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The Middle Nile Valley: Elements in an approach to the structuring of the landscape from the Greco-Roman era to the nineteenth century

E. Subias ; I. Fiz ; R. Cuesta

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Abstract

The construction of the Aswan Dam put an end to a form of relationship between people and the environment that had its origin in the pre-Pharaonic period. The annual Nile flood had been tamed and managed for centuries by the societies of the Nile delta. However, by the nineteenth century, attempts to modernize Egypt according to Western standards led to a gradual change in how the river was managed and exploited, focusing on permanent irrigation of the land. These changes took the form of successive hydraulic engineering projects that transformed the entire landscape. Our project aims to analyze how this long process took place, from the Greco-Roman period to the present day, by focussing on the middle valley of the Nile, in the area corresponding to the Oxyrhynchus nome (province), in order to reconstruct the methods of flood management and how they have transformed the landscape.

For this purpose, we have combined an analysis of archaeological and written documentation, consisting primarily of papyrological data and secondary sources. We have also combined a reading of the historical cartography with the identification of traces of dykes and canals from satellite images (CORONA, ASTER, Quickbird, Worldview 2), and related enhancing functions of satellite imagery. These data were organized and registered on a GIS geodatabase that enabled all the information to be analyzed and confirmed. Our initial findings define an ancient landscape, in which old channels structured the landscape around the nome. These channels, and their levees associated with dykes, favoured both the containment of water and terrestrial transport, in an area that would be completely inundated in the flood season. This combination of channels with some element of retention was important for territorial and administrative organization within the nome, the administrative territorial division of Egypt, and its subdivision the toparchy.

1. Introduction

The aim of this paper is to present the research undertaken by the authors in the Oxyrhynchus region, funded by the Spanish Ministry of Science and Innovation (HAR 2008-01623), Rovira i Virgili University (URV) and the Catalan Institute of Classical Archaeology (ICAC). A substantial part of the project focused on the reconstruction of the landscape as a basic underlying assumption for analyzing the administrative aspects of the area, i.e. the definition of the territory in each historical period.

That there was a close relationship in Ancient Egypt between the territorial division and the taxation system has been argued in several sources (Bonneau, 1987, p. 192). The Nome would have been a tax collecting unit based in the metropolis. Meanwhile, toparchies would have constituted the first level of concentration for taxed products, with towns acting as shipping ports.

As the history of Middle Egyptian agriculture suggests, this management structure was closely related to the hydraulic system, which had been established and subsequently strengthened since Ptolemaic times. This hydraulic system was composed of a network of levees and channels that divided the territory into zones of dip irrigation (called basins), and provided a means of transportation for crops. The hypothesis of this paper is that the network gave the pattern for the administrative structure. A basin consisted of a natural depression bounded by levees, the Nile and the foothills of the western and eastern elevations of the valley. These basins were flooded by channels, connected to the Nile, during the flood (Barois, 1887: 23).

Farouk Gomaà, together with Renate Müller-Wollermann and Wolfgang Schenkel, undertook an initial study focusing on the Pharaonic period in the 1980s, which was based on historical mapping and pedestrian prospecting. The results of that study include both on-site identification of ancient settlements and the location of some segments of ancient dykes, some of which might have been built in the Pharaonic era. Their findings are the starting point for our work, which is concerned with the structure of the nome in subdivisions and its major hydraulic management infrastructures, in order to gain a more in-depth knowledge of the settlement pattern in the Greco-Roman Period.

Historians of irrigation systems in Egypt have proposed different views of the development of knowledge and skills about flood control. We know that, around the large river systems, seasonal flooding was used as a form of irrigation. The focus is centred on the scales of management over time. That is, from an initial household/regional management adjusted to the nomos, to the current one with a trans-regional scope (perennial irrigation related to the Aswan Dam) giving sense to the relationship between nomo and basins. Thus, the main problem for our study is to distinguish landscape forms from different periods. Primarily, we need to discard the hydraulic forms that laid the foundations for permanent irrigation, changing the territorial structure in modern times. In this paper, we will set out the methods and techniques used in this research, and we will suggest that the landscape and administrative structure of the nome of Oxyrhynchus were closely related as a result of the flood and irrigation strategies prevailing in the Greco-Roman period.

2. Regional context

The research area (Fig. 1), located in the Middle Nile Valley, occupies a large area. It covers a large transect from a few kilometres further north, where the Bahr Youssef rises as a canal of the Nile, almost to the point where it reaches Fayum. This canal follows a very tortuous course, with a width between 50 and 60 m and a maximum depth of 6–8 m. It was historically responsible for supplying Fayum with flood waters, as well as for flooding the arable land, termed flood basins. The region being studied is between the modern locations of Maghagha and Samalut, covering an area of around 1304 km^2 approximately equivalent to the boundaries of the 19th century administrative division of Bani Swaif.

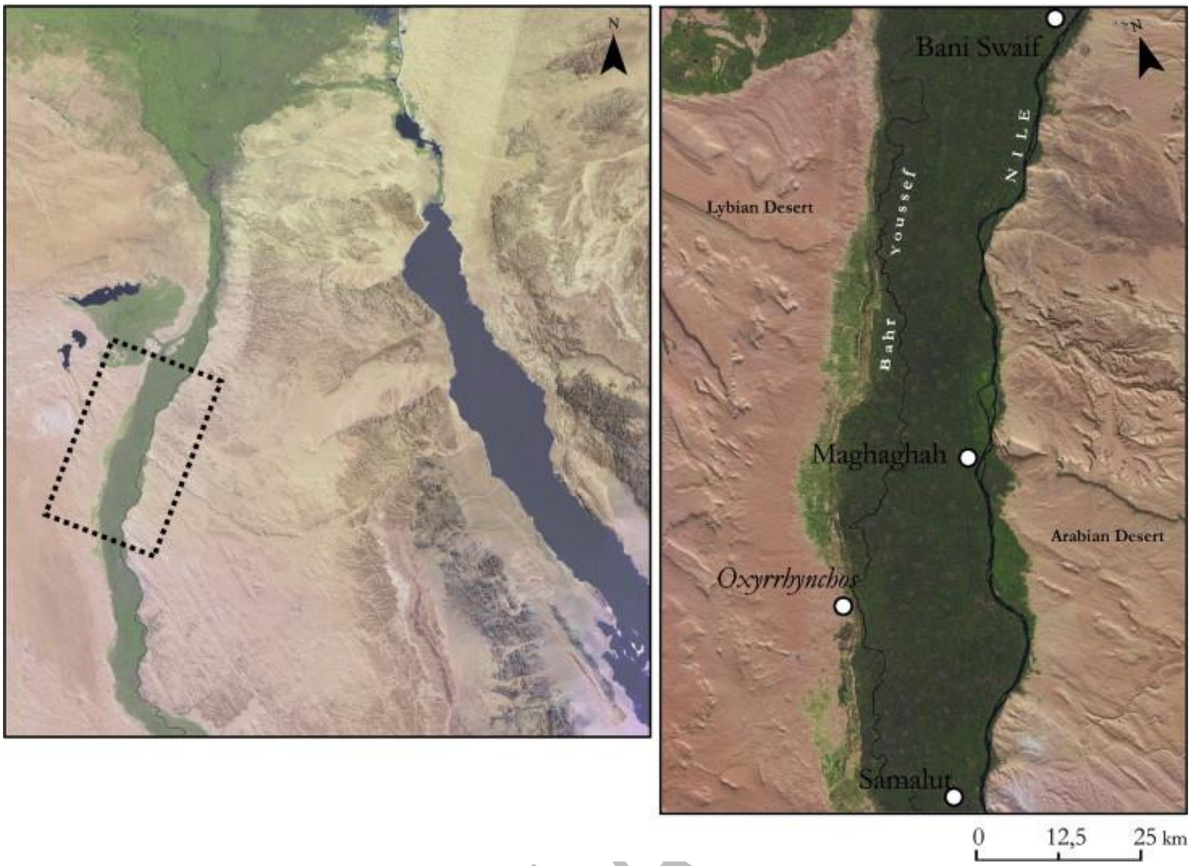

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Fig. 1. Location of the study area. Source: Landsat 7 Global Imagery Mosaic (Natural Color Pan-sharpened, data collected between 1999 and 2003). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

This zone of the Nile Valley has not been studied to the same depth from a geomorphological point of view as have some other areas further north or south (Hillier et al., 2007; Bunbury et al., 2008). Butzer (1959) presented a geomorphological study of the area and an initial proposal for its relationship with the archaeological sites.

As this is the widest part of the Middle Nile Valley, the landscape had great potential for agriculture and settlement, provided that flooding could be managed. Structuring this landscape first and foremost are the two major water courses located on the right and left sides of the valley: the Nile and its dependent canal, the Bahr Youssef.

For this reason, there had to be artificial channels for flooding the basins and their subsequent drainage in every period. These channels followed the course of the river (Bunbury et al., 2007; Hillier et al., 2007; Bunbury and Lutley, 2008). They were linked to levees and containment systems for the waters during the flooding periods between August and December. There are also geomorphological indications that the Bahr Youssef flowed directly east of the desert gravels in Classical times, something closely reflected in the flourishing conditions of human settlement in the western valley at the time. This also fits in with the aeolian activity in preceding and subsequent times (Butzer, 1959).

3. Materials and methods

In order to obtain a detailed knowledge of the Egyptian landscape and its transformations, each region must be studied using systems that enable archaeological data to be integrated with information on the modern physical environment, and the traces of the ancient landscape must be tracked using remote sensing devices. The nome of Oxyrhynchus, which was once densely populated, still retains some traces of its ancient settlements and infrastructure, although the landscape transformation process has accelerated since the Aswan Dam was built.

To study the changes in this area, we had to work backwards (Chouquer, 2000, pp 103–163; Rippon, 2008, pp 19–30) from the contemporary period in order to interpret the traces in the landscape, and we endeavoured not to confuse older hydraulic engineering projects with those that are more modern. As a result, we also undertook a large-scale study of the hydrographic structure of the Middle Nile Valley during the nineteenth century. This research also takes into account the sites and levees documented in 1991 by the team of Gomaà et al. (1991). These data has been stored and geo-referenced into a GIS.

3.1. Ancient cartography

An historical study of the landscape requires the compilation of all the available historical cartography for the Middle Nile Valley in order to study the landscape. We consulted the sources available in the Bibliothèque Nationale de France, the National Archives and The British Library. The resources consulted, and the essential maps providing relevant information are: Robert de Vaugondy (1753), who interpreted a map by Sicard (1722); the maps produced by the great French cartographer D'Anville (1727); the hydrological map of Egypt by Martin, together with the detailed cartography in the *Description de l'Égypte* (1813).

Although they provide highly interesting information, these maps must be used with caution, as they were produced at the beginning of modern cartography, and as such are large scale maps containing approximate and inaccurate topographical references. For this reason, the mapping must be assessed and verified for the purposes of orientation with the information that is now available.

The cartography produced by the French expedition led by Bonaparte, which culminated in the well known publication *Description de l'Égypte*, is an example of this problem. However, although topographic techniques had ostensibly improved during that period, major errors were committed during the project, which make it difficult – and sometimes even impossible – to make adjustments and adaptations with subsequent maps to include it in a GIS. The maps of the Atlas in the *Description de l'Égypte* are full of errors (wrongly located place names, erroneously situated dykes and canals) because the publishers did not understand the annotations by the geographical engineer R. Schouani, a member of the scientific committee who accompanied the expedition in the area under study (Gomaà et al., 1991). These inaccuracies make any georeferencing treatment impossible, mainly as a result of the enormous distortions in the maps corrected by computer.

Subsequently, a most accurate cartography was published in the second half of the nineteenth century. The maps produced since that period can be incorporated into a GIS, together with more modern maps, and detailed computerized corrections can be made. The nineteenth-century cartography we have used was based mainly on the *Carte Hydrographique de la Moyenne Égypte* by Linant de Bellefonds, produced in 1854 and revised in 1883. This map was very useful in the reconstruction of the Middle Valley as it was in the nineteenth century, not only due to its quality, but also because it includes useful names of places, features and details, such as the location and structure of dykes and regulators, and the location of several planned construction projects in 1854.

We thus compiled the modern maps (e.g. the 1:50,000 topographical maps by the Egyptian Survey Authority) and combined this cartography with 19th century maps. We also used the maps appended to the first editions of the books on Egyptian irrigation written by Jean Barois and William Willcocks, and published in 1887 and 1906 respectively. We also compiled, and geo-referenced topographical maps (1:50,000, 1:100,000, 1:200,000) produced between 1906 and 1939 by the Survey Department of Egypt, when the country was a British protectorate. The precision and detail of these maps was essential for detecting unused elements of hydraulic engineering (canals and dykes). Finally, the study of the irrigation system in Egypt was based on an exhaustive review of a series of publications dating from the eighteenth, nineteenth, and early twentieth centuries (Fiz, 2011, pp.146–158).

3.2. GIS and remote sensing

The archaeological site information documented by Gomà et al., as well as the modern cartographical data produced by the Egyptian Survey Authority (ESA), were incorporated into the GIS platform (ArcGIS 10.0). This allowed us to start the analysis of the images in two steps: searching for traces in the landscape, and reconstructing the oldest forms by discarding modern infrastructures. The detection of traces in the landscape (palaeochannels, drains, dams, reservoirs) was performed using the old maps, but mainly using high resolution satellite images, in which it is still possible to see evidence of the flood basin management system which was traditionally used in Egypt until the great reforms of the nineteenth century. We used medium (ASTER and Landsat) and high resolution (CORONA, QuickBird and WorldView II) images.

In certain conditions, histogram stretching of the images has not yielded adequate images, and we subsequently used highlighting techniques and analysis of satellite images, including Principal Components Analysis (PCA) and Tasseled Cap Transformation (TCT). These techniques enhance the multispectral images, eliminating the redundancy in the electromagnetic spectrum of the scene. For example, the synthesis capacity of PCA makes it a very useful technique for filtering the images prior to other multispectral analyses. Its application in archaeology has led to the detection of sites (Stafford et al., 1992), buried walls (Garbuzov, 2003) and archaeological anomalies on images from the IKONOS sensor. PCA and TCT are useful for multispectral images in areas where ground conditions, or the season in which the remote sensing platform was introduced, did not provide shape recognition. For example, both techniques were applied to images representing areas at the west of the Nile Valley. These areas are characterized by aeolian sands, and an application of histogram stretching techniques or the NDVI (Normalized Difference Vegetation Index) would not provide results (Fig. 2).

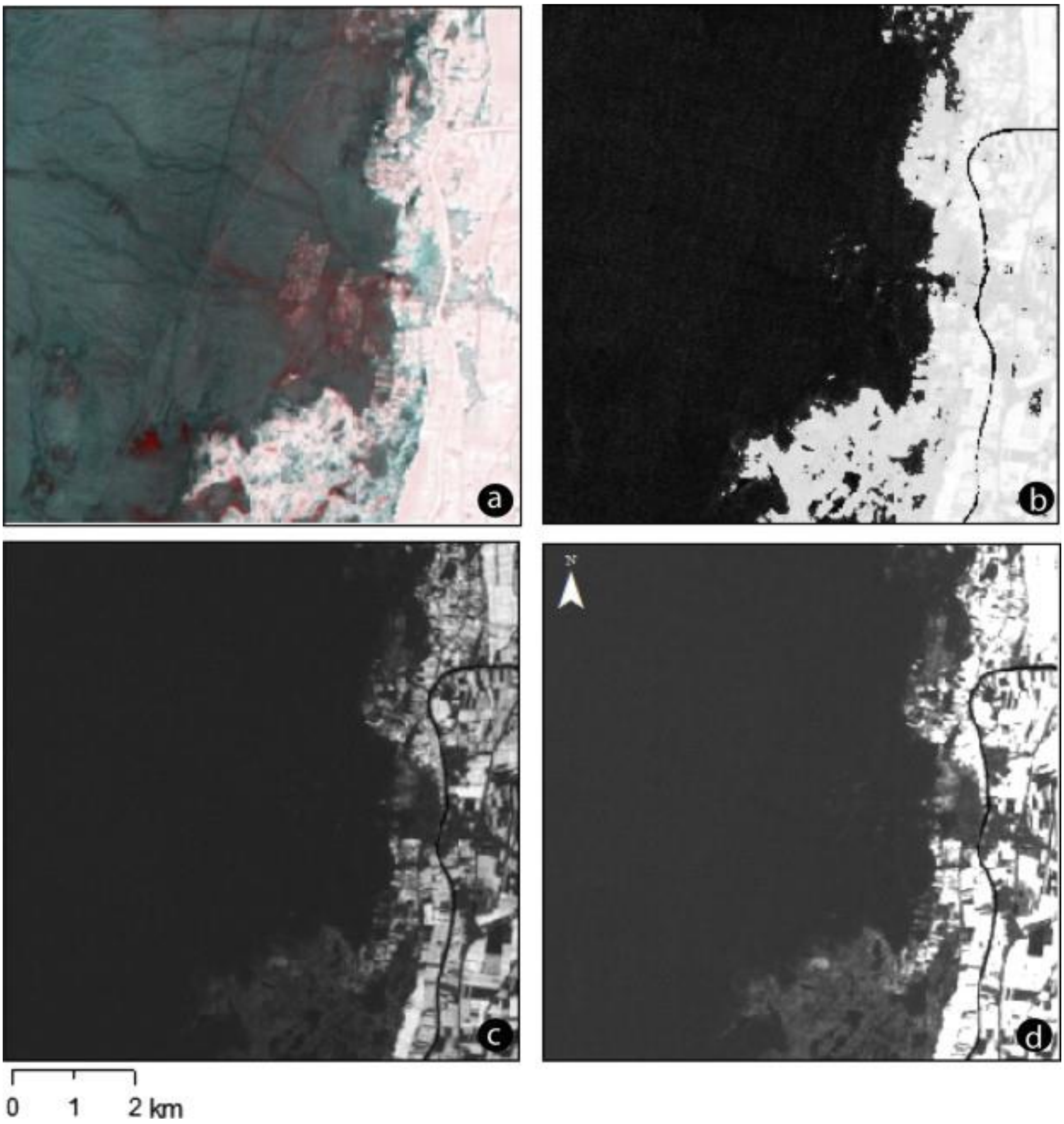

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Fig. 2. Different enhancement remote sensing results applied to the same Landsat scene. Sector of Oxyrinchus (Banhasa) a) PCA Components 3/2/2 b) NDVI. Histogram Equalize enhancement c) NDVI. Minimum-Maximum enhancement. d) NDVI. Standard Deviation enhancement. Source: Landsat TM. Acquisition date 06/21/1990. WGS84 36N Projection.

The CORONA images (Fig. 3) were produced during the Cold War between 1960 and 1975. Later, the Clinton administration declassified them in 1995 (Parcak, 2008: pp.52–57). These images are an extraordinary source of information on the Middle Nile Valley between 1960 and 1976. The Aswan Dam was built during this period, but the basin's flooding system still remained in some zones of the Middle Valley. The images show features and traces associated with this basin flooding system. However, the main problem is that these images were taken with analogue cameras, having panoramic lenses that cause substantial distortion (Goossens et al., 2006, pp. 749–750). This distortion is difficult to correct using photogrammetry programs. The problem lies in the vast expanse of territory covered by each image, and the need for uniformly distributed control points. Thus, to correct these problems, we used a sample of GCP (Ground Control Points) obtained from medium resolution ASTER images covering the whole valley of the Nile, and in some cases high resolution Quickbird images and Worldview2, in correcting and georeferencing the CORONA images. This rectification process was done using both data elevation models (DEM) of 30 m/pixel (ASTER GDEM) and 90 m/pixel (STRM-90).

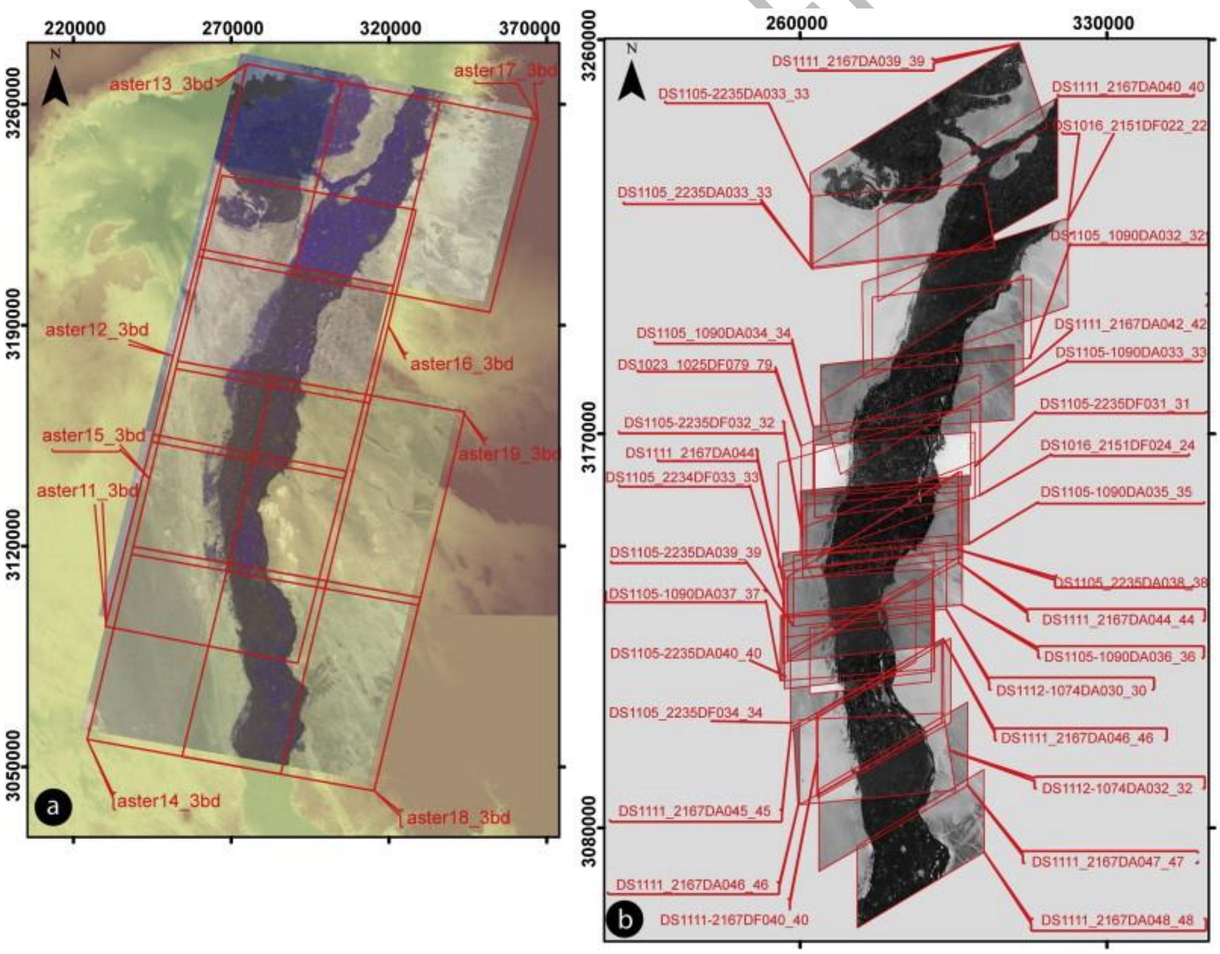

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Fig. 3. a) Mosaic of the different ASTER images covering the project area. STRM-90 DEM. b) Mosaic of the different CORONA images covering the project area.

These DEM's were also used to create topographical sections of the Nile's Middle Valley to detect possible channels and dykes. These sections were produced with the DEM-90 obtained from the STRM due to problems with the ASTER GDEM. This product enabled us to detect a series of anomalies that are not visible to the naked eye, on the map or in the Google Earth and Quickbird images. The initial explanation was that these anomalies were old dykes, levees and water reservoirs. This hypothesis seemed to be supported by a papyrus found in Oxyrhynchus 44.3167(BL 9), which specifically refers to the use of a circular construction that was sealed with a flood gate when the water reached its limit. However, similar to those described above, the ERSDAC GDEM webpage contains a recent revision, which discusses anomalies in the product. This revision refers to the product as being of an "experimental" and "research grade" nature, and this forced us to discard this hypothesis (Tachikawa et al., 2011, pp. 17–20).

3.3. Nile flooding and its management according to the sources of the eighteenth and nineteenth centuries

We also undertook the contextualization of the recorded data, in the knowledge that various authors in the eighteenth, nineteenth and twentieth centuries had observed the phenomenon of the flooding of the Nile, and how it was managed and administered. The historical study was based on a thorough reading of a series of publications produced in the eighteenth, nineteenth and early twentieth century. The first sources studied were the series of publications about Egypt published between 1809 and 1829 entitled *Description de l'Égypte, ou Recueil des Recherches et des observations qui ont été faites in Égypte pendant l'expédition de l'armée française*. The second source, which was also very important, was the book published in 1872 by Linant de Bellefonds (1872–1873): *Mémoire des principaux travaux d'utilité publique exécutés en Égypte depuis la plus haute antiquité jusqu'à nos jours.* Later, J. Barois, the principal secretary of the Ministry of Public Works in 1887, provides essential information on how the perennial irrigation system was organized in the Middle Nile Valley, almost fourteen years after the construction of the Ibrahimiya Canal. These works, therefore, completely transformed the hydraulic system of distribution channels and water drainage. Finally, Sir William Willcocks published the book *Egyptian Irrigation* just two years after Barois, and reissued it in 1913 with James Ireland Craig. This reprint is of major interest, as it lists the changes and projects that took place between the end of the nineteenth century and the beginning of the twentieth century.

3.4. Papyrological sources

The result of this approach was the creation of a map of the Middle Nile Valley prior to 1799, which we used to work in a new direction, involving cross-referencing the data from the papyrological sources mentioning aspects related to topography, irrigation systems and hydraulic engineering in Ptolemaic and Roman Egypt. The bulk of the information that we were able to use comes from the published studies written by various researchers including Bonneau (1993), Rowlandson (2007), Calderini and Daris (1935-2007), Pruneti (1981, 1989, 2001) and Benaissa (2009a,b), who systematically collected evidence of landscape structure and settlement, and worked on locating well-known place names.

4. Results

The use and application of methods, materials and software mentioned in the previous section has allowed the creation a geodatabase in a GIS incorporating all these forms of data. It has therefore been possible to represent the archaeological sites, as well as the silted ancient canals, and those dams that have been located. With all this information, and after conducting a process of discussion and synthesis, the structure of the hydraulic management system from the early to the end of the nineteenth century has been distinguished.

This analysis of the landscape based on historical mapping enabled us to locate the dykes that structured the valley in the nineteenth century. This accurately shows the nineteenth century strategy for irrigation in the region (Fig. 4): the area between the Nile and the Bahr Youssef was divided lengthways in order to keep flooding the agriculture in the western part, while major channelling and transportation infrastructures were developed in the eastern half, together with an agricultural system based on perennial irrigation. The analysis of the drainage system related to this radical project enables a distinction to be made between the waterways that contributed to the supply and drainage of the major basins, and the courses not related to the project. This new infrastructure took advantage of some elements of the old system.

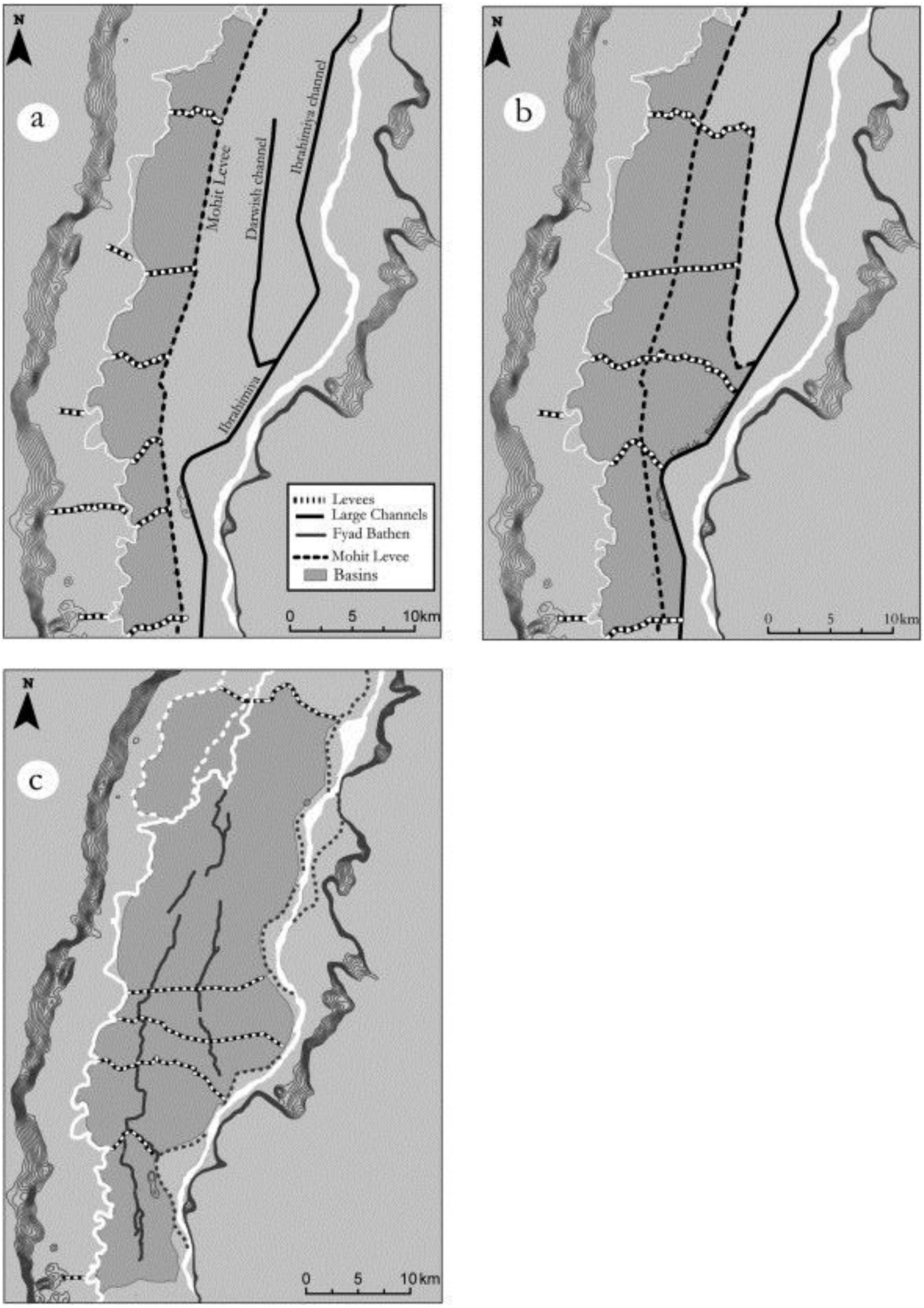

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Fig. 4. Evolution of the hydraulic management system of the Middle Nile Valley. a) 1887 b) 1870–1883 c) 1800.

We have identified sequences of watercourse fragments with a linear consistency, suggesting that they are remnants of a larger ancient course, prior to the modernization of the hydraulic system (Fig. 4, label c). By comparing these data with those provided by the papyrological sources, therefore, we suggest the location of a canal, known as Apollophanes, and another larger channel in the area between the Nile and the Bahr Youssef. Similarly, the combination of papyri evidence and remote sensing imagery enabled traces of other forms in the landscape to be located. These include paleochannels and former meanders that could have been used in the ancient world as natural features for circulation or storage, respectively.

Furthermore, locating and identifying the dams enabled us to calculate the approximate distances between them and, therefore, the length of the basins they contained. Comparing these distances with the metric units in use in the ancient world allowed us to determine – albeit within the limits of prudence that these approximations require – how the Middle Valley could have been structured.

Finally, the location of ancient canals and levees helps to measure the flood zones contained by dykes in the Greco-Roman world. This fact reinforces the hypothesis that the administrative divisions of nomes were due to a spatial distribution related to access to water.

5. Discussion

5.1. A perspective of the hydrographical Middle Nile Valley landscape in the eighteenth and nineteenth centuries

The Nile and the Bahr Youssef are the main natural watercourses that structure the valley in modern Middle Egypt. This fact, which seems obvious to us, may not have been so in ancient times, as the historical maps show that it was difficult to name and to describe it. Indeed, the branch of the Nile, which was, also known as the Joseph (or Youssef) channel, is sometimes called Moeris or even by another name as discussed below. We believe that this confusion is understandable, because there were other waterways in the area that competed with the Bahr for irrigation capacity, and because there were links between them. The maps of the seventeenth and eighteenth centuries, therefore, repeatedly show two or three major intertwined courses in this area of Middle Egypt, which created large islands of alluvial soil.

Other eighteenth-century maps show a different configuration of the river courses south of Fayum, with the inclusion of a large waterway between the Nile and the Bahr Youssef. Robert de Vaugondy (1753), in his interpretation of Sicard, called it *Moeris*, while D'Anville (1727) highlighted a very wide course called *L. Bathen*, starting near Gebel el Teir, located east of the Nile, opposite the modern Samalut, and connected to the Nile by a minor channel in the vicinity of Zohra. This origin is not consistent with the modern Bahr Youssef, and as such the thick trace seems to indicate a significant intermediate course that continued until the beginning of the Fayum, near Ehnasia. However, the earlier maps force us to consider the existence of a large longitudinal channel at least since the mid-eighteenth century, and, therefore, prior to the construction of the Ibrahimiya Canal in 1873. How can this discrepancy be explained? The course's overly broad representation on the older maps suggests that what is being emphasized is not so much the bed of a channel as a waterway that would overflow during the flood season, creating an elongated lake in the valley's central depression. This means that it was not a permanent irrigation canal, but lost its flow and became segmented during the dry season. It is not surprising that the middle area of the Nile was known to Al-Idrisi as the "gulf of the Nile" (Fehérvári et al., 2006, p. 6). Using these cartographical examples, we would like to emphasize that, before modern times, middle Egypt was criss-crossed by a network of channels of some importance.

The importance conferred on the main course, or *Bathen*, is in contrast to the width of the Bahr Youssef, which is shown as a trickle of water next to the desert. Between the Bahr Youssef and the *Bathen*, other transverse lines that divide the land are mentioned on the maps. These waterways linked the two streams, as they are graphically similar to the Bahr Youssef. Sicard's map in particular shows these traces near Beni Hassan, with another near Sandafa, another to the south of Garnous and others further north (Sicard, 1722). These courses were probably accompanied by containment dykes and acted as flood basins.

The two maps mentioned above have something in common: three water courses run parallel to each other in Middle Egypt. On the first map, the broadest channel is the middle one, which originates near Samalut. On the second, it is also the central channel, but it originates near Minia, and is, therefore, undoubtedly the Bahr Youssef, although it is labelled as Moeris. Finally, a third map calls the westernmost channel *Taneos Fossa* while the central course is called *Moeridis Lacus*, and it branches off the Nile at Heracleópolis, creating the "island" in the nome. What is significant in all cases is the importance of the channel that historically ran parallel between the Bahr Youssef and the Nile. Moreover, the Linant de Bellefonds map included a large western channel as a drainage project, and this presumably brought into line and connected some earlier courses such as the *Lycus Canalis*, which is shown further south. This also suggests that there may have been a series of channels to the north, that could have covered the wetland area at the foot of the Libyan chain. None of these channels follows the same path today, or at least they do not have the same continuity and location as shown on the eighteenth-century maps. The question is: when do these channels date from, and what are their origins?

These originated as a result of flood management in the ancient world, as containment strategy for water retention basins. The situation in Egypt prior to hydrographic management in the early nineteenth century is described in the *Description de l'Égypte*, providing us enough data for a reconstruction. The team of scientists that accompanied Napoleon's expedition to Egypt described how the system worked (Girard, 1823, pp. 496–497). The irrigation system consisted of a series of basins, separated by dykes, which were flooded by canals during the flooding season. Full advantage was, therefore, taken of the gradient of the Nile Valley all the way to its source, in order to facilitate a uniform distribution of water loaded with sediment. As well as holding the waters back, the dykes, built with reinforced earth, also acted as a communications system during flooding periods (Girard, 1813, pp. 352–353, 1823, p. 497).

These dykes, and especially the older ones, have a winding layout. This is because the breaches in the circulation points of the flow meant that the walls had to be repaired by moving them backwards or forwards from their original position. As a result, the dykes came to be arranged in a straight line as time passed (Barois, 1904, pp. 265–266). The waters were not only controlled by breaching the dykes. In some dykes, brick bridges had been built with arches, with each pillar acting as a regulator. These enabled the water to circulate after it had been held back for a sufficient length of time in the previous basin. The same work, when describing the hydrography of the province of Benisuef, lists three types of dykes: large, medium and small. The large dykes crossed the valley from one side to another, with the largest being the dyke of *Oukechechy* or *Kocheicha* (Martin, 1813, pp. 198–199) and the other dykes being: '(...) *Behabchyn*, *Safanyeh*, *Saftrachin*, *el-Noueyreh*, *Choubak, Ehoueh*, *Badahal ou el Chantour*, *Samalout*, *Menbaâl et Bardanoah'*.

Furthermore, in the *Description* the French scientists used the Arabic term Fyad Bathen to describe the flood canals that fed the basins. However, the same term, Bathen, used in other descriptions, was not a natural channel, but instead low-level locations, which retained the water throughout the year after the flooding took place (Jomard, 1809, p.104, note 2).

In the absence of documentation about the Mamluk period, we found sufficient items in the Description de l'Égypte to give us some idea of the hydraulic organisation of the Middle Valley. However, the list of the dykes in the text is not based on any geographical order enabling direct identification. A combination of Linant's plan (1855), which is more precise, and the *Description de l'Égypte* levees list, helped us to reconstruct the landscape as it was in 1800. There are phonetic variations between the place names used in the two sources, suggesting that the location of some of the dykes may be open to argument. The list of large dykes includes those that existed in 1800, and which could have structured the flood basins system in the Middle Valley. In addition, we constructed a final plan (Fig. 5) showing the flood basin organisation of the Middle Nile Valley in 1800. One of these basins is particularly interesting due to its size. We have called it Safaniya due to the tendency to use the name of the northern enclosing dyke of the basin. Schenkel (1994, p. 29) believed that the dyke of Safaniya could be dated from before 1800, identifying it as the Seper-merou that is mentioned in the Wilbour's Ramesside papyrus.

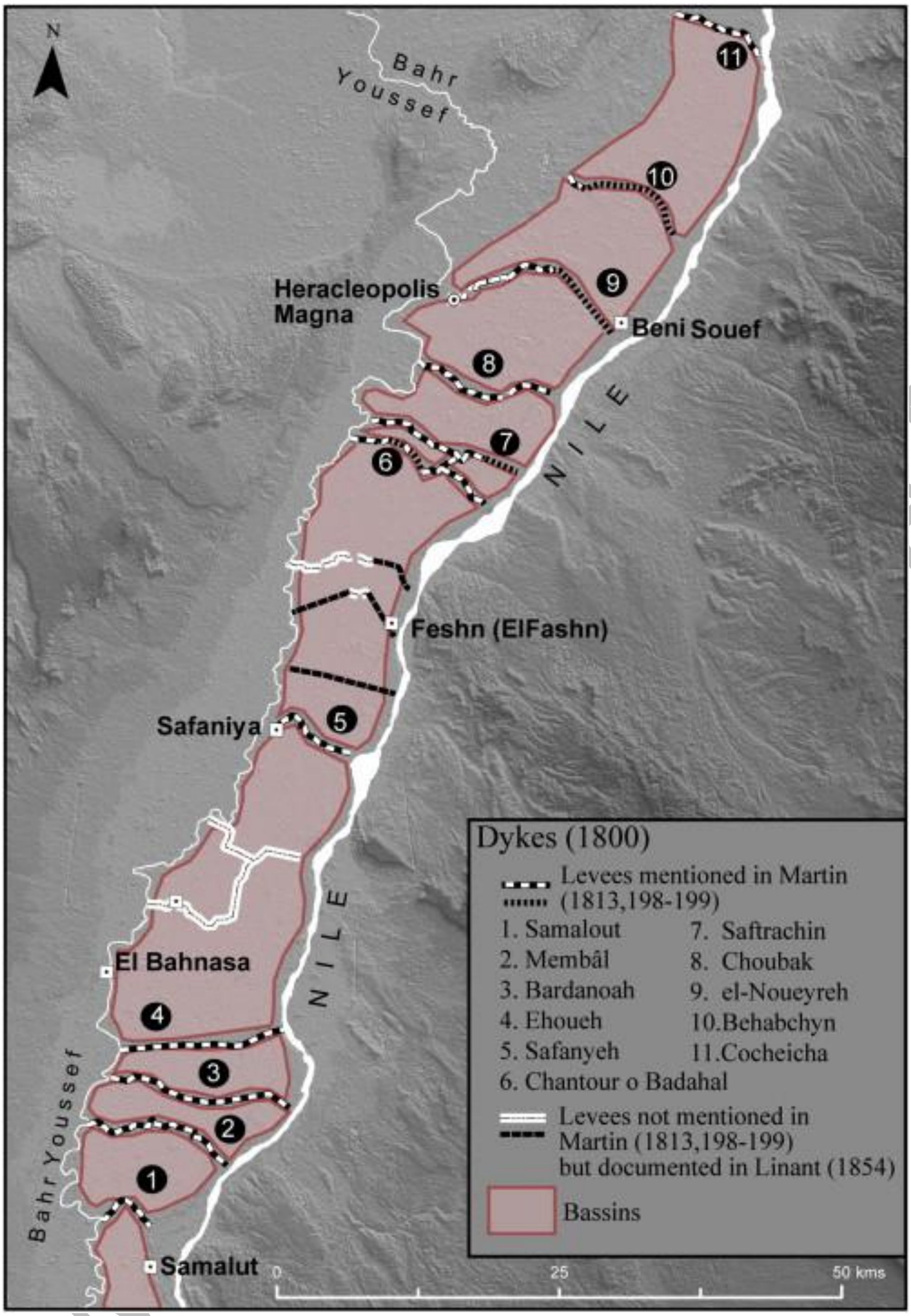

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Fig. 5. The Middle Valley hydrological management in 1800. Reconstruction of the basin system in 1800.

According to Butzer (1976, p. 12), the basins dating from prior to the nineteenth century reforms were longer and had greater capacity. The changes consisted mainly of the subdivision of the originals into other smaller basins. Butzer's opinion is of particular importance, given the large area covered by the two continuous basins separated by the dykes of Elloue, Safaniya, and Badahal, if this hypothesis is correct.

The observation of Barois (1904, p. 60) is interesting in this respect, as he maintains that the last basin in a chain is always the longest and widest. The reason for this was that if an unanticipated disproportionate flooding took place, or mistakes were made in the emptying manoeuvres, the solution was to create successive breaches in the chain of dykes, thereby relieving the overflow. The last basin, also the largest one of the chain, bore the excess water. However, a smaller basin meant that the dykes were subject to less tension and stress from the water stored. They also solve the problem caused by sharp gradients, thereby making the water easy and economical to distribute. According to this argument, the smaller basins of Bardanoah, Menbâal, and Ehoueh, and the larger basin defined by Safaniya, would form a chain of basins fed by the Bahr Youssef, the Nile and the various water collectors (*Fyad Bathen*).

The intermediate nature of the area between the two large basins separated by the dyke of Safaniya is interesting. Rough calculations, which we will specify in detail from here on, suggest that the distances between the dykes of Elloue and Safaniya, and the latter and Chantour, are both similar (around 26 km). This information suggests that this was a rational structuring of the space prior to the nineteenth century reorganisation. In this previous design, the Safaniya dyke would have been an important feature in the definition of spaces, as it is almost equidistant from the dykes of Elloue and Chantour (Fig. 5, labels 4,5 and 6).

5.1.1. Reconstructing the ancient flood basins

In previous research (Subías et al., 2011), we presented the traces of the dykes that may have been used in ancient times. We will consider another aspect in this area, which is related not so much to the dykes, but rather to the area irrigated by those infrastructures and its metrological conception.

According to Schenkel (1994, p. 31) the dykes in the Middle Valley are at a distance from each other that can be interpreted as multiples of the longitudinal Pharaonic measurement of the iterou (10.5 km). Finally, the author considered a hypothetical structure of basins based on the *iterou* or half *iterou* (5 and 6 km).

By superimposing mapping data and satellite images, we were able to accurately locate the traces of the dykes. We were, therefore, able to perform more precise calculations to determine the distances between the dykes. However, the dykes were structures that tended to change, because they broke and were repaired each year, and moved upwards or downwards at the breaking point. The elongation of a dyke may imply a variation of 6 km, as in the case of the el-Noueyreh levee mentioned in the *Description de l'Égypte*, which is in turn associated with the city of *Heracleopolis Magna*, located at one end of it. It is possible that the changes in the traces of dykes did not affect the ends, if the annual breaches did not occur. Based on this hypothesis, the ends of the transverse dykes from the Nile to the Bahr Youssef are, therefore, the benchmarks for approximate locations of the dykes. In these calculations, the distances obtained go beyond the *iterou*. This linear measure also appears, but only in three of the distances between dams. Other measurements obtained can be interpreted as multiples of other units of long distance, such as the *schoinos* of Eratosthenes (6300 m) and the Egyptian *schoinos* (7397 m).

These measures (Table 1) enable us to establish a hypothesis for the reconstruction of the basin management process in the Middle Valley (Fig. 6). The distances based on the *iterou* and the Egyptian *schoinos* would have enabled a major flood basin infrastructure to be created, while those based on the *schoinos* of Eratosthenes would have subdivided some of these large basins into secondary basins. These secondary basins allowed better management by preventing uncontrolled breaches resulting from tensions in dykes with excessive volumes of water, and also reduced the power, rather than the flow, of water as it entered the Fayum area. The *schoinos* of Eratosthenes was defined during the metrological reform of the *cubit* undertaken in the Hellenistic kingdoms, therefore these reforms most likely did not take place before the beginning of the third century BC (Ercolani, 2001, p.119).

Table 1. Approximated distances between dykes, and their equivalent values in the following units: *iterous*, Egyptian *schoinos* and *schoinos* of Eratosthenes. The levee number refers to the numbers labeled in Fig. 6d.

From Levee X to Levee Y Number of Levee on Fig. 6	Distance (meters)	Schoinos of Eratosthenes (6300 m)	% Error	Egyptian Schoinos (7397 m)	% Error	Iterou (10500)	% Error
-Nazlat Al-Muhadi – Manqatin Levee 1 – > Levee 4	12408	1.960	1.52%				
-Manqatin – > Membal Levee 4 – > Levee 5	7355			0.99	0.57%		
-Membal – Bernaoui/Bardanoah Levee 5 – Levee 6	6020	0.950	4.44%				
-Membal – Elloue/Ehoue Levee 5 – Levee 7	9951					0.95	−5.23%
-Banhasue – > El Garnus Levee 8 –> Levee 9	10483					1.00	0.00%
-Safaniya – > Badah/Badahal Levee 10 – > Levee 14	21546					2.05	2.60%
-Safaniya – > Saft Rachine	29335			3.97	0.86%		

From Levee X to Levee Y Number of Levee on Fig. 6	Distance (meters)	Schoinos of Eratosthenes (6300 m)	% Error	Egyptian Schoinos (7397 m)	% Error	Iterou (10500)	% Error
Levee 10 – > Levee 15							
-Membal – > Safaniya Levee 5 – > Levee 10	37934	6.02	0.35%				
-Saft Rachine – > Chobuk/Choubak Levee 15 – > Levee 16	6263	0.99	0.59%				
-Saft Rachine – > Nonewere/el Noureyreh Levee 15 – > Levee 17	14263			1.93	−3.59%		
-Nonewere/el Noureyreh – > Dandil/Behabchyne Levee 17 – > Levee 18	12403	1.97	−1.56%				
-Nonewere/el Noureyreh – > Cocheicha Levee 17 – > Levee 19	29,700			4.02	0.38%		

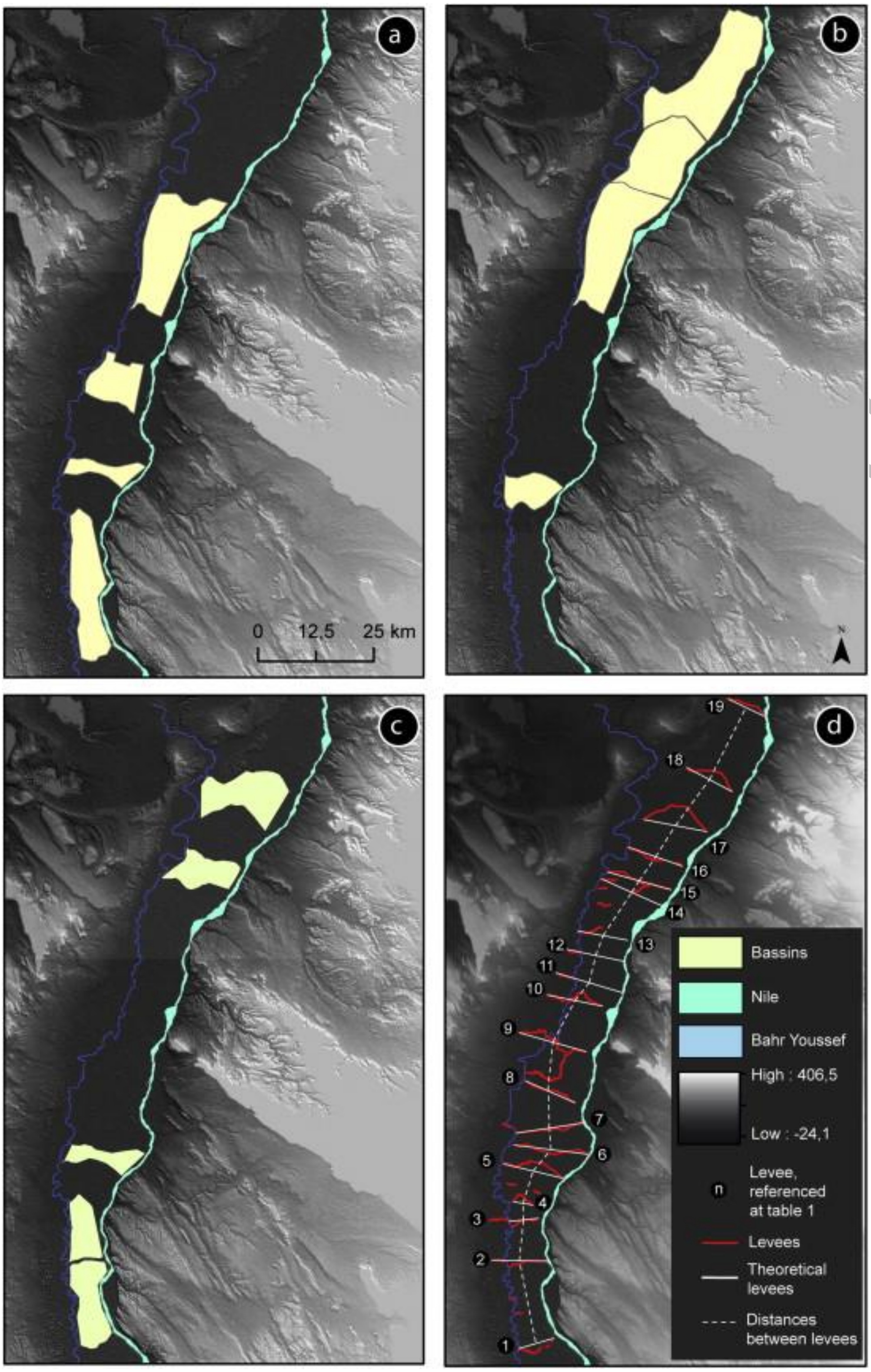

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Fig. 6. Evolution of the drainage basins system. Drainage basins with distances between dykes in a) *iterou* b) Egyptian *schoinos and* c) *schoinos* of Eratosthenes. d) Identified levees traces and hypothetical paths of the original levees taking as a fixed current origin and end. Location of points used to measure the distances between dikes. Source: DEM STRM-90. v 4.1.

5.2. An approach to the Nile Middle Valley landscape in Greco-Roman times

5.2.1. The western channels of the Bahr Youssef

The existence of an ancient course of the Bahr Youssef, and the fact that it would have experienced a movement eastward, has received some mention in the literature (Butzer, 1959, p.78). To address this problem, we must address the geomorphological dynamics of the Nile valley and the fluctuations of the water courses in this river system (Butzer, 1960). Irrigation works using channels must have begun very early in the history of Egypt, and that the landscape of the valley has changed a great deal throughout its history (Loiseau, 1999; Bunbury et al., 2008).

Regarding the possibility of a natural course to the west of the Bahr Youssef, the CORONA images very clearly show a band of moisture adhering to the desert foothills from Qena to the beginning of the Fayum (near Ehnasia). This feature follows the middle valley's profile, with lower areas on the edges of the larger bed due to the accumulation of silt from flooding at the edges of the watercourses (Hurst, 1954; pp. 30 and 39–48). Various silted channel segments flowing into the current course of the Bahr Youssef are next to this strip of moisture on the western edge of the nome of Oxyrhynchus. There is no continuity between these traces, but they are related to meanders of the river branch, and meander like the river itself, meaning that they are variations to it, such as between Muzura and Gafadun (Fig. 7) or further south near Sinara, where a thin flow surrounding the town appears, and also continues its course southward. The trace of the paleochannel practically disappears near Safaniya, but it reappears near Abu Bisht, and once again meanders towards the Bahr Youssef. No traces of the paleochannel are visible further south, and the current course runs further west, with no major fluctuations over a distance of about 8 km, near Oxyrhynchus. It may be assumed that the Bahr Youssef was canalised or remained stable at this point throughout the Greco-Roman period, in order to protect the city (Subías, 2011). To the south of Oxyrhynchus, another trace of the paleochannel emerges as far as the town of Abu Hisheima after another large meander, and then continues southwards. Beyond that, the trail is lost; perhaps it is concealed by a modern canal, or perhaps by the actions of the wind that have covered ancient sediments, as sand dunes have penetrated the western valley since the post-classical era (Butzer, 1959, p.78).

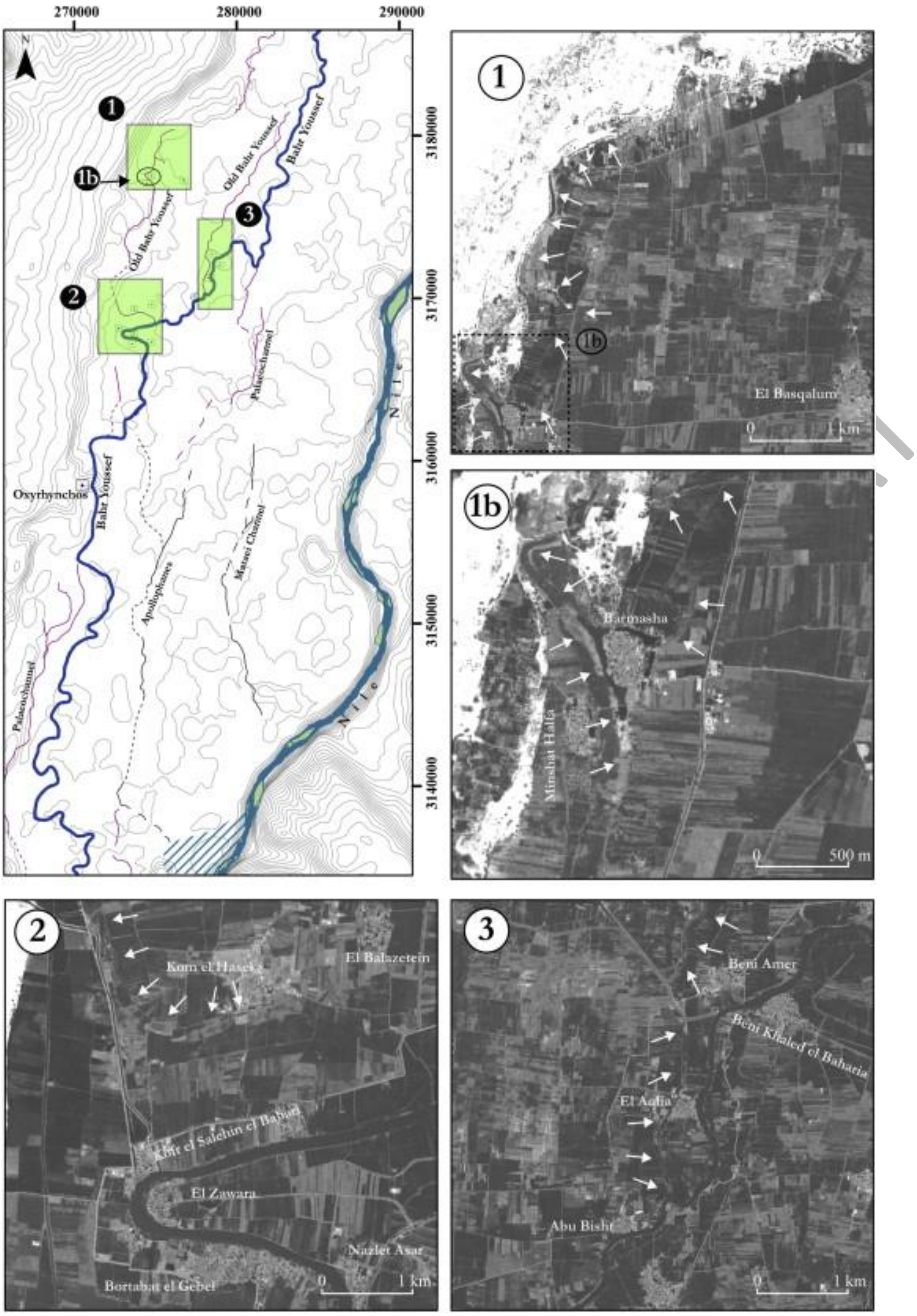

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Fig. 7. Details of the traces of canals and the old course of the Bahr Youssef. Source: CORONA satellite scene DS1105-2167DA042, Acquisition Date 02-Aug-1970.

The concept of paleochannel or dry canal has its own term in Greek: *koilas-koiloma* (Bonneau, 1993, p.18). This term was used to describe depressions which were filled with flood water, and retained the water for longer periods of time and created lagoons. Some sections of the silted channel appear to have been used until recently, as they are shown on maps dating from the early twentieth century. However, it is important to ascertain whether water flowed in ancient times in these segments, which are up to 8 km distant from the modern Bahr. This is suggested by the clarity with which the traces are still visible, and their consistency, which we will present based on an interpretation of the images. This idea is reinforced by reading a papyrus (P.Oxy LI 3638, 12), according to which there was an old channel to the north of Oxyrhynchus, located to the west of the Tomis channel, and adjacent to Sinara.

If all the courses identified from remote sensing images are confirmed as dating from the Greco-Roman era, it is possible to argue two things: 1. that a western channel may have coexisted with the Nile and the Youssef; 2. that the landscape of Middle Egypt was not based on roughly parallel watercourses, but instead on channels that crisscrossed each other, virtually enclosing agricultural units on "islands" that may have had some significance as a demarcation boundary.

The names of these watercourses, or at least some of their segments, have yet to be discovered by modern scholars. The problematic western channel was probably initially the one known as *Temy* in the Pharaonic period, which according to Goyon (2008) was the ancient course of the Bahr Youssef. However, there is another very significant name in the Greco-Roman context, which is *Oreinou Boreinou*, indicating a northern channel in the desert or the "limit" (Rowlandson, 1996, p.12 n.22 and Rowlandson, 2007, p.210 n.2). Interestingly, the papyrus that mentions it (P. Coll. Youtie II 68) also mentions the region of *Pella* to the south of Oxyrhynchus, which takes us to a different area than the one we were referring to as Temy, located near Sinara. So the *Oreinou Boreinou* was a channel to the north of what town or region? Is it possible that it is the same as the earlier one and that they were connected? In fact, there was another channel called *Mounthoteu*, the banks of which were related to those of *Pela*, *Sinary* and *Ision Tryphonis*, i.e. towns to the north and south of Oxyrhynchus (P. Oxy XLIX 3462), which must have been related in some way to *Paimis*, *Sinara*, and *Ision Tryphonis*. Finally, judging by the papyri, there were other channels in the nome of Oxyrhynchus, which were known as the "long one" or the "other one," (P. Coll. Youtie VI 988) compiled by Rowlandson (2007, p.210 n. 2) and as *Themothis* (P. Oxy XLVI 3268) near Phoboou, between *Ophis* and *Pankerke* (Benaissa, 2009a,b, p. 359), as well as the Apollophanes canal. The place names in the nome, which are abundantly documented by the papyri, and have been studied for decades as a source of knowledge for Oxyrhynchus, are now useful as an additional reference for interpreting the fossilized landscape.

5.2.2. A larger channel "between rivers" and its role as demarcation

The trace of the Apollophanes Canal, located between modern Bahr and the Nile, is one of the challenges for any study of the landscape of Middle Egypt in Ptolemaic and Roman times (Rowlandson, 2007, p. 210 note 2). Its existence is documented by a papyrus (SB XIV 12108 = ZPE 24, 1977, 133–7), and its importance is demonstrated by its consolidation in the third or fourth century BC.

We know that this channel started in the Nile and emptied into the Bahr Youssef, and was, therefore, a shortcut for the movement of people and goods from the central area of the Valley. If the canal had not existed, those travelling from the area between the nomes of Oxyrhynchus and Cynopolis would have had to travel up the river to the natural branch that provided access to the Fayum. However, while one of its functions was transit, it was also one of the channels responsible for structuring agricultural land, as suggested by the administrative division of the nome of Oxyrhynchus. The Middle Nile Valley is particularly wide, and although the two large natural streams irrigates it, the silt accumulated on the banks would have prevented a large overflowing of water during times of flooding. The Apollophanes Canal would have irrigated the central area of the nome in two distinct halves - one bordering the Bahr Youssef and the other along the Nile. Indeed, the administrative division of the nome included a western toparchy and an eastern toparchy (Rowlandson, 1996; Map 3).

Neither the Apollophanes canal nor any other canal with the same characteristics appears on the early nineteenth century maps, while a trace perpendicular to the Nile that can be interpreted as large dykes does appear. The canal may have disappeared as such during the major remodelling of the hydraulic system that took place during the nineteenth century, which led to segments being reused for drainage. Analysis of CORONA images show a number of reasonably well aligned channels, which could be interpreted as evidence of an ancient canal. The segments are often inconsistent in terms of the source and destination of the water, and as such, there is no logic that can be used to relate them to modern canals. Silted up and subsequently subdivided channels are visible, retaining their original length and the lengthways dykes and accompanying paths on each side.

It is worth recalling the references mentioned above in the *Description de l'Égypte* to the *Fyad Bathen* and the morphological structure of the Middle Valley, in which the opposing slopes of the Nile and the Bahr Youssef meet in the centre, creating a space where the waters of both converge during the flood season. The detection of a silted-up channel trace, which is unrelated to channels associated with the transformations of the nineteenth century, was compared with a section of the Middle Valley. This section (Fig. 8) shows how this channel would have been located in the lowest part of the valley, at the confluence of the gradients of the Nile and Bahr Youssef, to quote the *Description de l'Egypte*. We contend that the Apollophanes Canal could have been similar. As for its course, there are various geographical possibilities: other low areas closer to the Nile are visible in the same section, and are also consistent with traces of channels detected using cartography and satellite images.

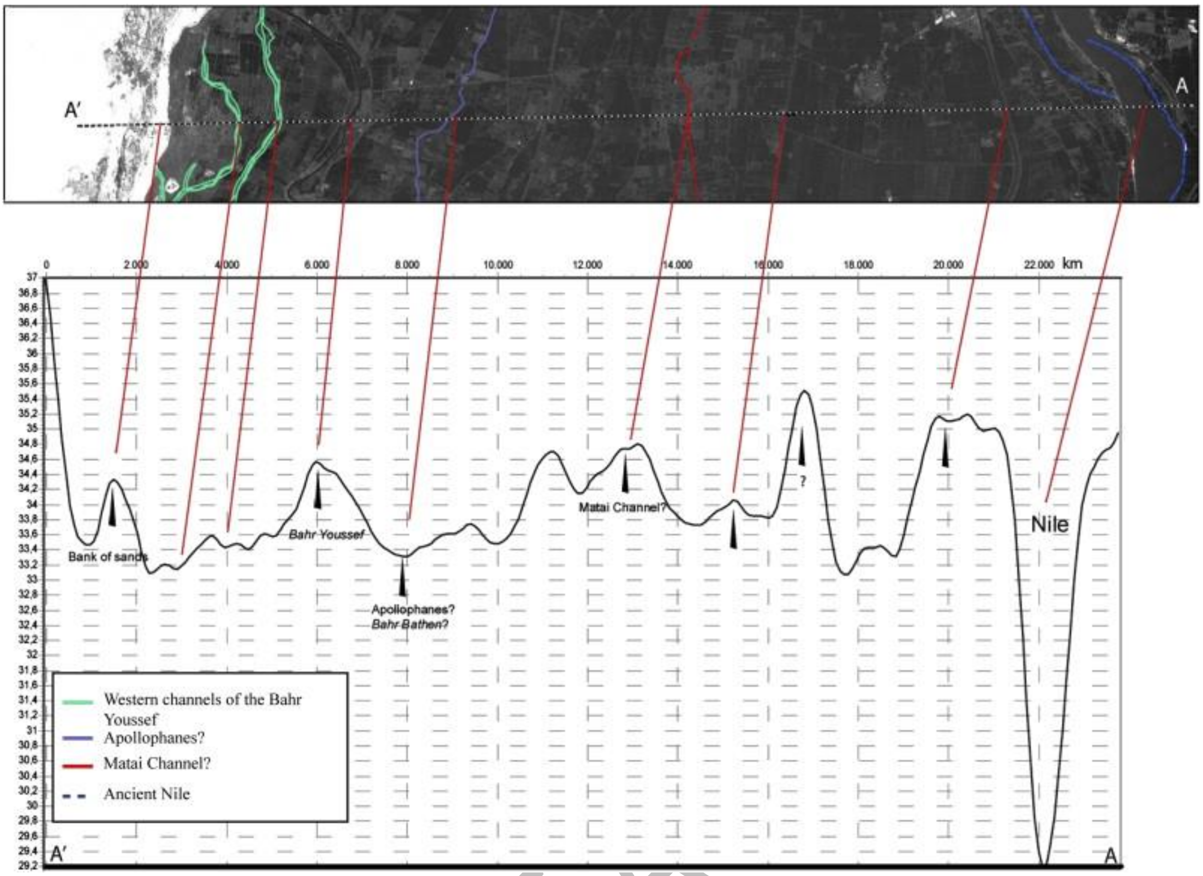

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Fig. 8. Middle Nile Valley section. Source: STRM-90 v 4.1 DEM. This DEM was smoothed highlighting shapes and removing minor irregularities using the ARCGIS Focal Statistics function. Source: CORONA satellite scene DS1105-2235DA038, Acquisition Date 18-Nov-1968. ED50 36N Projection.

During dry periods, the water was retained in these areas, in a continuous stretch, spanning the valley from the Nile to the Bahr Youssef. This continuity is emphasized by the modern sources in the *Description de l'Égypte*, which are undoubtedly the periods of optimal levels of the Nile's flooding in the early nineteenth century. For the same reason, based on data for the levels of Lake Qarun in El Fayum (Hassan, 1998, p. 36), we must assume that this continuity was maintained to the hypothetical Apollophanes canal (Fig. 9). However, a thorough study of the types of traces and their possible flow is necessary, in view of the Ptolemaic and Roman large-scale infrastructure programmes (Garbrecht, 1996).

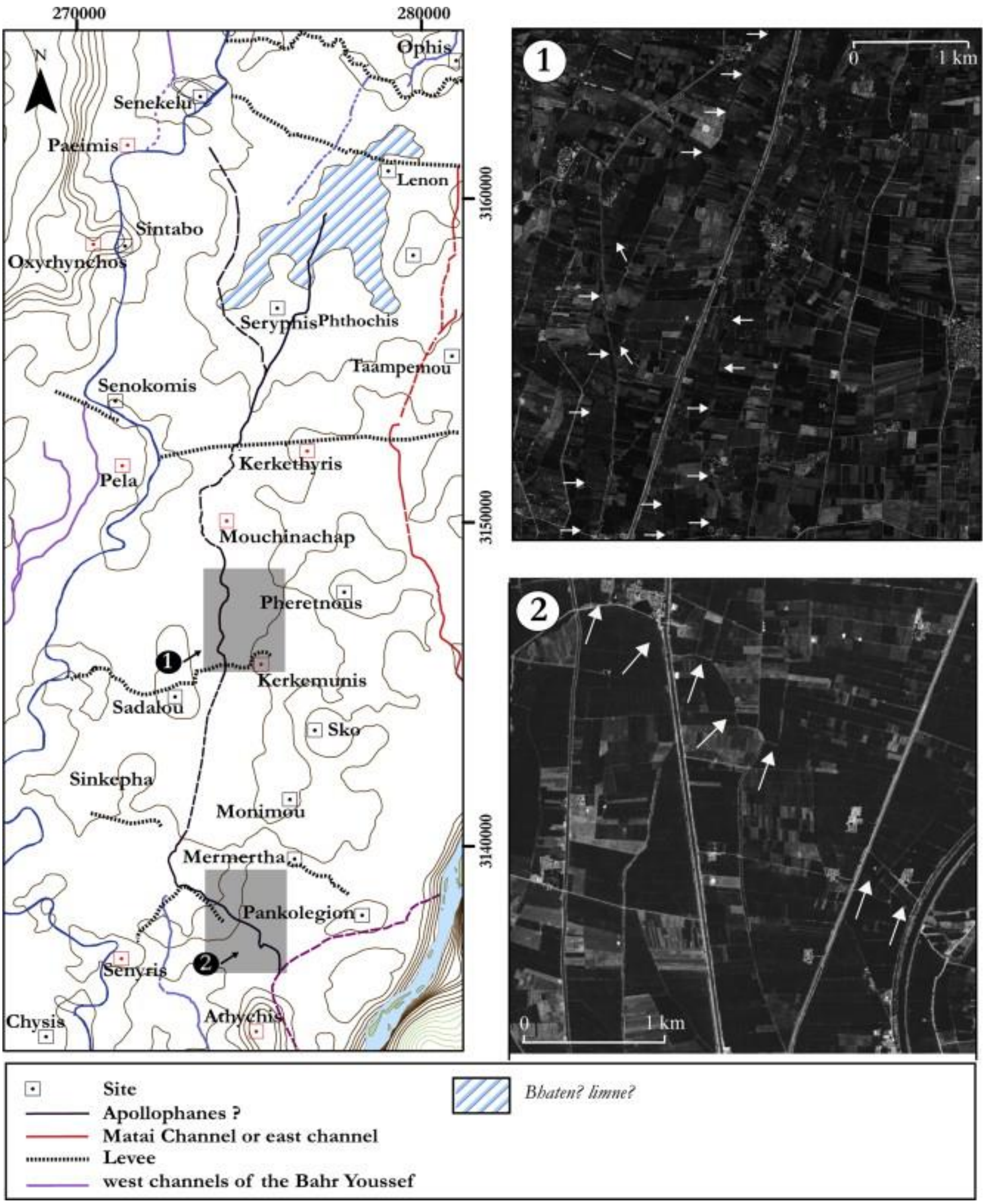

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Fig. 9. Traces of the supposed Apollophanes channel. 1. Source: CORONA satellite scene DS1205-2235DF032, Acquisition Date 18-Nov-1968 2. Source: CORONA satellite scene DS1111-2167DA044, Acquisition Date 02-Aug-1970. ED50 36N Projection.

The course of the Apollophanes canal can be reconstructed using the names of the ancient settlements that contributed to its maintenance, which suggests that it was at least 250 *schoinos* long. Some of these place names have been matched to modern settlements by various authors, though others have yet to be located. In this topographical study, we combined observations of the traces of palaeochannels with those of settlements on the landscape. Indeed, many modern towns contain traces of ancient settlements, which are characterized by the shape of a circular *tell* and make up the historic town centre of the modern settlement (Subías et al., 2011). This is a settlement in the floodplain, suitable for protecting the habitat of the flood and economising on arable land.

Youtie (1977) suggests that the settlements are listed, not in any linear order, but in terms of whether they belong to the higher or western toparchy. Thanks to work on the settlements of Oxyrhynchus mentioned above, some of the names mentioned in the papyrus have been matched to modern towns. Locating the settlements that are known on the GIS enabled us to assess the documents, and how consistent they are with the reconstructed channel traces. The direct result is very incomplete because few place names have been precisely located in this area, and there are also many traces of old settlements yet to be named. The main criterion was the enumeration in the papyrus, and we have suggested a hypothesis that would match the data according to a system listing the settlements alternating between the two banks of the channel and progressing in the direction of the current, from south to north (Fig. 10). As a result, given the assignment to one toparchy or the other, it follows that the Apollophanes canal could have acted as a boundary between the two toparchies.

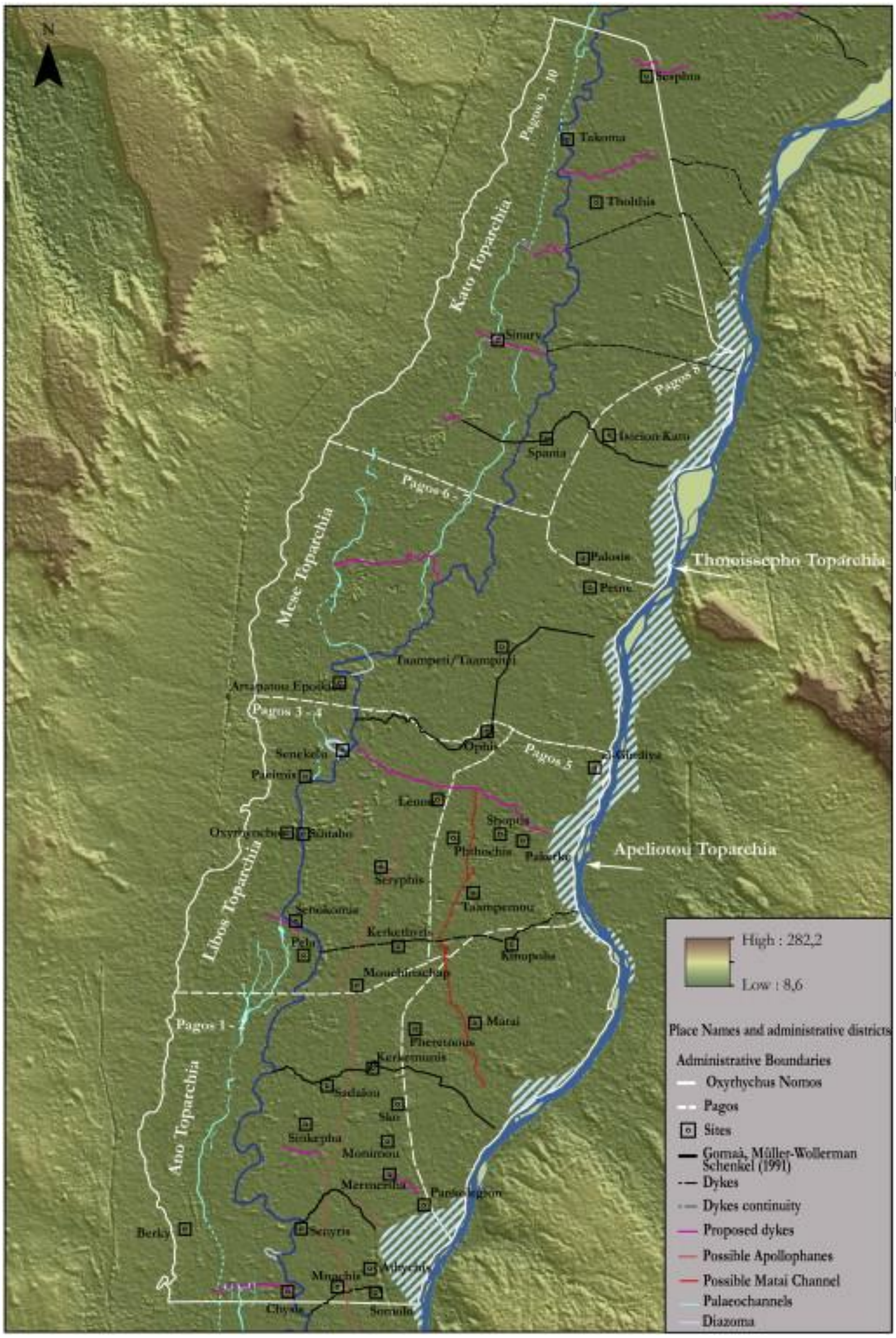

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Fig. 10. Archaeological sites plan, traces of channels and dykes, and proposed administrative boundaries. Source: STRM-90. v 4.1. DEM. ED50 36N Projection.

5.2.3. Other channels and lagoons in the eastern toparchy

The early nineteenth century maps, with numerous traces of channels and the major features of the drainage system, reveal something that is very clear: the difference between the western and eastern part of the nome. The western part contains a drainage channel system, with a pronounced NE-SW orientation, that converges towards a central area that is slightly depressed compared to its immediate surroundings. This confluence is located around the modern town of Utu el-Waqf. Almost none of these streams of water are related to the large artificial canals, it is therefore conceivable that they are part of another irrigation/drainage mechanism. As a result, there was presumably a particularly wet area in ancient times between *Lenon-Seryphis-Ptochis* (Abtuga). We know that the Greek lexicon for water in Egypt is rich and varied, and contains the concept of a temporary lake, *Limne*, which appears around twenty times in the Bonneau papyri (1993, pp. 53–54). Interestingly, this area is at the lowest altitude according to the contours on modern maps (Fig. 11). It is interesting to think that this configuration of the landscape could have continued to prevail until the eighteenth century, creating the lagoon-channel (*Lacus Moeridis*) on the maps. Note the nineteenth century difference between the Arabic terms of *Bathen* and *Fyad Bathen*, according to which the former would be equivalent to the concept of *limné*.

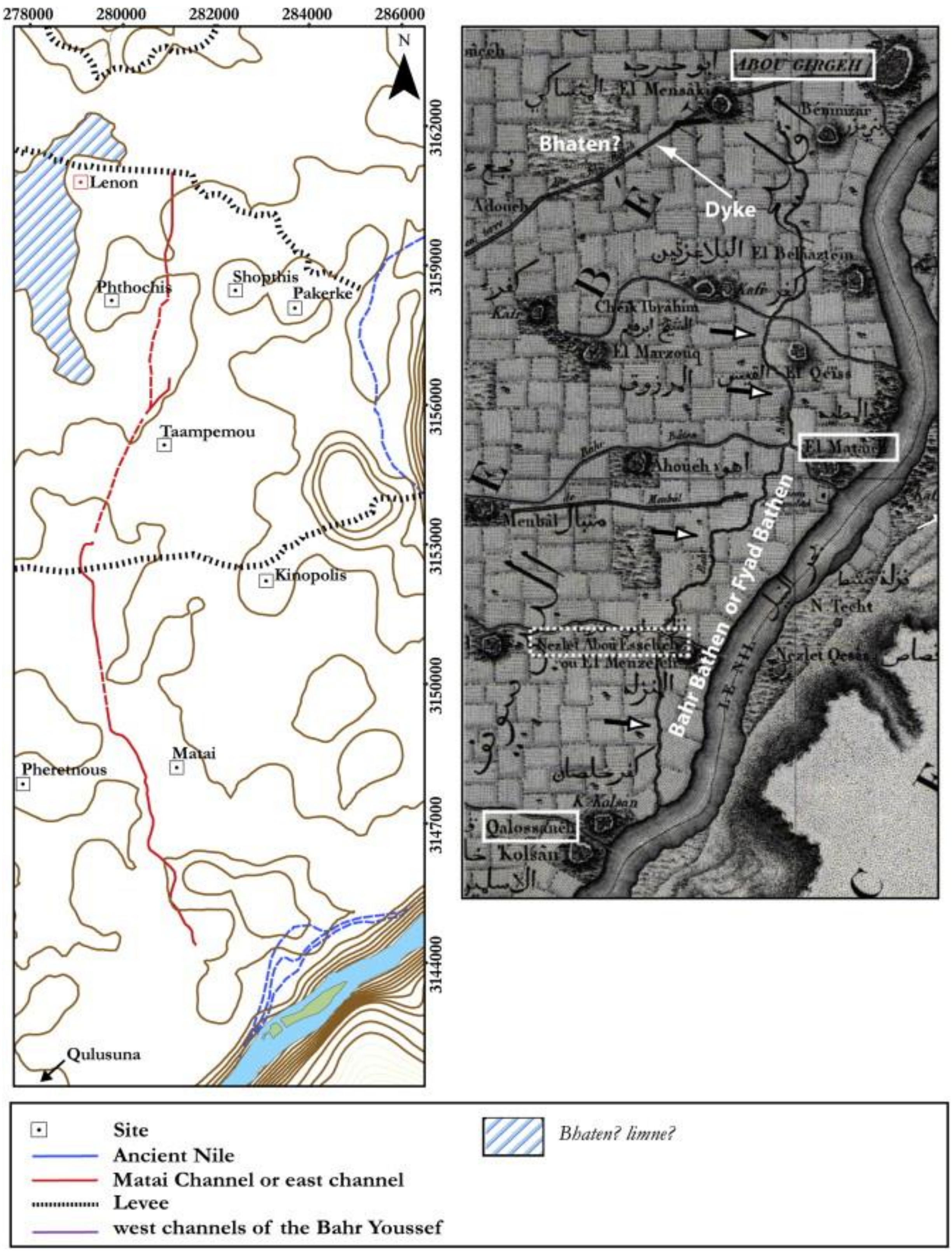

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Fig. 11. The channel 'between rivers'. Location map of the traces of the channel in the 'between rivers' area. Detail of the same sector in the plan in the *Description de l'Égypte*, showing one of the *Fyad Bathen* described by Martin (1813). ED50 36N Projection.

However, the eastern part presents few traces of drainage. It is now dominated by the presence of large modern channels and the railway network. In antiquity, the banks of the Nile were lands that were worst inundated than others that were farther away, due to the accumulation of sludge from flooding, which would have been an obstacle preventing the flood water from flowing freely. Moreover, this strip near the Nile shows signs of changes in its course, especially in the areas where the river meanders, with the formation of islands. The Bahr Youssef is similar, as meanders create diversions that are used to begin new courses or channels, and which we identified as silted traces. At one of these points, near Nazlat Abu Shihatah and Matai, there are traces of fragmentary palaeochannels, whose alignment suggests that they may have been longer in the past. However, the mouth of the channel is not visible in any of the traces. This is undoubtedly because the meander in the Nile at this point has shifted considerably since then (Fig. 12).

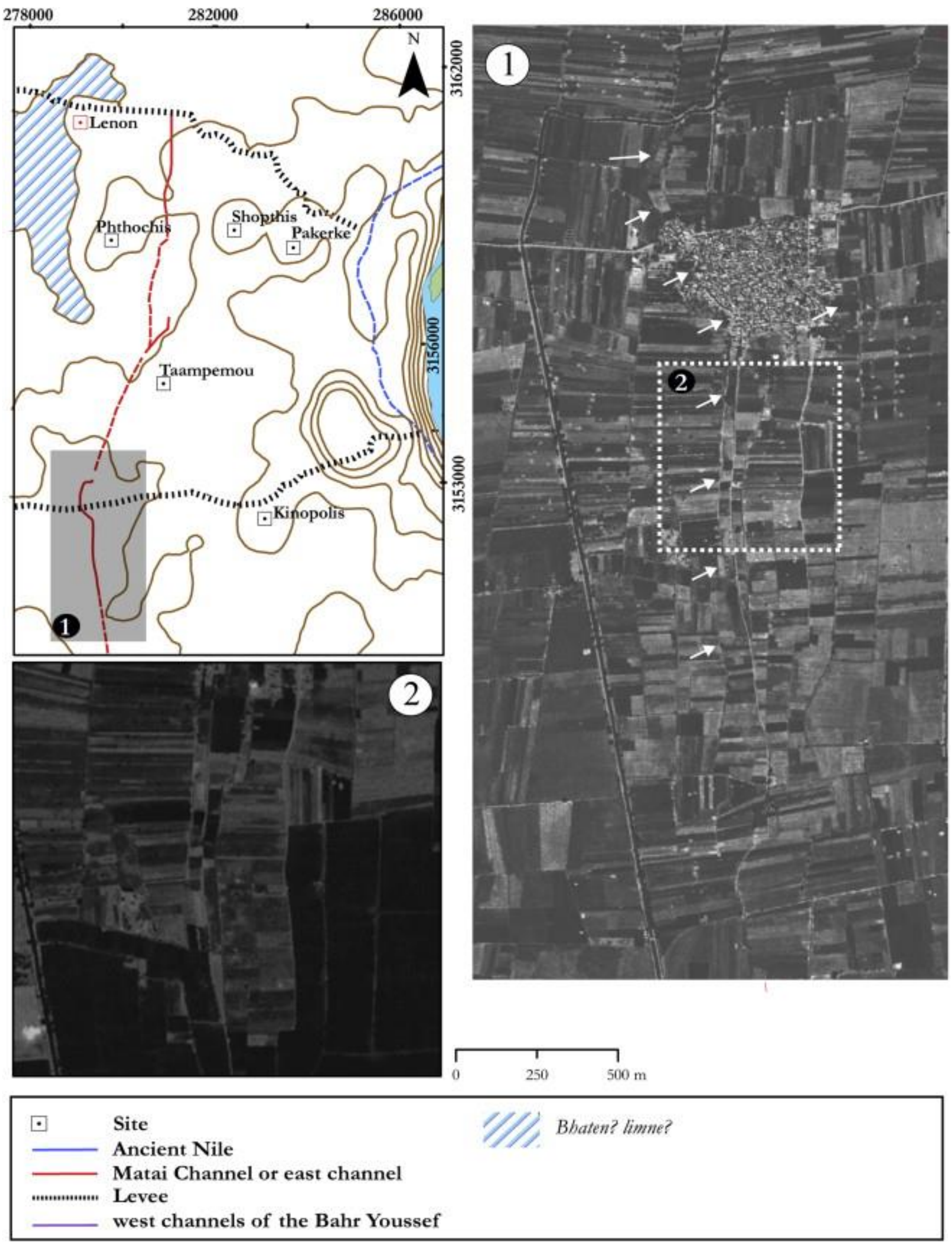

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Fig. 12. The channel 'between rivers'. Details of the CORONA scenes studied and the traces of the channel located 'between rivers.' Source: CORONA satellite scene DS1105-1090DA035, Acquisition Date 09-Nov-1968. ED50 36N Projection.

We believe that there was a channel to the east of the Apollophanes channel, which can be followed with some degree of clarity as far as a transverse dyke. The traces of channels continue northward, at least as far as the Tambidi area. We also know that there was a “bridge” or dyke that performed this task in the town (Benaissa, 2009a,b, p. 313). What its name was is hard to say. We have only shown the existence of a channel called *Temothis* that connected settlements such as *Ophis* and *Pankerke* located in this toparchy. Moreover, it is tempting to think that this channel could have been a demarcation line with the area belonging to the nome of Cynopolis, with cities including *Kynopolis* (Al-Qais) in the south and *Terythis* (Dahrut) in the northeast (Benaissa, 2009a,b, p. 334).

In short, the area “between rivers” shared by the western and eastern toparchy, which was the widest in the nome, would have been crossed by two intermediate channels (Apollophanes and another whose name we do not know, rising near Matai). This would have led to three administrative units in the intermediate area of the toparchy, aligned parallel to the direction of the current, in contrast to the typical layout in other regions, where the valley is narrower, and water rights issues are easier to resolve.

6. Conclusions

Despite occasional changes over the centuries, the pre-modern landscape of the Middle Valley initially remained faithful to the principle of small and medium-sized flood basins, that were accompanied by input and drainage channels connected to both the Nile and the Bahr Youssef. These basins not only occupied the space between the rivers, but also structured the western banks of the valley towards the desert.

We believe that the ancient channels, levees and basins structured the valley of the high, eastern and western toparchies, and also structured the landscape on the western edge of the entire nome. To do so, they were accompanied by dykes that were used for both containment and circulation, in an area that would have been completely flooded in the flooding season. The combination of the two infrastructures would have been not only a water management system, but also a means of structuring the settlement and the administrative-territorial distribution within the nome.

The result of this complex hydraulic landscape is a palimpsest of fossilized forms from canals and dykes, of which some traces are still perceptible, though only by means of satellite images. However, in order to identify them, and in particular to integrate them within a coherent discourse on the historical management of the resource, a reading of the trace is not sufficient. It must form part of a historical approach based on the written sources for each period and the related cartography. This contribution is, therefore, only an approximation, which must be combined with contributions from geomorphological analysis and geophysical prospecting.

References

- Barois, 1887
  J. Barois**Irrigation in Egypt**
  (1887)

Washington

- Barois, 1904
  J. Barois**Les irrigations en Égypte**
  (1904)
  Paris
- Benaissa, 2009a
  A. Benaissa**Rural Settlements of the Oxyrhynchite Nome**
  Timegistos Online Publication, Köln/Leuven (2009)
  A papyrological Survey, version 1.0
- Benaissa, 2009b
  A. Benaissa**Critical notes on the toponymy of the Oxyrhynchite nome**
  Zeitschrift für Papyrologie und Epigraphik, 170 (2009), pp. 186-190
- Bonneau, 1987
  D. Bonneau**Les hommes et le Nil dans l'Antiquité**
  A. De Réparaz (Ed.), L'eau et les hommes en Méditerranée (1987), pp. 187-198
  Paris
- Bonneau, 1993
  D. Bonneau**Le régime administratif de l'eau du Nil dans l'Égypte grecque, romaine et byzantine**
  (1993)
  Leiden-New York-Köln
- Bunbury et al., 2008
  J. Bunbury, A. Graham, M.A. Hunter**Stratigraphic landscape analysis: charting the Holocene movements of the Nile at Karnak through ancient Egyptian time**
  Geoarchaeology (2008), pp. 351-373
- Bunbury, 2007
  J.M. Bunbury, J.K. Hillier, A. Graham**Monuments on a migrating Nile**
  Journal of Archaeological Science, 34 (2007), pp. 1011-1015
- Bunbury and Lutley, 2008
  J. Bunbury, K. Lutley**The Nile on the move**
  Egyptian Archaeology, 3 (2008), pp. 3-5
- Butzer, 1959
  K.W. Butzer**Some recent geological deposits in the Egyptian Nile Valley**
  The Geographical Journal, 125 (1) (1959), pp. 75-79
  (Mar.)
- Butzer, 1960
  K.W. Butzer**Remarks on the Geography of Settlement in the Nile Valley During Hellenistic Times**
  Bulletin de la Société de Géographie d'Égypte, vol. 33 (1960), pp. 5-36
- Butzer, 1976
  K.W. Butzer**Early Hydraulic Civilization in Egypt**
  (1976)
  Chicago
- Calderini and Daris, 1935-2007
  A. Calderini, S. Daris**Dizionario dei nomi geografici e topografici dell'Egitto grecoromano + supplementi**
  (1935, 2007)
  Pisa-Roma
- Chouquer., 2000
  G. Chouquer**L'étude des Paysages. Essais sur leur formes et leur histoire**
  (2000)
  Paris
- D'Anville, 1727

J.B. D'Anville**Carte d'Égypte par J.-B. Bourgignon d'Anville (1697–1782), BNF GE – D – 9216, Colection D'Anville (CLXII)**
Bibliothèque Nationale de France (1727)

- Ercolani, 2001
E. Ercolani**Misurare e valutare: aministrazione, economia, e politica al mondo romano**
C. Corti, N. Giordai (Eds.), Pondera: Pesi e Misure nell'Antichità (2001), pp. 113-141
Modena
- Fehérvári et al., 2006
G. Fehérvári, *et al.***The Kuwait Excavations at Bahnasa/Oxyrhynchus (1985–1987) Final Report**
(2006)
Kuwait
- Fiz, 2011
I. Fiz**Fuentes, cartografía y teledetección y SIG: claves para reconstruir el paisaje del nomo oxirrinquita**
E. Subías, P. Azara, J. Carruesco, I. Fiz, R. Cuesta (Eds.), The Space of the City in Graeco–Roman Egypt. Image and Reality (2011), pp. 145-186
Tarragona
- Garbrecht, 1996
G. Garbrecht**Historical water storage for irrigation in the Fayyum depression (Egypt)**
Irrigation and Drainage Systems, 10 (1996), pp. 47-76
- Garbuzov, 2003
G.P. Garbuzov**The use of space remote sensing for archaeological mapping of the Tarman Peninsula, Russia**
Archaeologia Polona, 14 (2003), pp. 176-177
- Girard, 1813
M.P.S. Girard**Observations sur la vallée d'Égypte et sur l'exhaussement séculaire du sol qui la recouvre**
Description de l'Égypte ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française, Histoire Naturelle, vol. 9 (1813), pp. 343-404
Paris
- Girard, 1823
M.P.S. Girard**Mémoire sur l'Agriculture, l'industrie et le commerce de l'Égypte**
Description de l'Égypte ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française, L'État Moderne, vol. 6 (1823), pp. 491-700
Paris
- Gomaà et al., 1991
F. Gomaà, R. Müller-Wollermann, W. Schenkel**Mittelägypten zwischen Samalut und dem Gabal Abu Sir. Beiträge zur historichen Topographie des pharaonischen Zeit**
(1991)
Wiesbaden
- Goossens et al., 2006
R. Goossens, A. De Wulf, J. Bourgeois, W.T. Gheyle**Satellite imagery and archaeology: the example of CORONA in the Altai Mountain**
Journal of Archaeological Science, 33 (2006), pp. 745-755
ArticlePDF (1MB)
- Goyon, 2008

J.-Cl. Goyon**Une énigme de géographie religieuse de l'ancienne Égypte. Le nome "maudit" d'Oxyrhynchos (XIXe de Haute-Égypte**
M. Erroux-Morfin, J. Padró (Eds.), Oxyrhynchos. Un site de fouilles en devenir, colloque de Cabestany avril 2007 (2008), pp. 89-116
Barcelona

- Hassan, 1998
  F.A. Hassan**Climatic Change, Nile floods and civilization**
  Nature and Resources, 342 (1998), pp. 34-40
- Hillier et al., 2007
  J.K. Hillier, J.M. Bunbury, A. Graham**Monuments on a migrating Nile**
  Journal of Archaeological Science, 34 (2007), pp. 1011-1015
  ArticlePDF (880KB)
- Hurst, 1954
  H.E. Hurst**Le Nil. Description générale du fleuve. Utilisation de ses eaux**
  (1954)
  Paris
- Jomard, 1809
  E. Jomard**Mémoires sur le Lac Moeris comparé au Lac de Fayoum**
  Description de l'Égypte ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française, Antiquités Mémoires I, vol. 2 (1809), pp. 84-114
  Paris
- Linant de Bellefonds, 1872–1873
  M. Linant de Bellefonds**Mémoire des principaux travaux d'utilité publique exécutés en Égypte depuis la plus haute antiquité jusqu'à nos jours**
  (1872, 1873)
  Paris
- Loiseau, 1999
  J. Loiseau**Les avatars du lit: divagations du lit et morphologie des rives à hauteur du Caire (VIIe–XVIe siècles)**
  Médiévales, 18 (36) (1999), pp. 7-16
- Martin, 1813
  P. Martin**Description hydrographique des provinces de Beny-Souef et du Fayoum**
  Description de l'Égypte t.XVI, État Moderne, tome 2 (1813)
  Paris
- Parcak, 2008
  S. Parcak**Satellite Remote Sensing for Archaeology**
  (2008)
  New York
- Pruneti, 1981
  P. Pruneti**I centri abitati dell'Ossirinchite: Repertorio toponomastico**
  (1981)
  Florencia
- Pruneti, 1989
  P. Pruneti**Toparchie e pagi: precisazioni topografiche relative al nomo Ossirinchite. Repertorio toponomastico**
  Aegyptus, 62 (1989), pp. 113-118
- Pruneti, 2001
  P. Pruneti**Ancora su toparchie e pagoi dell'Ossirinchite. Addenda**
  Aegyptus, 81 (1–2) (2001), pp. 291-297
- Rippon, 2008
  S. Rippon**Historic Landscape Analysis**
  (2008)

York

- Robert de Vaugondy, 1753
  G. Robert de Vaugondy**Carte de l'Égypte ancienne et moderne dressée sur celle du père Sicard par Robert de Vaugondy, G. (1688–1766)**
  Bibliothèque Nationale de France (1753)
  Poste d'accès aux ressources électroniques IFN- 7759158
- Rowlandson, 1996
  J. Rowlandson**Landowners and Tenants in Roman Egypt**
  (1996)
  Oxford
- Rowlandson, 2007
  J. Rowlandson**Oxyrhynchus and its hinterland**
  A.K. Bowman, R.A. Coles, N. Gonis, D. Obbink, P.J. Parsons (Eds.), Oxyrhynchus. A City and Its Texts (2007), pp. 205-217
  London
- Sicard, 1722
  C. Sicard**Carte de l'Égypte ancienne, divisée en ses 58 nomes ou gouvernements de Sicard, C. (1677–1726)**
  Bibliothèque Nationale de France (1722)
  Poste d'accès aux ressources électroniques IFN- 7759288
- Schenkel, 1994
  W. Schenkel**Les systèmes d'irrigation dans l'Égypte ancienne et leur genèse**
  Archéo-Nil (1994), pp. 27-35
  Mai-Juin
- Stafford et al., 1992
  J.D. Stafford, D. Leigh, D. Asch**Prehistoric settlement and landscape change on alluvial fans in the upper Missisipi River valley**
  Geoarchaeology, 7 (4) (1992), pp. 287-314
- Subías, 2011
  E. Subías**Oxyrhynchos: metropolis and landscape**
  E. Subías, P. Azara, J. Carruesco, I. Fiz, R. Cuesta (Eds.), The Space of the City in Graeco–Roman Egypt. Image and Reality (2011), pp. 145-186
  Tarragona
- Subías et al., 2011
  E. Subías, I. Fiz, R. Cuesta**Elementos del paisaje del nomo oxirrinquita**
  E. Subías, P. Azara, J. Carruesco, I. Fiz, R. Cuesta (Eds.), The Space of the City in Graeco–Roman Egypt. Image and Reality (2011), pp. 187-210
  Tarragona
- Tachikawa et al., 2011
  T. Tachikawa, M. Kaku, A. Iwasaki, D. Gesch, M. Oimoen, Z. Zhang, J. Danielson, T. Krieger, B. Curtis, J. Haase, M. Abrams, R. Crippen, C. Carabajal**ASTER Global Digital Elevation Model Version 2–Summary of Validation Results**
  (2011)
  http://www.jspacesystems.or.jp/ersdac/GDEM/ver2Validation/Summary_GDEM2_validation_report_final.pdf
- Youtie, 1977
  H.C. Youtie**APLh, DIPLh, TRIPLh, TETRAPLh ERGACIA: P. Mich. Inv. 412Recto**
  Zeitschrift für Papyrologie und Epigraphik, 24 (1977), pp. 133-137