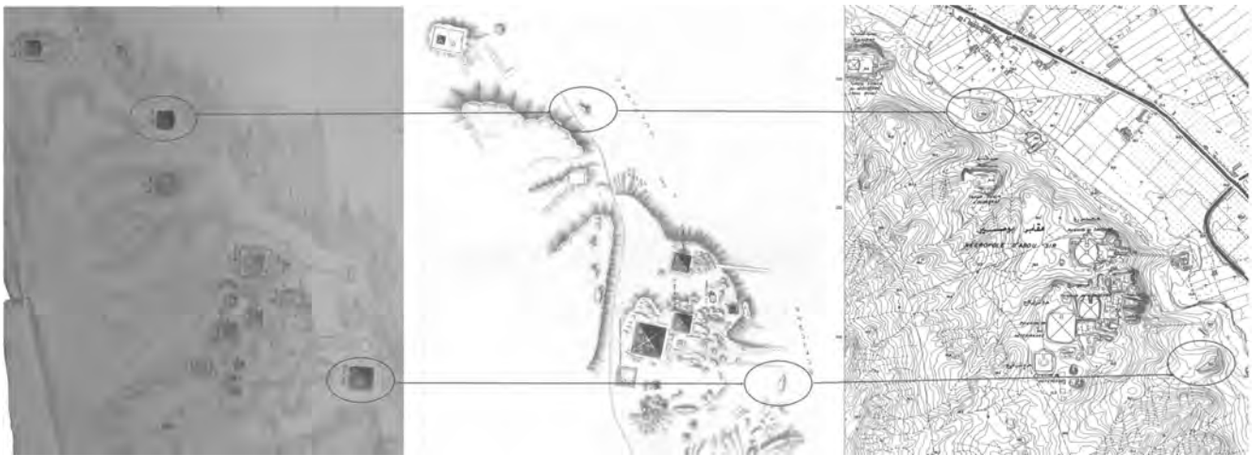

Fig. 1 Historical cartography of the Abusir plateau in comparison (from left to right): Lepsius' map (1849: pl. 32), De Morgan's map (1897: pl. 11) and the Franco-Egyptian map (EMHR 1978, sheet 21). The circles enclose the two missing Pyramids Lepsius XVI and Lepsius XXVIII

Glossing the past: the Fifth Dynasty sun temples, Abu Ghurab and the satellite imagery

Massimiliano Nuzzolo – Patrizia Zanfagna

On the northernmost foothill of the Abusir plateau, which is usually known as Abu Ghurab, a few hundred meters from the royal necropolis, the Fifth Dynasty pharaohs built some of the most intriguing monuments of ancient Egyptian architecture, the so-called sun temples. So far, however, only two of the six temples known from the textual sources of the time have been identified and systematically excavated, *i.e.* that of Userkaf and Nyuserre. Four sanctuaries still remain to be discovered. The present paper has thus the aim to shed some light on their possible locations by means of the combined analysis of archaeological evidence, historical cartography and new remote sensing imagery.

Over the past two decades, remote sensing techniques have been increasingly used in Egyptology for the study and reconstruction of the archeological landscape of ancient Egypt and the analysis of its topographical and spatial peculiarities. Important contributions have been provided by several scholars, especially as regards the improvement of the cartography of some key areas of ancient Egypt, thanks to the combination of satellite data with modern on-ground tools, such as geophysical surveying and 3D modeling programs. This has led to a better understanding of important aspects of the landscape organization and exploitation in ancient Egypt, as well as to the detailed mapping of specific areas, *e.g.* Thebes, with significant implications and results not only for the scientific community, but also for the touristic and site management activities.[1]

In some cases the use of remote sensing tools has also led to the identification of unknown structures, or even entire sites, hidden under the sand and no longer visible to date. The archaeological exploration carried out in the late 1990s and early 2000s in South Sinai by Sarah Parcak and Gregory Mumford, for example, significantly contributed to the discovery of several previously unknown sites as well as the identification of a complex system of communication, dating back to the Old Kingdom, between the Red Sea coast and the copper mines of the Wadi Maghara (Mumford – Parcak 2003: 83–116; Parcak 2004a: 136–141; Mumford 2006: 13–67).[2]

On a smaller, intra-site scale, it is also worth mentioning the studies of the main sites of the Memphite necropolis. These investigations largely contributed to the knowledge of the area as regards both specific monuments, and the topography and environmental evolution of key sites of the necropolis itself, such as Giza,[3] Saqqara[4] and Abusir.[5]

The area of Abusir – and particularly the area of Abu Ghurab, which is the northernmost foothill of the Abusir plateau – has a primary position in the perspective of the present paper. In fact, starting from January 2017, a three-year based research project ("Rise and Development of the Solar Cult and Architecture in Third Millennium BC Egypt") has been launched at Charles University in Prague under the auspices of the Grant Agency of Czech Republic (GA ČR, No. 17-10799S). The project – which is directed by the main writer and includes a varied team of specialists from both the above-mentioned university and L'Orientale

University of Naples, Italy, with which Charles University signed an agreement for archaeological cooperation in 2015 – has the scope, among others, to reassess the overall topography of the site of Abu Ghurab and, at the same time, to contribute to the identification of the missing sun temples.

In fact, out of the six sun temples known from epigraphic and historical sources, only two of them have been archaeologically excavated so far, *i.e.* the sun temples of Nyuserre and Userkaf (Borchardt 1907; Ricke 1965 and 1969). Since January 2010, the former has also been the object of an overall field re-examination by an Italian archaeological mission – from L'Orientale University of Naples – of which the present writer is co-director (see Nuzzolo – Pirelli 2011; D'Andrea – Pirelli – Iannone – Nuzzolo – Zanfagna 2014: 48–98). However, the location of four sun temples is still completely unknown, and although it is a widespread opinion that these temples must have been located nearby the other two (*cf.* Verner 2014: 209),[6] their precise identification has never been addressed in detail in past scholarship, up to the point that some scholars have even casted doubts on their existence (Stadelmann 2000: 529–542).

The location in Abu Ghurab of at least some of these temples is instead supported by the main historical source of the time, *i.e.* the Abusir papyri, which tells us that the sun temple of Neferirkare (actually one of the missing temples) was reached twice a day by boat from the pyramid of the same king, with the aim to perform religious and administrative duties (Posener-Kriéger 1976: 519–520; Nuzzolo 2007: 233). Visually, Abu Ghurab appears nowadays as a restricted area for the solar temples (and the solar aspects of the king's cult), contiguous to the main royal necropolis for the king's funerary cult, and this would logically indicate that the other sun temples, too, should be located nearby the ones already known (Nuzzolo 2015: 303–304).

The search for the missing sun temples is also extremely promising when we consider that in the sites of Abusir and Abu Ghurab, we have the chance, not very common for other Egyptian sites, to base our analysis on the cross-examination of an extensive historical cartography of the area with either the Photogrammetrical Map scaled 1:5000 (which was realized in 1978 by the Egyptian Government and the French Aviation IGMF), or the remote sensed imagery derived from both optical and radar sensors. Moreover, the Abu Ghurab/Abusir area offers scholars an incredibly unique case of investigation of ancient sacred landscapes because of its chronologically limited use in a time span of around 100 years, roughly corresponding to the Fifth Dynasty. In fact, the main architectural features of the site were shaped and arranged in the natural setting in the time span between Userkaf and Djedkare, and no longer significantly affected for the coming millennia.

In a paper published in 2013, the present author already emphasized the importance of the combined application of remote sensed data and historical cartography for the improvement of our knowledge of the area of Abusir/Abu Ghurab, as well as for the possible identification of its missing structures, in particular the sun temples (Nuzzolo 2013: 163–176). Nowadays, however, the most recent developments of satellite technology, and particularly the generation of the COSMO Sky-Med satellites – and the SAR (Synthetic Aperture Radar) images generated therein – compared and combined with the traditional panchromatic images, such as the ones available through the Google Earth system, allow us to investigate the abovementioned area with an increased level of accuracy which has not been possible so far.

It is not the matter of the present paper to discuss the importance and the benefit of the new radar technology and imagery for Egyptology, given that several studies have definitely proven that they are extremely useful tools of investigation (Parcak 2004b: 63–78; Parcak 2010: 362–382).[7] Nor will I discuss the differences among the available panchromatic and radar images and all the properties of the latter for archaeological research in desert areas (in this regard, see the wide résumé available in Parcak 2009: 41–80).

What has to be stressed instead – especially in the perspective of future investigations in the field, which is also one of the aims of the abovementioned project – is the importance of applying this technology to the Abusir/Abu Ghurab case study. This approach can offer not only a better vision and understanding of the sun temple area in Abu Ghurab, but also complement our knowledge of the overall topography of the Fifth Dynasty royal necropolis of Abusir, which was actually considered, together with Abu Ghurab, as a single conceptual and geo-cultural unit in the Old Kingdom.

Before analyzing the new satellite imagery, we will begin by summarizing the archaeological and topographical investigation of the site in the last centuries, in order to get a wider view of the development of the exploration and knowledge of the sun temple area.

Historical cartography and explorations of Abu Ghurab

As with most Egyptian sites, the modern exploration of the area of the sun temples in Abu Ghurab can be dated back to Napoleon's expedition. In the famous *Description de l'Égypte* the French *savants* recorded the presence of "pyramides en ruines" – certainly corresponding to the actual pyramids of Abusir – and of a very small structure which is called an "éminence que l'on croit avoir été une Pyramide", most likely Nyuserre's sun temple (Description 1809: pl. 1).

The second brief description of the site was elaborated by the explorers Howard Vyse and John Shae Perring in the years 1837–1938. Although they focused their attention on the cartographical and topographical report of the pyramid field,[8] the two scholars also recorded, with the number 12, the presence of a small building – supposed to be a pyramid – on the northernmost hill of Abusir, known as the "Reeghah village" (Vyse 1842: 10–12, and fig. 2). The explorers also drew the remains, simply called "ruins", of a structure supposed to be the valley temple, which was connected by a causeway to the upper temple. The position of these "ruins" on their map of the temple area is noteworthy since they lay on the same east-west axis of the upper temple, a feature which does not

correspond to the real position of the valley temple of Nyuserre's sun temple (see also Borchardt 1907: pl. 2). The sun temple of Userkaf, laying about 500 m to the south of Nyuserre's one and unearthed by Herbert Ricke in the 1950s, is not mentioned at all in the description of the archaeological area by Perring and Vyse.

It was only in the 1840s that an accurate and detailed topographical map of the entire area of Abu Ghurab and Abusir was produced (fig. 1). This was the result of the famous expedition by Karl Richard Lepsius, who investigated the site on the way from Giza to Saqqara and Southern Egypt. Although the area of Abusir was not the main target of the investigation of the Memphite necropolis, the German scholar's team was nonetheless very accurate in drawing the monuments of the Abusir plateau,[9] where we can clearly see, besides the royal pyramids, the remains of Nyuserre's sun temple, named Pyramid XV, as well as, for the first time, what would later on be revealed to be the sun temple of Userkaf, recorded in his map as Pyramid XVII (Lepsius 1849: 129–131, and Bl. 32).

Lepsius' drawing of Nyuserre's temple is particularly remarkable when we consider that it is not limited to the overall plan of the monument but also includes several important details, such as the obelisk, described as a pyramid resting on a sort of square pedestal, an inner, open-air courtyard surrounded by an enclosure wall, and two rounded artifacts/blocks (?) in the south-eastern and north--eastern corners of the central courtyard.[10] The causeway and the valley temple, with its two large columns in the façade, are also accurately outlined, as well as a large rectangular-like structure enclosing the valley temple itself, which was later identified by Borchardt as the enclosure wall of the pyramid town (Borchardt 1907: 7–8, and pl. 2).

After Lepsius, a few other scholars significantly contributed to our knowledge of the site although they did not focus on topographical issues: among them, special mention is due to two German scholars, Eduard Meyer and Kurt Sethe, whose scholarship was decisive for the identification of Lepsius Pyramid XV as the sun temple of Nyuserre (see Nuzzolo 2013: 163–164, with further bibliography).

At the close of the nineteenth century, Abu Ghurab first, and soon after Abusir, were again explored by two important Egyptologists, Jacques de Morgan and Ludwig Borchardt. In 1897, De Morgan carried out the most accurate and comprehensive mapping of the Memphite necropolis hitherto achieved (see fig. 1). The map, which can still be considered one of the best cartographical achievements in Egyptology, included Abu Ghurab, Abusir, Saqqara and Dahshur, while excluding Giza (De Morgan 1897: pl. 11). It must be noted, however, that in the case of Abu Ghurab and Abusir, De Morgan's map is less accurate than that of Lepsius. In particular, the overall plan of the sun temple of Nyuserre is more a sketch than a real plan: the altar of the central courtyard is not recorded in the right position;[11] the sun temple of Userkaf is simply a red, rectangular-like sign on the map. The lack of accuracy in the drawing of this portion of the Memphite necropolis is even more evident when we compare it to Lepsius' map. This overlapping clearly evidences the absence of many pyramids and "minor" structures in De Morgan's plan.[12]

Finally, in 1898, Ludwig Borchardt reached the Abu Ghurab hillock and started working in the sun temple of Nyuserre. This can be considered the beginning of the systematic archaeological exploration of the Abusir plateau. Between 1898 and 1908, the German Egyptologist investigated the main part of the Fifth Dynasty royal necropolis, unearthing, besides Nyuserre's sun temple (Borchardt 1907),[13] four royal pyramids and several "minor" pyramids and private tombs (Borchardt 1907, 1909 and 1910), establishing a lasting association between the necropolis and his name in the history of Egyptology.

However, as far as the area of Abu Ghurab is concerned, and despite the accurate and masterful work conducted in the sun temple, Borchardt did not elaborate a new topographical map of the entire site, limiting his work to a new, accurate plan of the sun temple of Nyuserre.

The same goes, *mutatis mutandis*, also for Herbert Ricke's excavation of the sun temple of Userkaf in the years 1952–1955. The Swiss scholar carried out careful and detailed fieldwork, resulting in a two-volume publication (Ricke 1965 and 1969). Here, however, there is no new, updated topographical map of the area of Abu Ghurab.

It was only in 1978, with the photogrammetric map, scaled 1:5000, elaborated by the French Aviation for the Egyptian Ministry of Housing and Reconstruction that we finally obtained a more extensive and updated cartography of the entire area of the Memphite necropolis, with the basic contour plans of sites and monuments therein (fig. 1).[14]

The analysis of the satellite imagery of the Abu Ghurab site, as well as the comparison with the traditional cartographical material, is therefore particularly important for a general reassessment of the topographical and archaeological features of the area, as well as for the indications it may provide on the undiscovered monuments.

Some preliminary considerations on the satellite imagery

In this paper, we have used two different kinds of sources:

1) satellite panchromatic images from Google Earth (fig. 2), freely available online;
2) new generation SAR (Synthetic Aperture Radar) images (fig. 3) from the constellation of the COSMO-SkyMed satellites (acronym of Constellation of Small Satellites for Mediterranean Basin Observation), elaborated in recent years by the Italian Space Agency (ASI).[15]

Google Earth images provide us with a rather accurate view of the earth and have been extensively used for the investigation of several sites worldwide with important results. However, being panchromatic images of the Earth, their quality highly depends on the general weather conditions, especially the amount of sunlight and elements that can decrease visibility, such as clouds, fog, humidity, *etc.* Moreover, they are taken at specific times of the year, depending on the movement and parameters of the satellites' sensors. Nevertheless, they are important to testify what is the current state of visibility of archaeological artefacts on the ground, as well as the overall geomorphology of the area, and with this sole scope they will be used here.

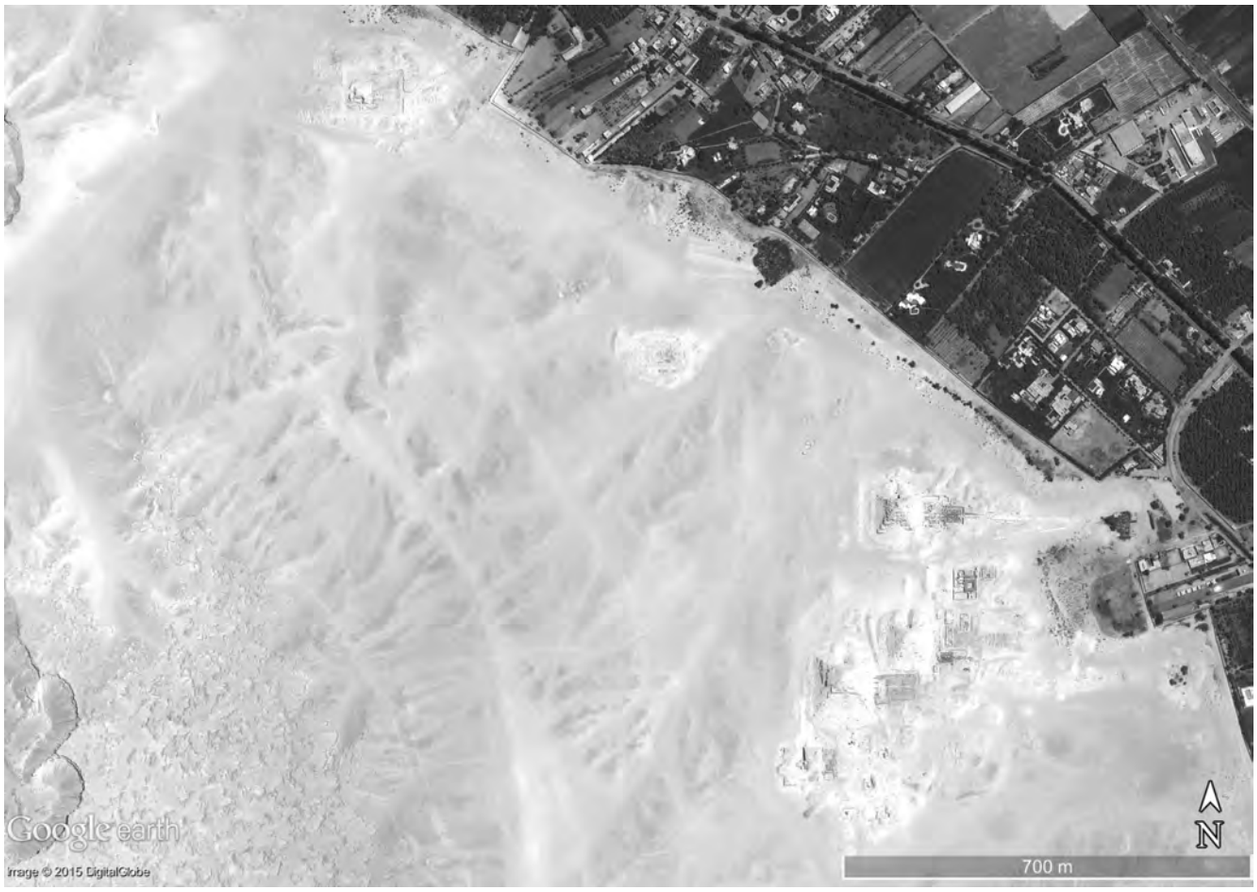

Fig. 2 Satellite Google Earth image of the area of Abusir/Abu Ghurab (Digital Globe 2015)

The SAR images, on the contrary, operating in the radiometric X band, are not influenced by the weather and therefore offer the chance to generate very high resolution images of specific sites observed several times a day. Moreover, the radar sensors generate highly reflective images which have a higher level of penetration of the ground (in particular the sand) than panchromatic images, giving us the chance to detect structures hidden under the top layers of the surface.

The integration of these two types of satellite imagery is thus particularly fruitful, especially as regards the areas on the border between the cropland and the desert. While this area consists mostly of desert sand, the moisture of the soil can still surface in the case of archaeological structures hidden under the sand, which absorb the underground water, favoring the growth of rather sparse vegetation above them. When investigated by means of the radar sensors, the structures/artefacts underneath have a specific reflectance, which may of course vary significantly depending on the material they are composed of, *e.g.*, limestone, mud brick or sand. Moreover, in this marginal area between the cropland and the desert, the archaeological structures, if present, are usually hidden a few dozen centimeters below the sand.[16]

Based on this assumption, the images have been processed through "context operators", such as filters and detectors emphasizing contours, in order to improve the images' features and to extract surface and sub-surface discontinuities. This has allowed us to detect structures covered by sand and to obtain a detailed picture of the geometric and material characteristics of the analyzed landscape. These geo-referenced images have then been overlaid with the panchromatic images, the topographical data, and the above-mentioned historical maps. As a result, it has been possible either to re-locate already known structures, currently covered by sand/vegetation, or to search for new, unknown structures.

An important aspect of the study was also the analysis of the archaeological structures which had already been excavated and published in the past, in order to have some precise parameters of reference for our search for new evidence. In particular, we have analyzed the plans of the valley temples of the sun temples of Nyuserre and Userkaf by overlaying them with the available satellite imagery (especially the SAR images). This emphasizes some features of the vegetation overlying these structures which is extremely useful for further research in the area. This procedure proves to be particularly important in the case of Userkaf's sun temple, whose valley temple plan is still partially recognizable from the satellite under the vegetation. The analysis of the features of these temples and the comparison with the satellite imagery concerning the already known valley temples of the Abusir pyramids, *i.e.* Sahure's and Nyuserre's, allow us to proceed "by analogy" in the search for missing or new archaeological evidence, especially if we consider that these structures should have

Fig. 3 COSMO-SkyMed Image of the area of Abu Ghurab and Abusir. Processed under license from ASI – Agenzia Spaziale Italiana. All rights reserved (© ASI, courtesy by e-GEOS)

very similar positions in the overall topography of the area as well as common architectural and planimetric characteristics, such as, for example, the shape and the orientation.

The search for lost sun temples: satellite imagery, historical cartography and archaeological data

Based on the above methodological preamble and the analysis of the historical development of the exploration of the area, we can proceed to discuss the results of the cross-examination of the data and to clarify some elements of the monumental topography of Abu Ghurab and Abusir which are not entirely clear.

Attention is mainly focused on two impressive structures which were carefully recorded by Lepsius but disappeared in the later maps, namely Lepsius Pyramids XVI and XXVIII (Lepsius 1849: 130–131, 137–138, and pl. 32). The former has never been investigated, while the latter, although briefly explored by Borchardt at the beginning of the twentieth century (Borchardt 1910: 147), is still far from clear.

Lepsius Pyramid XVI

According to Lepsius' description, Pyramid XVI was situated in the area between the sun temples of Userkaf and Nyuserre, around 400 m south-east of the latter (Lepsius Pyramid XV). Lepsius describes the building as a "Ziegelpyramide" (brick pyramid) with a base perimeter of around 75 m. We have no data on the height of this alleged pyramid but the term used by Lepsius to define the building, *i.e.* "Berge", suggests a rather sizable structure (Lepsius 1849: 130–131, pl. 32.). Lepsius concludes his description by stating that the extant sides of the structure were oriented towards the cardinal points (see fig. 1). In 1897, De Morgan mapped the building as a small, insignificant dot, without any description (De Morgan

1897: pl. 11), while in 1898, namely only one year later, Borchardt did not mention the building at all in his publication of the archaeological excavation of Nyuserre's sun temple (Borchardt 1907: 1–6).[17] Based on notes made by Lepsius in his notebook on the shape and topographical position of Pyramids XVI and XXVIII, Sethe, who was the editor in chief of Lepsius' work, raised doubts on the actual existence of this structure and suggested that Lepsius might have gotten confused and mapped a single pyramid twice (Lepsius 1849: 138).[18]

In 1987, comparing the map by Lepsius and the aerial view of the Abu Ghurab site (see Ricke 1965: frontispiece), Aidan Dodson very briefly gave attention to this structure, reviving Lepsius' idea that it could have been a pyramid, and specifically a Thirteenth Dynasty pyramid (Dodson 1987b: 231). No archaeological element was, however, called into account to support this interpretation except for the location of the pyramid close to the cultivated area, as is the case with the other Thirteenth Dynasty pyramids analysed by the same scholar in another paper (Dodson 1987a: 36–45). Ladislav Bareš responded to Dodson's theory by suggesting that Lepsius Pyramid XVI was more probably a Middle Kingdom pyramid (Bareš 1988: 118–119). He himself, however, has to admit that the presence of Middle Kingdom royal monuments in Abusir is not supported by any archaeological or historical elements. Finally, Dodson's idea that Lepsius Pyramid XVI was a Thirteenth dynasty pyramid was very recently revived by Christoffer Theis. However, as in Dodson's paper, Theis' hypothesis is mainly based on the position of the pyramid at the edge of the cultivated area, as well as on the material used for its construction (according to Lepsius' account), namely mud bricks and not limestone, as would be logical in the case of both Old and Middle Kingdom pyramids (Theis 2009: 335–336).[19] More recently, Dušan Magdolen, in a paper on the history of sun temples, also gave attention to Lepsius Pyramid XVI as an interesting and promising area for future investigations, although he did not provide any archaeological-historical discussion on the possible nature of this monument (Magdolen 2012: 25–26, 31).

Nowadays, thanks to the combined analysis of the abovementioned topographical map made in 1978 (EMHR 1978, sheet 21), the satellite imagery of the area and the evidence still visible in the ground, we can provide some new elements for the comprehension of this mysterious structure.

In fact, based on the analysis of the isohypses of the 1978 map (see fig. 1), we can note the existence of a *tell* – situated very close to the valley temple of the sun temple of Userkaf – which is higher (28.6 m) than the surrounding area, whose isohypses are around 20 m. This aspect seems particularly significant when we consider that the archaeological evidence is situated on the border between the cropland and the desert, which is usually a rather flat area, as also demonstrated by the isohypses of the other valley temples of both the pyramids and the sun temples of the area of Abusir/Abu Ghurab, all situated at a height of about 20 m.

On the Google Earth imagery (fig. 2), the *tell* has the aspect of a sandy hill whose contours are quite precisely evidenced on three sides by sparse vegetation. The *tell* on the Google Earth imagery clearly matches both Lepsius Pyramid XVI and the abovementioned hill evidenced in the 1978 map (see also Nuzzolo 2013: 166–168).

The analysis of the SAR images of the area (fig. 3) also confirms the existence of archaeological evidence in the same topographical positions. The spectrometric characteristics of the area, especially when we apply various filter contours to the satellite images (see pl. 4 [F]), show rather evident traces of a rectangular-like structure whose north--western and north-eastern sides are particularly evident on account of the high reflectance of this area compared to the surroundings. A third side (south-eastern) of this structure is also quite visible, although not so highly reflective as the other two. The central part of this structure, corresponding to the highest part of the hill on the Google Earth image and the 1978 map, is not particularly reflective. This may signify that this was the core of the hidden building, which is nowadays buried under a deeper layer of sand which hampers the SAR penetration into the terrain. Alternatively, this may imply that the core structure was made of mud bricks, which are not as reflective as limestone (or other kind of stones, *e.g.*, granite or quartzite). Most importantly, the structure evidenced by the SAR image does not seem to be oriented either on the north-south or on the east-west axis, an element which, although in this preliminary stage of analysis, would lead us to exclude the possibility that Lepsius Pyramid XVI could really be a pyramid.

Last but not least, the *tell* in account is also clearly recognizable by means of direct observation on the ground. It is characterized by the presence, on the surface, of several limestone fragments, as well as of a number of chips of granite and quartzite, although they are quite haphazardly scattered on the spot and do not demonstrate, *per se*, the presence of archaeological evidence underneath.

The first logical conclusion that comes to mind is thus that this structure could be a sun temple, or better the valley temple of a sun temple (Nuzzolo 2013: 166). Indeed, the structure is located in between two solar sanctuaries, and according to the Abusir papyri, as already mentioned, all the sun temples should be located quite close to the respective pyramids, so as to be reached twice a day by boat to perform religious and administrative duties (see footnote above).

Against this opinion, one could argue that the area might have been used as a funerary field for Early Dynastic mastabas, which were indeed found at the edge of the cultivation zone on the north-western side of Nyuserre's sun temple (Radwan 1991: 305–308; Radwan 2000: 509–514). However, these mastabas usually do not present a significant elevation aboveground (as is instead the case with Pyramid XVI) either before or after excavation. This seems to be confirmed by the fact that even the large predynastic mastaba tombs at Saqqara do not appear as impressive as Pyramid XVI in any nineteenth- or twentieth-century maps, including the above-mentioned ones by Lepsius and De Morgan. Moreover, the orientation and size of the building as evidenced by the SAR image, appear more suitable with (although not exclusive for) a valley temple rather than an Early Dynastic mastaba.

Whatever the case, the significant size of the mound, still visible today on the ground and on the Google Earth

image, the presence (in Lepsius' account and in a surface survey) of stone artefacts, as well as the orientation of the building as evidenced by the remote sensing, seem to confirm that the structure should be identified as a significant architectural building. Taking into account the consolidating construction activities carried out by Fifth Dynasty pharaohs up to the reign of Nyuserre, and the location of the latter temple, suggesting a symbolic and architectural continuity with the monuments of his royal predecessors, it is thus possible that Lepsius Pyramid XVI was indeed a sun temple, or the valley temple of a sun temple (Nuzzolo 2013: 166–169).

If the core of this hypothesis is correct, this would confirm the fact that the sun temple area was quite restricted and uniform in terms of topographical features, forming a sort of consecrated field for the solar aspects of the king's cult, next to the royal necropolis for his funerary cult (see also Nuzzolo 2015: 303–304).

In the current state of our knowledge, however, and even if we admit the correctness of the above hypothesis, it is impossible to establish which sun temple may potentially be hidden under the sands. On the one hand, Neferirkare's sun temple would appear as the most obvious candidate, being by far the most cited one in the epigraphic sources of the time (Nuzzolo 2007: pl. 1; Nuzzolo 2010: tab. 1). On the other hand, however, Sahure's sanctuary – which should be, theoretically, the closest to the sun temple of Userkaf, being the second one to have been built – may equally be a suitable candidate, although the temple is mentioned in the contemporary textual sources only a few times (Nuzzolo 2007: pl. 1; Nuzzolo 2010: tab. 1).

Regardless of the question of the identification of the above-mentioned structure, what is even more interesting is that the SAR images may testify to the presence of another structure in the area in account. In fact, immediately to the south-east of the area just discussed, the SAR images

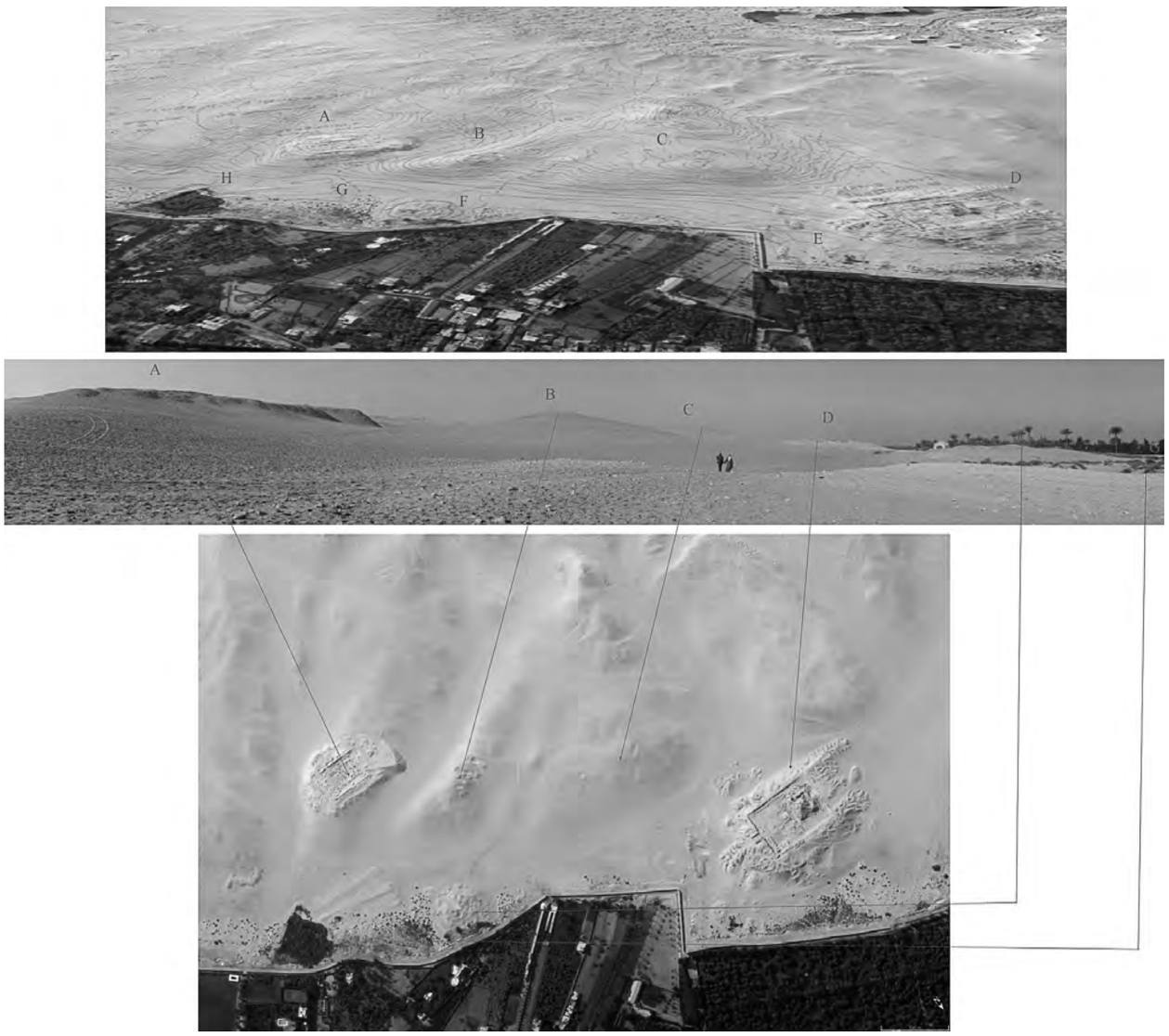

Fig. 4 Overview of the area of Abu Ghurab with the indication of the main monuments: (top) digital model of the area based on Google Earth and the topographic data; (middle) an image of the area from the ground; (down) satellite Google Earth image (Digital Globe 2015). A, H: Userkaf's sun temple and valley temple; B–C: the two hills in between Userkaf's and Nyuserre's sun temples; D–E: Nyuserre's sun temple and valley temple; F: the hill corresponding to Lepsius Pyramid XVI; G: area with a consistent presence of unknown archaeological remains

show the presence of an intense concentration of artefacts under the vegetation, which may actually feature the corners of another square/rectangular structure with the same orientation as the previously described one (see pl. 4 [G]).

We do not have enough data at the moment to maintain with certainty that this is a separate structure and not a part of the previously discussed one. However, it is worth noting that upstream from the valley area we are dealing with, in the area between the two unearthed sun temples of Userkaf and Nyuserre, we have at least two wide hills which could serve as a large and suitable location for the upper temple of a solar complex (fig. 4 [B-C]). These *tells* are particularly impressive when observed in the field and are clearly distinguishable in both the Google Earth imagery and the 1978 photogrammetric map, where they are marked with a isohypse of 44.1 m and 50.9 m respectively (figs. 1 and 5), namely much higher than the hill where the sun temple of Nyuserre is located, at the height of 34.6 m. The latter mound was so inconvenient, from the architectural standpoint, as to force the architects of Nyuserre to build a huge artificial platform to support the temple on the northern side (Borchardt 1907: 26–27). Therefore, if the two above-mentioned *tells* were natural in origin, the choice for the location of both the sun temples of Userkaf and of Nyuserre would appear rather unsuitable and inconvenient from both topographical and architectural standpoints, especially for Nyuserre, who had the entire plateau of Abu Ghurab at his disposal when he assumed the throne.

In another paper I had argued that one of the possible reasons for the location of the sun temple of Userkaf might have been the inter-visibility with other prestigious monuments located at Saqqara, Giza and Dahshur (Nuzzolo 2015: 292–293). The height of the hill where Userkaf's sun temple is located should also have played a central role in his final choice, when we consider that the sun temple, being a completely new monument specifically dedicated to the sun god, had to play the role of a symbolic landmark of the sacred landscape of the early Fifth Dynasty. The same criteria of visibility and interconnection with previous royal monuments should certainly have been taken into account also by Nyuserre. However, as already said, the hill where Nyuserre's sun temple was built is neither the highest one nor the most comfortable in Abu Ghurab. This would logically seem to demonstrate that the two hills to the south of Nyuserre's sun temple might have been already occupied when Nyuserre started building his sun temple so as to force him to erect the monument in that specific position.

Unfortunately, these two still unexplored *tells* between Userkaf's and Nyussere's sun temples, when investigated by means of the SAR technology (see pl. 4 [B–C]), do not present spectrometric features comparable with the valley area and do not show any archaeological evidence hidden below ground. Additionally, no trace of archaeological material is visible today on their surfaces, nor was it in the past (see also Bareš 1988: 119). We have to bear in mind, however, that, if a sun temple was actually located here, it may lay under several meters of sand and this would hinder its identification by means of the sole SAR images, which using the X band, cannot penetrate so deeply into the terrain (see above concerning the depth of penetration of the SAR images).

Lepsius Pyramid XXVIII

Lepsius Pyramid XXVIII was situated at the south-east corner of the Abusir necropolis (see fig. 1), not too far from the valley temple of Nyuserre's pyramid (Lepsius 1849: 137–138, pl. 32). Lepsius describes the pyramid as a remarkable building, composed of mud bricks and several small limestone blocks, and oriented towards the cardinal points. The size of this building, in particular, is very interesting when we consider that, based on Lepsius' account, the pyramid had a square base of about 95 m and a considerable height, which is, however, not specified: "Die Höhe ist ganz beträchtlich" (Lepsius 1849: 137). If the account of Lepsius is right, this pyramid would be the largest of all of the Abusir pyramids except Neferirkare's.

In De Morgan's map, this pyramid is completely missing, although the presence of an anomalous hill in the same topographical position is recorded (see fig. 1). During the excavations of the pyramid complex of Sahure in 1908, the site was briefly investigated by Borchardt, who concluded that it was probably a Middle Kingdom pyramid (Borchardt 1910: 147). However, his interpretation of the building is not entirely convincing. Indeed, in his report, we find very little evidence suggesting that the structure is a Middle Kingdom pyramid.

First of all, Borchardt did not completely dig the structure because of the high groundwater level: as a consequence, he could only investigate the top layer of the site and he was not able to reach either the oldest levels of the building or its foundation, a crucial part to determine the date of a structure due to the great difference between Old and Middle Kingdom architecture in the lower levels. He also could not find any evidence of the casing stones of this building, which would also have helped him establish the date as well as the shape and slope of the pyramid.[20]

Secondly, besides some small, intrusive decorated objects of the Late Period, Borchardt found mainly a few fragmentary blocks of limestone, quartzite,[21] basalt and granite, as well as some small pottery sherds datable from the late Old Kingdom to the early Middle Kingdom. In the only trench he was able to dig, only a few mud brick structures were found, together with a large concentration of *tafla* clay. These archaeological findings would agree more with a pyramid temple rather than an actual pyramid, and with an Old Kingdom rather than a Middle Kingdom date, also considering that Middle Kingdom pyramids are usually composed mostly of mud bricks, which were not found in the area.

Thirdly, according to Borchardt himself, Lepsius Pyramid XXVIII seems to have been somehow connected to other mastaba tombs situated further to the south-east of the pyramid itself and dated to the late Old Kingdom, or the beginning of the First Intermediate Period at the latest (Borchardt 1910: 147–149, and pls. 2 and 15).[22]

Last but not least, it is also worth noting that no royal pyramid of the Middle Kingdom is actually missing and, as far as we know, the site of Abusir does not seem to have been used during the Middle Kingdom by the members of the royal family, whose tombs are located elsewhere. The area, instead, was the centre of official and popular cults devoted to the Fifth Dynasty rulers buried here (especially Nyuserre) during the late Old Kingdom and throughout the

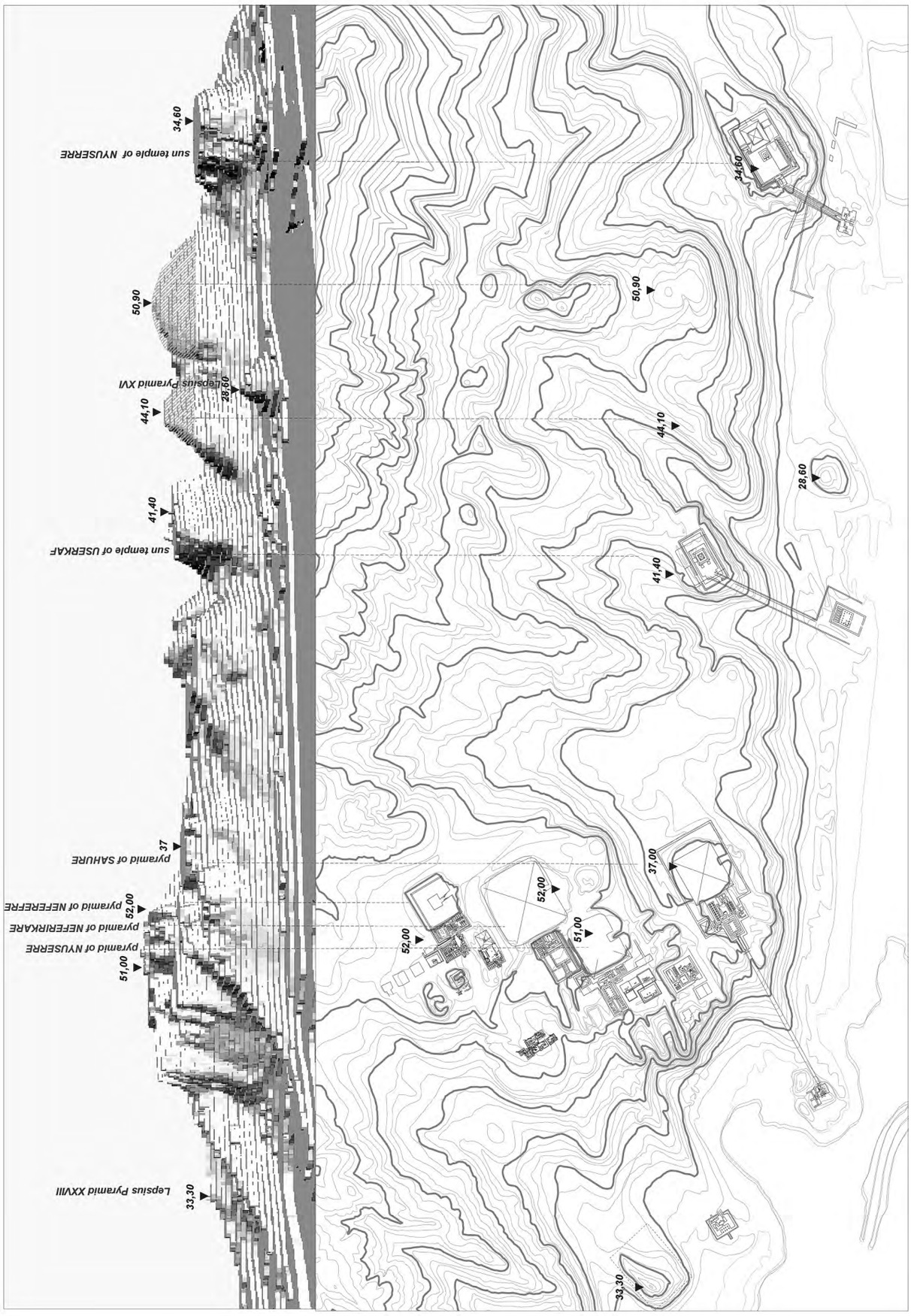

Fig. 5 Topographic map of the area of Abusir and Abu Ghurab with isohypses and the related elevation model. Basic contour plans of the both pyramids and sun temples are overlaid.

First Intermediate Period (Morales 2006: 311–341). However, in this period, too, at least in the current state of our knowledge, the site does not seem to have been chosen as the seat of royal monuments (Daoud 2001: 193–206; Málek 2001: 241–258).

Since Borchardt's work, Lepsius Pyramid XXVIII has been the object only of brief considerations. In the already mentioned 1987 article, Aidan Dodson proposed that also this pyramid – like Pyramid XVI – might have been a Thirteenth Dynasty pyramid, although he could not exclude the possibility that it may have something to do with the installations of the valley temple of Neferefre's pyramid (Dodson 1987b: 232). Contrarily, Ladislav Bareš proposed that this area might have been only a natural hill (Bareš 1988: 117–118). This assumption was mostly based on a geomagnetic survey carried out in the site in the years 1978–1979 by the Czechoslovak team headed by Miroslav Verner (Verner – Hašek 1981: 75–76). We have to note, however, that the anomalies measured by the above survey concerning the elevation and conformation of the terrain were actually limited to a small part of the hill. Moreover, the survey confirmed the presence of "small mud brick structures (tombs?) scattered on its surface" (Verner 1992: 121), something which would seem to confirm the archaeological findings made by Borchardt without really clarifying the matter of their nature and date.

Christoffer Theis, in his recent article, also criticized the idea of a natural hill and attributed the pyramid to the Thirteenth Dynasty (Theis 2009: 336). Once again, however, as in the case of Pyramid XVI, in support of this interpretation there are only indirect arguments, *i.e.*, the location of the pyramid close to the cultivated area (a feature unusual for the Old Kingdom) and the material used for its construction (according to Lepsius' account), namely mud bricks and not limestone as in the Old Kingdom. On the other hand, the buildings were a mix of mud bricks and limestone according to Borchardt (1910: 147; see also notes 21–22).

The satellite imagery of the area and its combined analysis with the 1978 photogrammetric map can now give us some new information. The analysis of the isohypses in the latter map (fig. 1) shows the presence of a rather sizable *tell*, 33.3 m high, namely much higher than the surrounding area which is around 20 m high. This *tell* is also clearly visible in the Google Earth imagery (fig. 2). But it is the analysis of the SAR image which gives us the most interesting elements. The latter image (fig. 3) in fact shows the presence of a square-like structure, which seems to match the size proposed by Lepsius for his Pyramid XXVIII (about 95 m). However, most remains are nowadays visible on the eastern and southern sides; the northern side is also recognisable though not entirely preserved; the western side, instead, seems completely missing.

An important aspect of this structure is that its central part is less reflective than the enclosure walls. This would suggest an empty structure which may somehow match the architectural typology of other Fifth Dynasty pyramids of the necropolis: a massive enclosure wall with a large central pit left open for the construction of the pyramid's substructure, to be filled later on during the construction work. This is the same technique which is still clearly visible – both on the ground and in satellite imagery – in the case of Neferefre's pyramid (Verner 2001: 304–306), as well as in other "minor" pyramids of the necropolis, such as, for example, Lepsius Pyramids XXIV and XXV (Verner 1994: 372–374, and fig. 2).

However, we cannot underrate the fact that the high reflectivity of the area in the SAR image may also be partially due to the steep gradient of the *tell*. In fact, the reflectivity of the radiometric X band varies significantly according to the gradients of monuments/natural hills in consideration: the *tell* in account (Lepsius Pyramid XXVIII) has indeed a significant slope, particularly on the eastern side, and the satellite has a look side rightwards (see footnote 15 for the characteristics of the SAR image). Whatever the case, it is interesting, but also puzzling, to note that, as far as we can see from the satellite images, the building is not perfectly oriented on the cardinal points, being slightly shifted towards the north-west.

The identity of this building is even more mysterious than that of Lepsius Pyramid XVI. On the one hand, the elements we have hitherto examined seem to indicate that Lepsius Pyramid XXVIII would hardly be a Middle Kingdom pyramid, as suggested by Borchardt, and in any case – even if we accept hypotheses of Dodson and Theis – a strange pyramid, given its not very precise orientation. On the other hand, however, when we consider the history of the Fifth Dynasty and the overall topography of the area of Abusir and Abu Ghurab, we note that no royal pyramid of this period is missing.[23] Magdolen has thus suggested that it might have been a sun temple, notably Menkauhor's (Magdolen 2012: 27). In the view of the present author, however, the area is not suitable for the location of a sun temple due to the proximity to the edge of the cultivation zone, which would not have allowed the temple to have a proper valley temple. We should also consider the fact that at least two (if not three) of the sun temples known so far are located in a specific area to the north-west of the Abusir royal pyramids in order to be contiguous to, but clearly separated from, the pyramid field.

Considering the topographical position of Lepsius Pyramid XXVIII, the most likely hypothesis would be that the structure was the valley temple of Neferefre's pyramid, which is almost exactly on the same east-west axis of Lepsius Pyramid XXVIII. In this sense, we might add that Maragioglio and Rinaldi, during their survey of the area, recorded the existence of a narrow causeway, partially visible in their time, running south-east of the pyramid for a few dozen meters (Maragioglio – Rinaldi 1970: 180; Maragioglio – Rinaldi 1975: tav. 5). However, this identification of Lepsius Pyramid XXVIII as a valley temple of Neferefra's pyramid complex seems in contrast with the small size of the king's pyramid – which was not completed due to the likely premature death of the king – and the fact that there seems to be no mention of the valley temple in the papyrus archives of Neferefre's pyramid.[24]

Therefore, we cannot exclude the possibility that the structure was not connected at all with the Fifth Dynasty. In this regard, either previous or later dates are theoretically feasible. In fact, in the area of Abusir South, which is only a few hundred meters from Lepsius Pyramid XXVIII, some Third Dynasty mastabas were identified by the

Czech mission in the early 1990s (Verner 1995: 78–84), as well as, in more recent years, a huge mastaba (AS 54) precisely dated to the reign of Huni (Bárta 2011: 41–50). In 2015, an impressive boat, certainly dated to the same period, was also found adjoining the above AS 54 mastaba.[25] These findings seem to testify to the presence of a top elite cemetery in the area, possibly even members of the royal family. This is very interesting when we consider that we still do not know the precise location of the pyramids of at least three kings of the Third Dynasty, including Huni, to whose reign the AS 54 mastaba is datable.

As for a later date, we have already said that the site was frequented during the First Intermediate Period, when it became the centre of popular cults devoted to local rulers, as is especially the case with Nyuserre. The area around his funerary temple and the causeway was largely occupied by mastabas, or smaller tombs (Schäfer 1908: 15–109), and many of these tombs can be dated with a certain precision to the reign of King Merikare (Daoud 2001: 205–206). When we consider that there is no certainty on the location of Merikare's pyramid,[26] it seems at least reasonable to also take into account the possibility that Lepsius Pyramid XXVIII might be the tomb of this king.

The latter conclusions may appear somehow speculative, lacking any new archaeological investigation/excavation in the ground. However, we should not forget that the pyramid of Menkauhor was also supposed to be in Saqqara exclusively on the basis of indirect elements, before the excavations carried out by the Supreme Council of Antiquities in the late 2000s eventually confirmed its identity as Lepsius Pyramid XXIX, in the area to the north-east of Teti's pyramid in Saqqara (see footnote 24).

Conclusion and future perspectives

The combined analysis of modern remote sensing technology with available historical cartography of the area of Abu Ghurab and Abusir clearly demonstrates that several important elements of the sacred landscape of this area must still be clarified or even discovered. Particularly in the area of Abu Ghurab, in between the two so far unearthed sun temples of Userkaf and Nyuserre, the presence of ancient structures (Lepsius Pyramid XVI) hidden under the sand appears both historically and archaeologically plausible, and thus deserves a further and in-depth field investigation.

This is, among others, one of the main objectives and goals of the above-mentioned research project "Rise and Development of the Solar Cult and Architecture in Third Millennium BC Egypt," which aims to contribute to the identification of the missing sun temples and to further our historical knowledge of the area of Abusir/Abu Ghurab.

The first step will be thus to go in the field, in Abu Ghurab, in the valley area corresponding to Lepsius Pyramid XVI, to accomplish a wider geo-physical and geomagnetic survey, which can give us some useful, preliminary information on both the nature of the soil and the presence and features of the buried archaeological structures described above. Later on, a wider archaeological campaign is scheduled in order to ground-truth the hypotheses advanced so far. This field-work is all the more important when we consider that this area of Abu Ghurab has never been systematically explored, and will hopefully open new avenues of research in the history of the Fifth Dynasty royal necropolis.

Acknowledgment

This study was done within the research project entitled "Rise and Development of the Solar Cult and Architecture in Third Millennium BC Egypt", supported by the Grant Agency of the Czech Republic (GACR), Grant no. 17-10799S.

Notes:

1 On this subject, see in particular the various activities of the Theban Mapping Project led by Kent Weeks (http://www.thebanmappingproject.com/), as well as Piccione (2006) and Pimpaud (2012: 175–184), with further bibliography. The latter study has now evolved into a complete GIS map of the Western necropolis (Archaeological Map and Atlas of Western Thebes) which is available online at: https://independent.academia.edu/AlbanBricePimpaud.

2 We have to note, however, that the interpretations of the archaeological evidence found on the sites, as well as its chronological horizon, were often mistaken. For a general reassessment see Tallet – Marouard (2016: 135–177).

3 The site of Giza has undergone a long-lasting and still ongoing process of mapping using diverse methods of research. The results of this work, conducted by the Ancient Egypt Research Associates, under the direction of Mark Lehner, are available online at: http://www.aeraweb.org/projects/gpmp/.

4 The site of Saqqara has certainly been the main focus of scholarly attention due to its central position in the history of the Memphite necropolis. The most comprehensive work on the Saqqara plateau, including all the maps and satellite images hitherto available, is Bresciani – Giammarusti (2003). However, several studies were produced on specific parts of the necropolis as well as on the use of diverse methods of field analysis, such as, for example, geophysics. In this context, it is worth mentioning here some case-studies: Jeffreys – Tavares (2001: 27–32); Dobrev (2010: 51–65); Mathieson – Dittmer (2007: 79–93).

5 Works at Abusir were mainly conducted by the Czech team from the Charles University, first under the direction of Miroslav Verner, and later Miroslav Bárta. The main results of this survey are available in Bárta – Brůna (2006: 10–14).

6 Verner also expressed the possibility that the temples, or at least one of them, notably Neferirkare's, may be located further to the north of Abu Ghurab, towards Zawiyet el-Aryan (Verner 2014: 211). This hypothesis however is not supported by any archaeological elements, while all data so far known seems to indicate that the temples are indeed in Abu Ghurab/Abusir.

7 As far as the specific case of the new COSMO-SkyMed radar imagery and its use and value for archaeological investigation, see also Lasaponara – Masini (2013: 71–78), with further bibliography.

8 The two scholars also introduced for the first time in Egyptology the toponym "Abusir" to indicate the royal necropolis of the Fifth Dynasty. In fact, the previous explorers included this area within the larger pyramid field of Saqqara, using the name Abusir for the sole area of the lake and the village around it, as is the case, for example, with the Napoleonic map.

9 The maps of Lepsius' expedition were actually drawn by the architect Georg Gustam Erbkam; see Freier – Grunnert (1984: 45–48).

[10] It is interesting to note that Borchardt was not able to find any significant artefact or structure in the south-eastern corner of the central courtyard, while he found the impressive alabaster basins of the so-called "slaughterhouse" at the opposite corner, see Borchardt (1905: pls. 2 and 6).

[11] This altar, which was not present in Lepsius' drawing of the sun temple, was actually discovered during the winter of 1882–1983 by Henry Windsor Villiers Stuart, a British parliamentary and special envoy to Egypt (see Nuzzolo 2013: 171, no. 29).

[12] On the contrary, the map of Saqqara drawn by De Morgan was definitely much more precise and accurate than the one achieved by Lepsius, also because of the contribution to the topography of the area given by Mariette, with his famous map of central and north Saqqara, which was published only after he passed away, see Mariette (1889: 2, pl. 2).

[13] In fact, the sun temple of Userkaf was also identified and briefly explored by Borchardt, although not systematically excavated, during the fieldworks in Sahure's pyramid (see Borchardt 1910: 149–150). The reading of the name of the temple was, however, wrong, since Borchardt followed the first reading by Sethe (1889: 111–117). Only after the discovery of a vase on the Greek island of Kythera, did Sethe himself rectify his first reading by adopting the new and correct name of *Nḫn-Rᶜ* (see Sethe 1917: 55–58).

[14] Egyptian Ministry of Housing and Reconstruction, Cairo 1978 (1:5000), sheets 21–22: from now on EMHR.

[15] In the present paper, we have employed two SAR images, both recorded in high-resolution quality in the Spotlight Enhanced Mode Acquisition. The images cover an area of 10 km^2 in size, with a spatial resolution of 1 m^2. Their polarization is HH. The first image (Catalogue ID SAR2 100594323) was acquired on October 1, 2009; start time: 3.41.48 pm; stop time: 3.41.56 pm. The technical parameters are: near range incidence angle 58924; far range incidence angle 59298; center scene off-nadir angle 51490; look side: right; orbit number 9814. The second image (Catalogue ID SAR3 100939057) was acquired on May 22, 2013; start time: 3.28.47 pm; stop time: 3.28.55 pm. The technical parameters are: near range incidence angle 58937; far range incidence angle 59311; center scene off-nadir angle 51490; look side: right; orbit number 24745. COSMO-SkyMed Product. Processed under license from ASI – Agenzia Spaziale Italiana. All rights reserved. © ASI, courtesy of e-GEOS.

[16] See the case, mentioned below, of the Early Dynastic mastabas found by Ali Radwan in Abu Ghurab. The mastabas were discovered at a depth of around 30–50 cm below the walking surface of the site.

[17] Borchardt did not record this structure also in his brief description of Userkaf's sun temple, which was quickly investigated during the excavation of Sahure's pyramid (see Borchardt 1910: 149–150).

[18] Sethe himself, however, adds a brief note recorded by Lepsius in his notebook about Pyramid XVI. In this note Lepsius seems to confirm his previous description of the structure, by adding that it was a mix of mud bricks and small stone artefacts.

[19] Theis also says that, according to Lepsius' account, Pyramid XVI was characterized by an outer mantle made of limestone blocks, but actually there is no mention of these limestone blocks in Lepsius' publication (see Lepsius 1849: 130–131).

[20] "Ein Versuch, am Fuße des Hügels in unserem Graben tiefer zu gehen und etwa Reste der Bekleidung dieser Pyramide zu finden, wurde durch das bald hervorsickernde Grundwasser verhindert" (Borchardt 1910: 147).

[21] The word used by the German scholar is actually "rot und braun Sandstein" but we know, from the sun temple description, that in both cases we are dealing with quartzite (see Borchardt 1905: 41 and Borchardt 1910: 147).

[22] This date has been partially amended by Verner, who suggested that Borchardt was in fact digging subsidiary burials of the late Old Kingdom which were clustered around early Old Kingdom mastabas of which Verner had found the remains further to the south of the area excavated by Borchardt (*cf.* Verner 1995: 78–84; also Bárta 2001: 17–19).

[23] Besides the known pyramids of the Fifth Dynasty in Abusir (Sahure, Neferirkare, Neferefre and Nyuserre) and Saqqara (Djedkare and Unas), only two pyramids are still objects of discussion. However, none of them can fit Lepsius's Pyramid XXVIII. In fact, the pyramid of Menkauhor should probably be identified as the so-called "Capless Pyramid", *i.e.* Lepsius XXIX at Saqqara (see Hawass 2010: 153–170), although many scholars had previously put forward a different theory. Málek (1994: 203–214), for example, maintained that the pyramid belonged to the First Intermediate Period king Merikare. See also Silverman (2009: 47–101), who suggests that, whoever its original owner, the pyramid may have been usurped by Amenemhat I. The pyramid of the ephemeral ruler, Shepseskare, has otherwise to be placed very likely in between Sahure's pyramid and Userkaf's sun temple (see Verner 2001: 581–602).

[24] It is not entirely clear whether the mention of the *ḥwt-nṯr* in the archive may refer to the valley temple or to the entire complex (see also Posener-Kriéger – Verner – Vymazalová 2006: 349).

[25] http://cegu.ff.cuni.cz/en/2016/02/01/a-unique-boat-from-the-pyramid-age-discovered-at-abusir-by-the-expedition-of-the-czech-institute-of-egyptology/.

[26] Málek (1994: 203–214) maintains that the pyramid of Merikare was to be identified as the Lepsius Pyramid XXIX at Saqqara but we have seen before that this pyramid is very likely to be attributed to King Menkauhor.

Bibliography:

Bareš, Ladislav

1988 "A Note to the Thirteenth Dynasty at Abusir", Varia Aegyptiaca 4, pp. 117–120.

Bárta, Miroslav

2001 *The Cemeteries at Abusir South I*, Prague: Charles University in Prague [Abusir V].

2011 "An Abusir Mastaba from the Reign of Huni", in: Callender, Vivien Gae – Bárta, Miroslav – Coppens, Filip – Janák, Jiří – Krejčí, Jaromír (eds.). *Times, Signs, and Pyramids. Studies in Honour of Miroslav Verner on the Occasion of His Seventieth Birthday*, Prague: Charles University in Prague, pp. 41–50.

Bárta, Miroslav – Brůna, Vladimír

2006 *Satellite Atlas of the Pyramids*, Plzeň: Dryáda.

Borchardt, Ludwig

1907 *Das Grabdenkmal des Königs Ne-user-reᶜ*, Leipzig: Hinrichs'sche Buchhandlung [Ausgrabungen der Deutschen Orient-Gesellschaft in Abusir 1902–1904. Bd. 1].

1909 *Das Grabdenkmal des Königs Nefer-ir-ka-reᶜ*, Leipzig: Hinrichs'sche Buchhandlung [Ausgrabungen der Deutschen Orient-Gesellschaft in Abusir 1902–1908. Bd. 5].

1910 *Das Grabdenkmal des Königs Śᶜ3ḥu-reᶜ. Bd. I*: *Der Bau*, Leipzig: Hinrichs'sche Buchhandlung [Ausgrabungen der Deutschen Orient-Gesellschaft in Abusir 1902–1908. Bd. 6].

Bresciani, Edda – Giammarusti, Antonio

2003 *The North Saqqara Archaeological Site. Handbook for the Environmental Risk Analysis*, Pisa: University Press.

D'Andrea, Andrea – Pirelli, Rosanna – Iannone, Giancarlo – Nuzzolo, Massimiliano – Zanfagna, Patrizia

2014 "The Italian archaeological mission in the sun temple of Niuserra at Abusir: the use of combined technologies and the new perspectives on the monument", Newsletter Centro Interdipartimentale di Servizi per l'Archeologia 5, pp. 48–98

Daoud, Khaled A.

2001 "Abusir during the Herakleopolitan Period", in: Bárta, Miroslav – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2000*, Prague: Charles University in Prague, pp. 193–206.

De Morgan, Jacques
1897 *Carte de la nécropole Memphite. Dahchour, Sakkarah, Abou-Sir*, Le Caire: Ministère des travaux public.
Description 1809
2007 *Description de l'Égypte. Publiée par les ordres de Napoléon Bonaparte*, *Vol. V*, Paris: Editions Taschen (17th ed.).
Dobrev, Vassil
2010 "Quest for the lost kings of dynasty 6", in: Raffaele, Francesco – Nuzzolo, Massimiliano – Incordino, Ilaria (eds.). *Latest Research and Recent Discoveries in Egyptology. Proceedings of the First Neapolitan Congress of Egyptology, Naples 18–20 June 2008*, Wiesbaden: Harrosswitz, pp. 51–65.
Dodson, Aidan
1987a "The Tombs of the Kings of the Thirteenth Dynasty in the Memphite Necropolis", Zeitschrift für Ägyptische Sprache und Altertumskunde 114, pp. 36–45.
1987b "The Thirteenth Dynasty Pyramids at Abusir?", Varia Aegyptiaca 3, pp. 231–232.
Freier, Elke – Grunert, Stefan
1984 *Eine Reise durch Ägypten. Nach den Zeichnungen der Lepsius-Expedition in den Jahren 1842–1845*, Berlin: Henschel Verlag.
Hawass, Zahi
2010 "The excavation of the Headless Pyramid, Lepsius XXIX", in: Hawass, Zahi – Der Manuelian, Peter – Hussein, Ramadan Bassir (eds.). *Perspectives on Ancient Egypt. Studies in Honor of Edward Brovarski,* Cairo: American University in Cairo Press [Supplement aux Annales du Service des Antiquités de l'Égypte 40], pp. 153–170.
Jeffreys, David – Tavares, Ana
2001 "An integrated mapping project for the Saqqara plateau and escarpment", in: Bárta, Miroslav – Krejčí, Jaromír (ed.). *Abusir and Saqqara in the Year 2000*, Prague: Charles University in Prague, pp. 27–32.
Lasaponara, Rosa – Masini, Nicola
2013 "Satellite Synthetic Aperture Radar in Archaeology and Cultural Landscape. An Overview", Archaeological Prospection 20, pp. 71–78.
Lepsius, Karl Richard
1849 *Denkmäler aus Ägypten und Äthiopien, Bd. I.,* Berlin – Leipzig: Nicolaische Buchhandlung.
Magdolen, Dušan
2012 "Einige Bemerkungen zur Suche nach den verschollenen altägyptischen Sonnenheiligtümern der 5. Dynastie", Asian and African Studies 21/1, pp. 14–34.
Málek, Jaromir
1994 "King Merykare and his Pyramid", in: Berger, Catherine – Clerc, Gisele – Grimal, Nicolas (eds.). *Hommages à Jean Leclant*, Cairo: Institut Francais d'Archeologie Orientale [Bibliothéque d'étude 106], pp. 203–214.
2001 "Old-Kingdom rulers as "local saints" in the Memphite area during the Middle Kingdom", in: Bárta, Miroslav – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2000*, Prague: Charles University in Prague, pp. 241–258.
Maragioglio, Vito – Rinaldi, Celeste
1970 *L'architettura delle piramidi menfite. Parte VII. Le Piramidi di Userkaf, Sahurâ, Neferirkarâ. La Piramide Incompiuta, le Piramidi minori di Abu Sir*, Rapallo: Tipografia Canessa.
1975 *L'architettura delle piramidi menfite. Parte VIII. La Piramide di Niuserrâ, la «Small Pyramid» di Abu Sir, la Piramide «Distrutta» di Saqqara, ed il Complesso di Zedkarâ Isesi e della sua Regina*, Rapallo: Tipografia Canessa.
Mariette, Auguste
1889 *Les mastabas de l'Ancien Empire*, Paris: Vieweg.
Mathieson, Ian – Dittmer, John
2007 "The Geophysical Survey of North Saqqara", Journal of Egyptian Archaeology 93, pp. 79–93.
Morales, Antonio
2006 "Traces of official and popular veneration to Nyuserra Iny at Abusir. Late Fifth Dynasty to the Middle Kingdom", Bárta, Miroslav – Coppens, Filip – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2005,* Prague: Charles University in Prague, pp. 311–341.
Mumford, Gregory
2006 "Tell Ras Budran (site 345): Defining Egypt's Eastern frontier and mining operations in South Sinai during the Late Old Kingdom (Early EB IV/MB I)", Bulletin of the American Schools of Oriental Research 342, pp. 13–67.
Mumford, Gregory – Parcak, Sarah
2003 "Pharaonic ventures into South Sinai: El-Markha Plain Site 346", Journal of Egyptian Archaeology 89, pp. 83–116.
Nuzzolo, Massimiliano
2007 "The sun temples of the Vth Dynasty: a reassessment", Studien zur Altägyptischen Kultur 36, pp. 217–247.
2010 "The Vth Dynasty Sun Temples Personnel. An overview of titles and cult practice through the epigraphic evidence", Studien zur Altägyptischen Kultur 39, pp. 289–312.
2013 "From Lepsius to Borchardt. Archaeological investigations at the Fifth Dynasty Sun Temples in Abu Ghurab", in: Betrò, Marilina – Miniaci Gianluca (eds.), *Talking along the Nile. Ippolito Rosellini, travellers and scholars of the 19th century in Egypt,* Pisa: University Press, pp. 163–176.
2015 "Royal Authority, Divine Legitimization. Topography as an element of acquisition, confirmation and renewal of power in the Fifth Dynasty", in: Coppens, Filip – Janák, Jiří – Vymazalová, Hana (eds.). *7. Symposium zur ägyptischen Königsideologie. Royal versus Divine Authority*, Wiesbaden: Harrassowitz [Königtum, Staat and Gesellschaft früher Hochkulturen 4.4], pp. 289–304.
Nuzzolo, Massimiliano – Pirelli, Rosanna
2011 "New archaeological investigation in the sun temple of Niuserra in Abu Ghurab", in: Bárta, Miroslav – Coppens, Filip – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2010/2*, Prague: Charles University in Prague, pp. 664–679.
Parcak, Sarah
2004a "Finding new archaeological sites in Egypt using satellite remote sensing: case studies from Middle Egypt and the Delta", in: Wang, Chuan (ed.). *International Conference on Remote Sensing Archaeology*, Beijing: Chinese Center for Remote Sensing Archaeology, pp. 136–141.
2004b "Satellite Remote Sensing Resources for Egyptologists", Göttinger Miszellen 198, pp. 63–78.
2009 *Satellite Remote Sensing for Archaeology*, London – New York: Routledge.
2010 "The Skeptical Remote Senser: Google Earth and Egyptian Archaeology", in: Ikram, Salima – Dodson, Aidan (eds.). *Beyond the Horizon. Studies in Egyptian Art, Archaeology and History in Honour of Barry J. Kemp*, Cairo: Supreme Council of Antiquities Press, pp. 362–382.
Piccione, Peter
2006 *Satellite Survey of Western Thebes. A differential GPS Mapping Project of the Private Tombs of Sheikh Abd el-Qurnah, Geographical Information System for the Theban Necropolis* (http://spinner.cofc.edu/olgis/survey/).
Pimpaud, Alban-Brice
2012 "Une carte archéologique de Thèbes-Ouest: élaboration d'un SIG pour la connaissance du patrimoine thébain", Archeologia e Calcolatori supplemento 3, pp. 175–184.
Posener–Kriéger, Paule
1976 *Les archives du temple funéraire de Néferirkarê–Kakaï (Les Papyrus d'Abousir): traduction et commentaire*, Le Caire: Institut français d'archéologie orientale [Bibliothéque d'étude 2].
Posener–Kriéger, Paule – Verner, Miroslav – Vymazalová, Hana
2006 *The Pyramid Complex of Raneferef. The Papyrus Archive*, Prague: Charles University in Prague [Abusir X].

Radwan, Ali
1991 "Ein Treppengrab der 1. Dynastie aus Abusir", Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo 47, pp. 305–308.
2000 "Mastaba XVII at Abusir. Preliminary results and general remarks", in: Bárta, Miroslav – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2000*, Prague: Charles University in Prague, pp. 509–514.
Ricke, Herbert
1965 *Das Sonnenheiligtum des Königs Userkaf. Bd. I Der Bau*, Kairo: Schweizer Institut [Beiträge zur ägyptischen Bauforschung und Altertumskunde 7].
Ricke, Herbert
1969 *Das Sonnenheiligtum des Königs Userkaf. Bd. II Die Funde*, Wiesbaden: Steiner [Beiträge zur ägyptischen Bauforschung und Altertumskunde 8].
Schäfer, Heinrich
1908 *Priestergräber und andere Grabfunde vom Ende des Alten Reiches bis zum Griechischen Zeit vom Totentempel des Neuserrê*, Leipzig: Hinrichs [Ausgrabungen der Deutschen Orient-Gesellschaft in Abusir 1902–1908. Bd. II].
Sethe, Kurth
1889 "Die Heiligtümer des Re im Alten Reich", Zeitschrift für Ägyptische Sprache und Altertumskunde 27, pp. 111–117.
1917 "Ein ägyptisches Denkmal des Altem Reichs von der Insel Kythera mit dem Namen des Sonnenheiligtums des Königs Userkef", Zeitschrift für Ägyptische Sprache und Altertumskunde 53, pp. 55–58.
Silverman, David
2009 "Non-royal Burials in the Teti Pyramid Cemetery and the Early Twelve Dynasty", in: Silverman, David – Simpson, William Kelly – Wegner, Josef (eds.), *Archaism and Innovation: Studies in the Culture and Society of Middle Kingdom Egypt*, New Haven: Yale University Press, pp. 47–101.
Stadelmann, Rainer
2000 "Userkaf in Saqqara and Abusir. Untersuchungen zur Thronfolge und der 4. und frühen 5. Dynastie", in: Bárta, Miroslav – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2000*, Prague: Charles University Press in Prague, pp. 529–542.
Tallet, Pierre – Marouard, Gregory
2016 "The Harbor Facilities of King Khufu on the Red Sea Shore: The Wadi al-Jarf/Tell Ras Budran System", Journal of the American Research Center in Egypt 52, pp. 135–177.
Theis, Christoffer
2009 "Die Pyramiden der 13. Dynastie", Studien zur Altägyptischen Kultur 38, pp. 311–342.
Verner, Miroslav
1992 "Archaeological Survey of Abusir", Zeitschrift für Ägyptische Sprache und Altertumskunde 119, pp. 116–124.
1994 "Abusir Pyramids. Lepsius no. XXIV and no. XXV", in: Berger, Catherine – Clerc, Gisele – Grimal, Nicolas (eds.). *Hommages à Jean Leclant*, Cairo: Institut français d'archéologie orientale [Bibliothéque d'étude 106], pp. 372–374
1995 "An Early Old Kingdom Cemetery at Abusir", Zeitschrift für Ägyptische Sprache und Altertumskunde 122, pp. 78–84.
2000 "Who was Shepseskara and when did he reign?", in: Bárta, Miroslav – Krejčí, Jaromír (eds.). *Abusir and Saqqara in the Year 2000*, Prague: Charles University in Prague, pp. 581–602.
2001 *The Pyramids. The Mystery, Culture and Science of Egypt's great Monuments*, London – New York: Grove Press.
2014 *Sons of the Sun. Rise and Decline of the Fifth Dynasty*, Prague: Charles University in Prague, Faculty of Arts.
Verner, Miroslav – Hašek, Vladimír
1981 "Die Anwendung geophysikalischer Methoden bei der archäologischen Forschung in Abusir", Zeitschrift für Ägyptische Sprache und Altertumskunde 108, pp. 68–84.
Vyse, Howard
1842 *Appendix to Operations carried on at the pyramids of Giseh in 1837 containing a survey by J. S. Perring. Vol. III*, London: Weale.

Abstract:

The sites of Abusir and Abu Ghurab, with their unique mingling of funerary and religious architecture, and the incredible heritage of written papyrus documents, represent a crucial area for the understanding of the historical, architectural and religious evolution of Old Kingdom Egypt. However, many of their topographical and archaeological features remain unclear, especially as regards the identification of the four missing sun temples, which are documented in textual sources of the time but have been never located. The present article wishes to further our knowledge of the sacred landscape of the area during the Fifth Dynasty thanks to the combined analysis of archaeological data, the historical cartography of the area, and new remote sensed imagery.

Abusir – Abu Ghurab – sun temples – Lepsius XVI – Lepsius XXVIII – remote sensing – satellite imagery – historical cartography

Massimiliano Nuzzolo
(*massimiliano.nuzzolo@ff.cuni.cz*)
Czech Institute of Egyptology, Faculty of Arts, Charles University
Patrizia Zanfagna
(*patrizia.zanfagna@comune.venezia.it*)
Municipality of Venice, Italy, Office for Architecture, Territorial Planning and GIS-systems