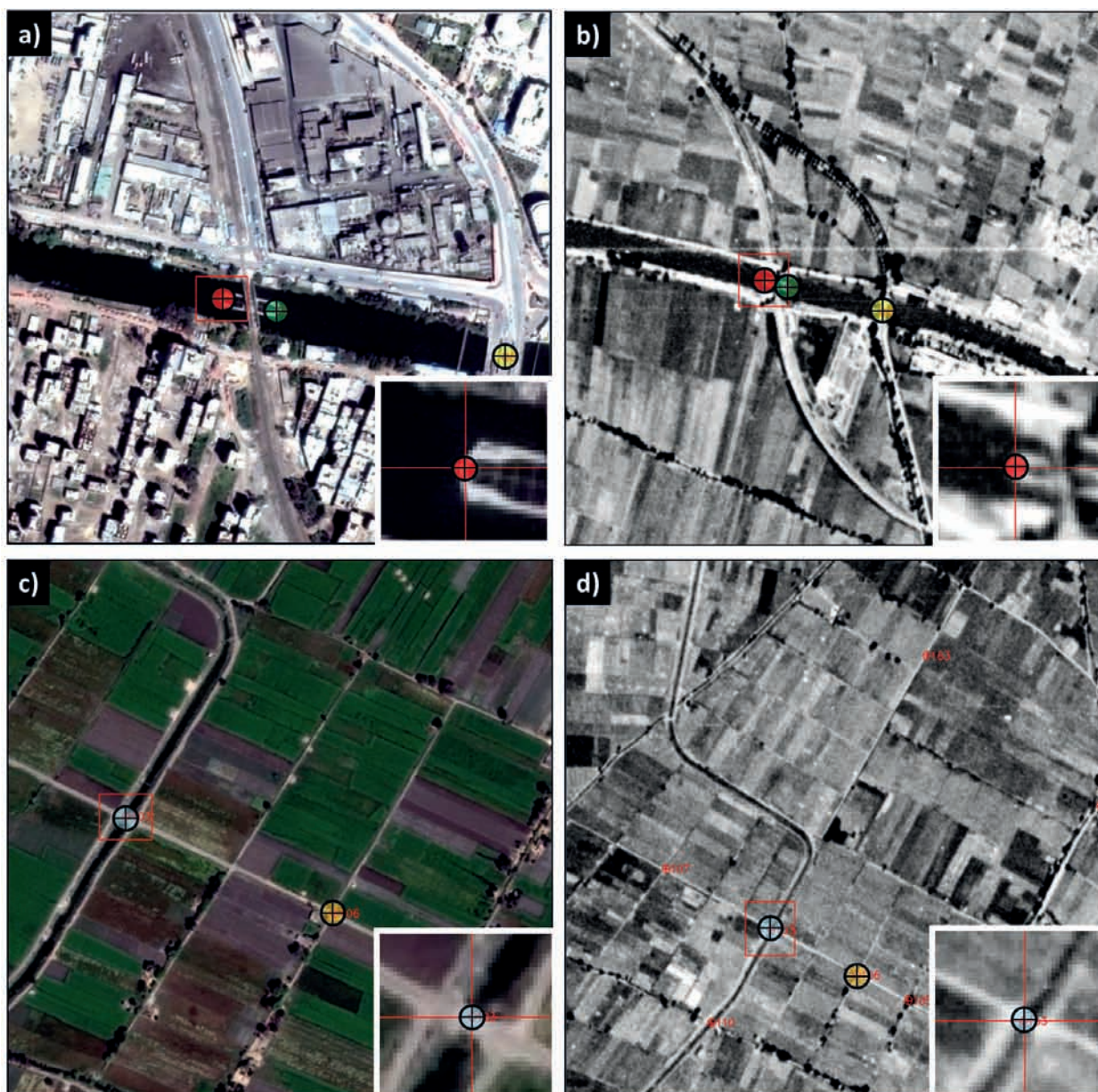


Fig. 1 Examples of the image-to-image registration and collection of ground control points: a) Southern Zagazig in the year 2012, b) same location in the year 1969, c) surroundings of Zagazig in 2012 and d) 1969 (at different scales).

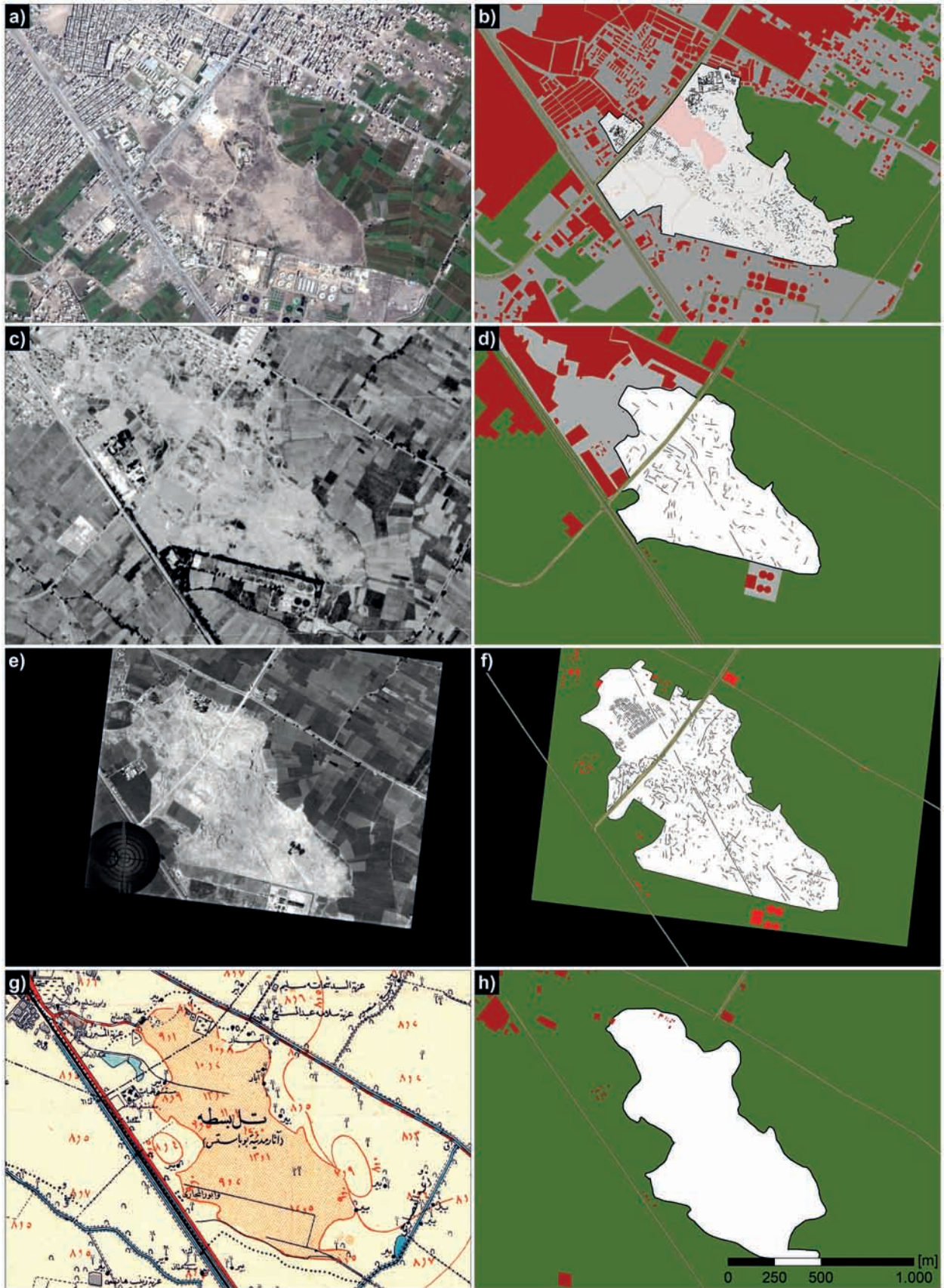


Fig. 2 Georeferenced maps and remote sensing datasets of Bubastis (left) and manually digitized land cover maps (right): a) & b) ESRI Basemap 2012, c) & d) CORONA Imagery (1969), e) & f) WW-II Imagery (1943), g) & h) Survey of Egypt Maps (SoE) (1935).

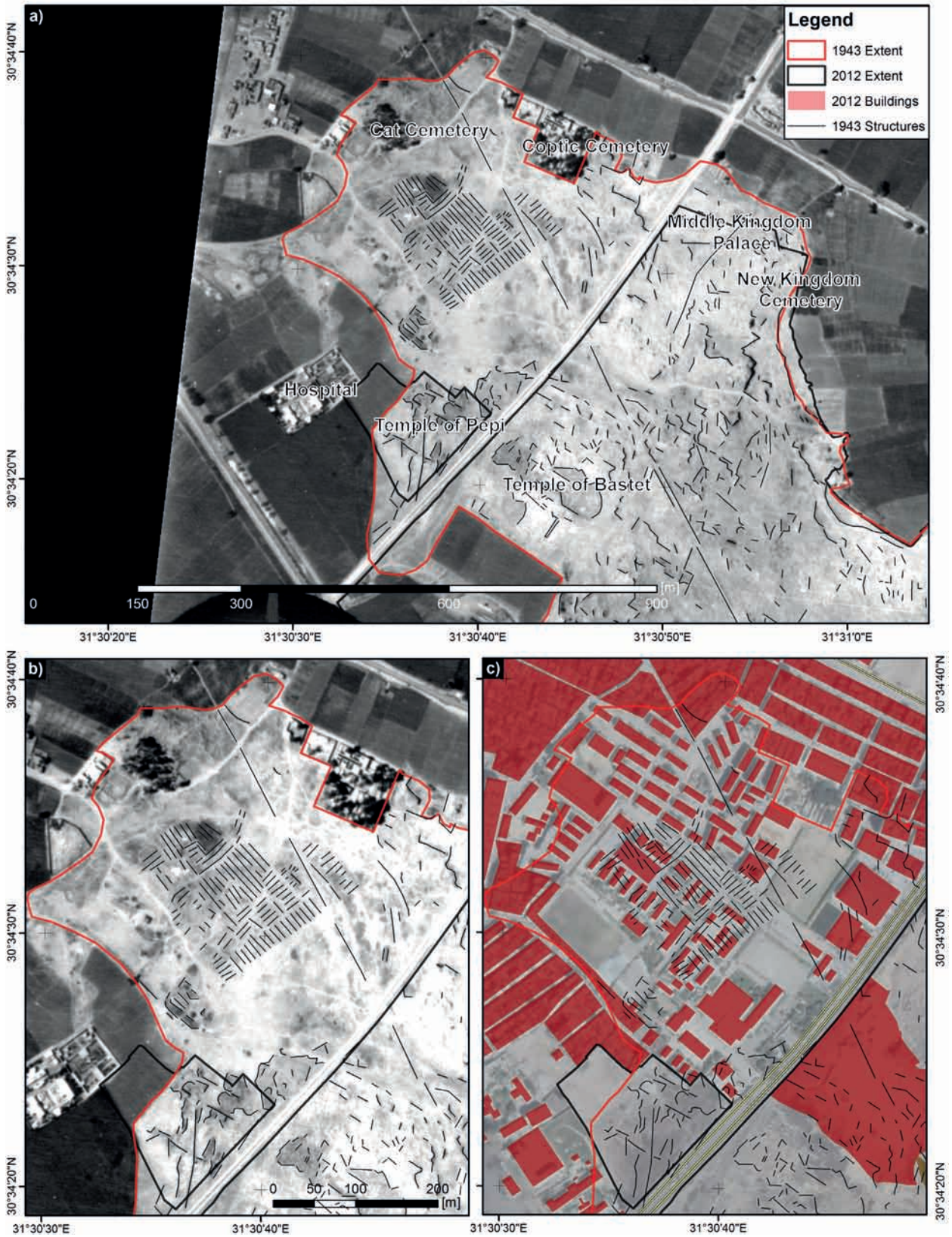


Fig. 3 Georeferenced WW-II Imagery: a) digitized surface structures and overlay of the extent of the site in 1943 and 2012, b) close-up of the north-western part of the tell and c) overlay of the digitized surface structures and today's situation. Red and grey polygons indicate buildings and urban areas.

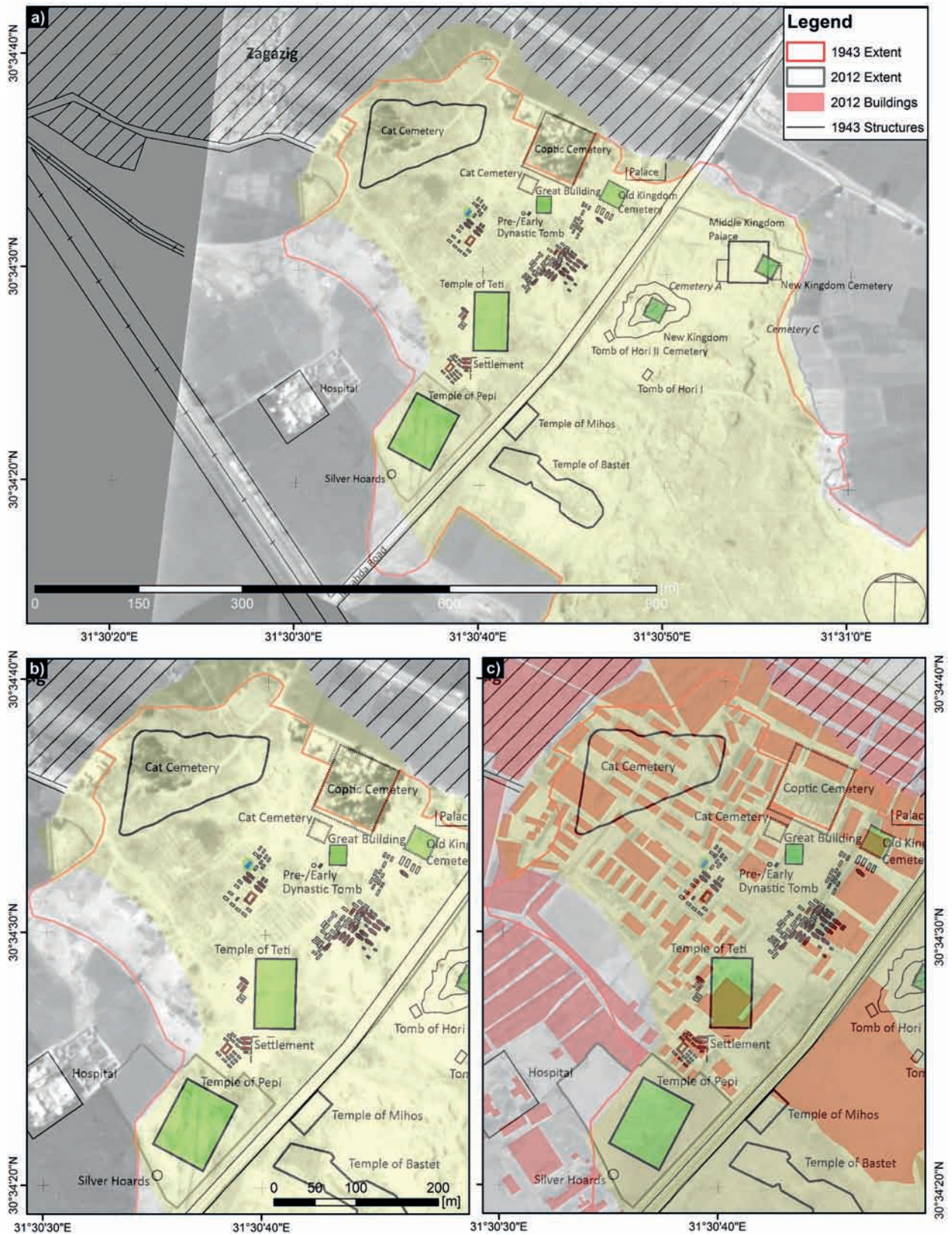


Fig. 4 Georeferenced WW-II Imagery: a) digitized map of El-Sawi's from 1979 with the addition of the elite cemeteries of the later Old Kingdom known from the excavations of Bakr 1979–1989 on the north-eastern tell and overlay of the extent of the site in 1943 and 2012, b) close-up of the north-western part of the tell and c) overlay of El-Sawi's map and today's situation. Red and grey polygons indicate buildings and urban areas.

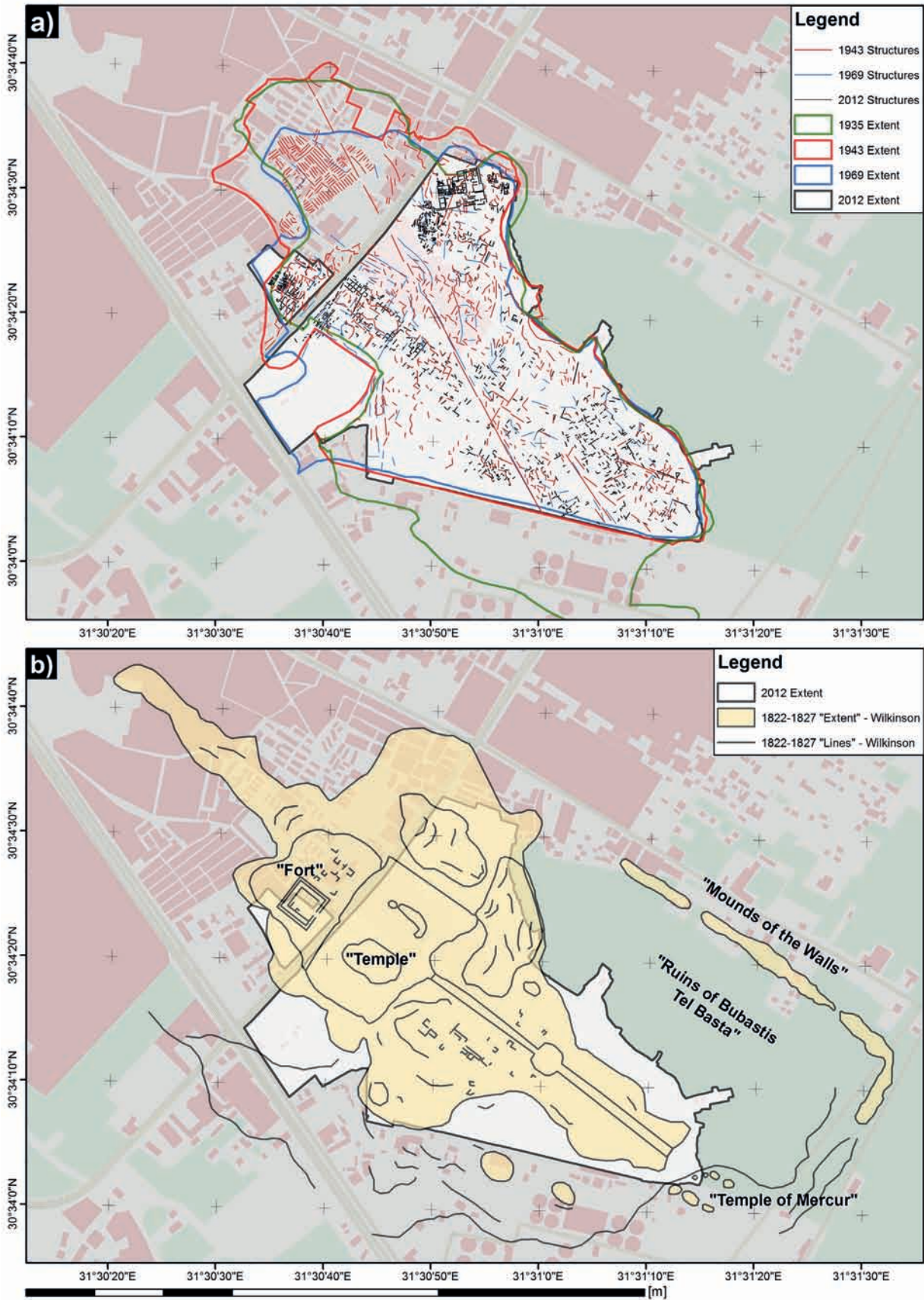


Fig. 5 GIS-Analysis: a) extent of the site in 2012, 1969, 1943, 1935 and digitized visual surface structures in 2012, 1969 and 1943, b) digitized and georeferenced version of Wilkinson's map and overlay with today's situation.

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