

## SUN TEMPLE OF NIUSERRA IN ABU GHURAB: REPORT OF THE SEASON 2018-2019

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### Introduction (*R. Pirelli*)

In recent years the re-excavation and re-consideration, in the light of new archaeological methodologies and technologies, of ancient monuments, already discovered at the turn between the Nineteenth and the Twentieth century, has become an important avenue of research in Egyptology. One such case, which has got important echo in the media and newspapers, has been the tomb of Kairsu, in the central necropolis of Abusir, nearby the Fifth Dynasty pyramid of Neferirkara. The tomb, only briefly explored by Ludwig Borchardt in the early years of the Twentieth century, has been in fact completely re-excavated by the Czech mission working in the site during the 2018 season, with surprising discoveries (*Bárta et alii* 2020, esp. 36, n. 2).

A similar case is represented by the sun temple of Niuserra in Abu Ghurab which has undergone in the last 10 years systematic re-investigation and re-excavation by means of the archaeological mission from Università degli Studi di Napoli "L'Orientale"<sup>1</sup>. Works in the area started in 2010 and after some interruption during the years 2011-13, due to the Arab Spring, continued in 2014-15 and then in 2017-19.

The first campaigns had the purpose to re-consider the data already available on the spot, in particular with the aim to study, document and virtually reconstruct the original structure of the whole temple complex (upper temple, causeway and lower temple) (*Nuzzolo, Pirelli* 2011; *D'Andrea et alii* 2014). Borchardt's reconstruction of the monument was in fact not fully convincing in many aspects, without considering the fact that he never approached subjects which are pivotal for current archaeological and Egyptological research, e.g., the study of the material culture.

These first documentation campaigns had important effects also on the preservation of the site. During the years 2011-13, when the mission was not active in the site, the temple unfortunately underwent several attacks by looters and plunders, which provoked the damage, and sometimes even the loss, of important - actually unparalleled - architectural remains. In this sense, the very first documentation work in the temple done, in two phases (January and December) in the year 2010, before the Arab Spring, was pivotal to document the original shape of the stairway leading to the roof of the storehouse, later completely destroyed, as well as the central alabaster altar, which was only damaged and then partially restored (*D'Andrea et alii* 2014, 73, 76, figs. 28-30).

During the campaigns 2014-15, therefore, the main goal of the mission was to re-document the entire temple complex from the scratch, with the aim to scan the visible structures in order to have a new and complete documentation of this unique monument of ancient Egypt. At the same time, an overall re-consideration of the temple complex and its main components, from both an architectural and symbolic standpoint, was carried out, with the aim of traditional archaeological field-work and, first and foremost, by means of an in-depth architectural analysis of the existing material. The latter, however, was also accompanied by the use of new methodologies of documentation and technologies of virtual reconstruction, such as the BIM (Building Information Modeling), which gave a dramatic escalation to our work in terms of quality and variety of the analysed and collected data (*Bosco et alii* 2018; *Bosco et alii* 2019).

Finally, in 2017, we started with the real re-investigation of the temple by means of an accurate cleaning of the wind-blow sand which had been deposited on the site since its first excavation in the years 1898-1901 as well as, when necessary, with small sondages in targeted areas of the complex (*Nuzzolo et alii* 2018). This new phase of our sun temple investigation and documentation - that was well continued, with other targets, into the years 2018-19 - was also possible thanks to the external support of a wider research project conducted by one

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<sup>1</sup> Mission co-directors (concession of the Egyptian Ministry of State for Antiquities and Tourism): Rosanna Pirelli and Massimiliano Nuzzolo. The project is granted by the Italian Ministry of Foreign Affairs and International Cooperation and by the Interdepartmental Centre for Archaeological Services, Università degli Studi di Napoli "L'Orientale" (Scientific Responsible: Andrea D'Andrea).

of the present writers (Massimiliano Nuzzolo) at the Czech Institute of Egyptology, Charles University, Prague<sup>2</sup>.

Before dealing in more details with the core of the last 2018-19 season, we will provide here a brief summary of the main results and activities of the previous seasons, especially of those which are fundamental for the overall understanding of the temple complex and have not been included in the reports already published of this Newsletter on the past campaigns.

#### THE 3D SURVEY OF THE SUN TEMPLE: SEASONS 2010-17 (A. Bosco, A. D'Andrea)

In 2010 a survey project was launched with the aim to provide a digital replica of the monument as well as to check the graphical documentation provided by Borchardt. The research program was not focused on the investigation of the digital object from a mathematical point of view, but rather on the need to reconstruct a virtual environment in which displaying the existing archaeological remains of the sun temple from different perspectives. In order to evaluate in a better way some features of the monuments, such as basic measurements (height and width, slope and inclination), the survey was carried out by different 3D equipment, such as laser scanner and photogrammetry. These technologies, whose outputs can be easily merged, have provided high-resolution replicas that can be shown in a virtual space to highlight possible relationships among architectural components belonging to such a complex monument. Differently from the modelling approach, typical of the 3D reconstruction process, the methodology based on 3D reality deals with the accuracy of the geometry of the replicas, thereby providing the opportunity to test alternative hypothesis based on scientific measurements. The digital object can be used to propose the possible original shape of the temple but also to obtain a more in-depth view of the architectural layout of the monument for any restoration project. Finally, these technologies allow a quicker and accurate data-acquisition that can be completed within a single season of two or three weeks of field-work. Over these 10 years of works various equipment were used also with the aim of testing different methodologies in the field of the data-collecting and processing; to manage this huge amount of collected data coming, an information system has been

implemented, replaced recently by a more accurate approach (D'Andrea *et alii* 2014; D'Andrea *et alii* 2018; Bosco *et alii* 2019).

The first survey campaigns dated back to 2010, through two on-site missions carried out in January and December. The objectives of the first year were limited to the acquisition of the main components of the temple: the chapel and the room of the seasons on the southern side; the warehouse on the North-eastern side; the area of the "obelisk structure" (see below for this definition) to the West; the altar in the central courtyard. In total 47 scans were shot with a Zoller & Frohlich Imager 5003 (Fig. 1), a weighted phase-based laser scanner. The alignment of these scans was carried out by a topographic network implemented by means of a total station. Unlike current technologies, the laser scanner used in 2010 did not include a digital camera for the acquisition of the colour data. Therefore, in order to create the necessary textures for a photorealistic three-dimensional replica of the temple, an accurate photographic campaign was also carried out. To ensure the accuracy of the subsequent alignment and registration phase, a numbering system for shots, targets and photos was defined. This approach allowed a correct post-processing phase enabling a precise roto-translation of the shots and the final texturing of the point-clouds. From the 3D replica, some graphic information, such as plans and sections, were extracted documenting the state of conservation of the monument. The results of these first two campaigns were encouraging, as they allow to determine the correct measurements of some not clear parts of the temple.

In the 2014 season a new laser scanner (Faro Focus 3D X130) was tested in combination with a complete photogrammetric campaign done with the aim to provide a more detailed and realistic 3D replica of the temple. To avoid the use of the topographic grid installed in the previous mission - fearing that in the meantime it had also been partially removed - a more accurate and precise phase shift-based laser scanner was used. This instrument was much lighter than the previous one and equipped with a digital camera. Moreover, the software of the laser scanner allowed to align automatically the shots with a good level of reliability without any topographical references (Fig. 2). The main target of this mission was the execution of new scans to integrate the previous survey and the conclusion of the data acquisition of the entire area. As one of the main issues was the integration of data collected in the previous season, the first scans were aimed at capturing some geometrical features visible in the replica carried out in 2010. In the post-

<sup>2</sup> Project title: "Rise and Development of the Solar Cult and Architecture in Third Millennium BC Egypt", funded by the Czech Science Foundation - Grant Agency of Czech Republic (GAČR), project no. 17-10799S - duration 2017-2019: <https://cegu.ff.cuni.cz/en/research/grants/the-rise-of-solar-cult/>.

elaboration phase it was then possible to merge all the scans and compare possible inconsistencies. Furthermore, the new point-cloud representing the whole monument could be used as 3D grid to scale and rotate the point-clouds obtained by the photogrammetry or by new laser scanner data-acquisition campaign. The survey covered three macro-areas: the base of the “obelisk structure”; the area around the altar; the whole surrounding wall of the monument; the main door of the temple. In total 56 scans were shot in 6 days. For some areas, which presented a particular complexity or the presence of inscriptions or decorative elements, the laser scanner was integrated with a photogrammetric acquisition. This technique, carried out by a Canon 450D reflex camera with an 18mm lens, was used to survey: the main entrance gate of the temple; the area of the alabaster basins (Fig. 3); the so-called “purification area”; the South-western corner of the “obelisk structure” (see further below for definition of the last two areas). The photos were processed by means of a well-consolidated methodology. For the scaling and roto-translating of the point-clouds of each single area, the 3D grid provided by the laser scanner was employed. From the whole point-cloud of the temple we extracted the coordinates necessary to geo-reference the replicas obtained by the photogrammetry. At the end of the processing, 4 high-resolution 3D replicas were provided: main entrance gate, 620 photos (97,295,254 triangles); area of the alabaster basins, 400 photos (55,897,717 triangles); “purification area”, 600 photos (31,086,761 triangles); South-western corner of the “obelisk structure”, 690 photos (20,000,000 triangles). All the shots and the replicas obtained by the SfM (Structure from Motion) technique have been geo-referenced and integrate in a whole model assembled by the geometry of the laser scanner enriched by the high-resolution image provided by the photogrammetry.

The third survey campaign, conducted in 2017, was addressed to document the archaeological evidence brought to light during the cleaning of some architectural elements that were no longer visible. This activity involved the southern corridor of the temple; the western and southern sides of the “obelisk structure”; the North-eastern corner of the temple; the whole area of the storerooms. Furthermore, the survey affected the northern artificial terrace supporting the monument as well as the causeway going from the valley temple to the main entrance gate of the upper temple. During this season a new methodology was tested, which is based on the exclusive use of photogrammetry without laser scanner. Taking into account the targets of the field-work, that were focused on small

sondages and cleaning of some parts already investigated by Borchardt, we decided to use an Osmo DJI, equipped with a Sony X3 sensor. This tool, mounted on a light telescopic pole (2.5-3m height), allowed to shoot photos in a fast way guaranteeing a good level of superimposition among the different images; a gimbal, assembled in the device, ensuring the stabilization of the shooting avoiding blur effects (Figs. 4-5). For the digital replica of some inscribed blocks not *in situ* a Nikon D750 full-frame reflex camera was used. This 24.3-megapixel camera allowed the acquisition of very high-resolution photos useful for the reproduction of millimetric details in 3D. About 20 granite and quartzite blocks were surveyed by the Nikon (Fig. 6); they once belonged to the “obelisk structure” and the storerooms, and all showed specific peculiarities, such as traces of the hieroglyphic inscriptions and/or unique architectural details (e.g. door hinge marks). Additionally, we also documented photographically the limestone basins of the northern “slaughterhouse” or “purification area” as well as the walls of the two side (northern and southern) corridors leading inside the temple from the main gateway. The point-clouds generated by this photogrammetric campaign were scaled and roto-translated on the basis of the coordinates extracted from the whole 3D model carried out during the previous campaigns. This method allowed a precise integration among the different models created in all the different seasons.

In ten years of field-works, conducted in the course of the different campaigns, a full 3D strategy has been set-up: more than 100 scans and 5.000 photos have been carried out and a complete replica of the Temple has been provided. The digital object, reproducing in details a particularly complex and rich monument, can be easily explored and examined. From the virtual model it is possible to extract measurements of whatever part of the temple and to analyse, in-depth, any of its architectural components. This approach enables to speed the works on the field by separating the acquisition phase carried out in Egypt by the processing steps achieved in Italy. The creation of a good topographical network, even if virtual in the case of the temple of Niuserra, support all the following phases (alignment, registration, merging of the scans and the photogrammetric replicas) that could be realised in the laboratory at the end of the on-site survey.

Additionally, since 2010 an information system has been implemented to manage this large *corpus* of spatial data. A GIS was developed at the beginning of the project to compare the results coming from the digital acquisition with the plans

provided by Borchardt. The increasing number of scans, photos and data describing the monument, required the development of more powerful management systems. The next section describes the challenge of the implementation of a BIM to handle all the data collected in the field, standardise them and finally enable a virtual reconstruction of the given monument based on transparent data available for, and usable by, all scholars.

THE ABIM DEVELOPMENT (A. Bosco, A. D'Andrea, P. Zanfagna)

Since the first campaign, it was clear that traditional systems for the management and analysis of data surveyed by 3D reality-based technologies were not effective to support an ambitious project aimed at offering new reconstructive hypothesis.

After an initial attempt to deal with the data by a standard GIS, this solution was abandoned. As a GIS manages mainly 2D objects, the richness of the 3D replica, obtained by a laser scanner, had to be reduced into more manageable drawings, such as plans, sections and elevations. Even if this approach enables a good management of the spatial and textual information providing significant thematic maps, one of the limits of GIS lies on the 2D visualisation and, mainly, on geospatial services and infrastructures in relation with the Earth's surface. Even if GIS can manage multiple datasets and work as a data unifier encouraging users to integrate and share easily their spatial data, this technology does not offer a detailed 3D visualisation and is not able to organize huge volume of data related to a building.

For this reason, since 2014 the implementation of a BIM emerged as an effective solution to manage all the information acquired during the on-field activities, both the 3D data and all the field notes provided by the archaeologists. Furthermore, unlike traditional modelling technique based exclusively on the geometrical reconstruction of a building, a BIM is a complete information system containing parametric objects, geometries, materials, textures. Currently BIM is a standard to manage the whole life cycle of a building involving the contribution of different experts.

As the BIM has been not properly designed for the archaeological objects, one of the main challenges is to adapt this approach to the needs of the historical analysis. This has led to the creation of an ABIM (Archaeological BIM), which has been set-up to combine the digital survey with the parametric reconstruction of archaeological structures, often preserved for few centimetres. In this perspective, ABIM represents a way to share, in a virtual environment, all the data (photos, drawings,

descriptions, annotations) related to a monument; it works as big repository linking whatever type of data to one another, and constituting the base of a reasonable, transparent and verifiable reconstruction of the archaeological evidence.

In order to implement an ABIM for the sun temple of Niuserra, the monument was thus analysed to facilitate the composition and decomposition of all the architectural elements according to different levels of detail of representation. This step, so-called reverse-engineering, aimed at identifying the phases of the construction design ranging from individual blocks to the whole building. The process focuses on the creation of a digital model, assembled by different objects (walls, floors, roofs, architraves, columns, bases, doorsteps, etc.), starting from the point-clouds (see also Bosco *et alii* 2019, 163-171).

In the first campaigns the scans were mainly used to extract 2D outputs (sections, plans, elevations) finalised to document the monument and its state of conservation, whereas BIM enables a deeper workflow through the creation of parametric 3D objects enriched by a formalised description. The whole point-cloud was imported into Autodesk BIM software, Revit Architecture, and used to model a plan-volumetric base supporting the decomposition of the design of the temple. To create the parametric objects from the scans, a hierarchy of the various architectural elements was identified according to the semantic concepts (categories, families, types, instances) managed by Revit. As the software has been designed for modern buildings, specific archaeological categories, describing the architectural elements of the Temple, were created and mapped on the standardised libraries provided by Revit. These new categories were associated to the components of the technological and constructional system underlying the model. This hierarchical organization eventually contributed to the formal and physical description of the 3D reconstruction of the monument. The 3D survey was used as precise and geometrical reference for the implementation of the parametric objects (as-built process); then, each object was assigned to a specific category and detailed information associated (code, material, dimensions and origin) (Fig. 7). The implementation of a specific library is linked to a precise level of decomposition of the archaeological structure identified by a "Level of Detail" (LoD). In order to enrich the description of the parametric objects, another library was set-up for the documentation of the ancient building materials. At the end of the BIM implementation process, the resulting model offered the opportunity to deepen some open questions on the reconstruction of some crucial parts of the monument, as well as to provide

some suggestions for virtually rebuilding the temple (Fig. 8).

One good example of this procedure is the reconstruction, done during the third campaign, of some collapsed blocks originally belonging to the casing of the South-western corner of the “obelisk structure”. These blocks, all composed of fine white limestone and characterized by considerable dimensions, were surveyed and imported into Revit. The blocks were then assembled to fill the missing elements of the “obelisk structure” - notably its South-western façade - and suggest a final reconstruction. Furthermore, by assigning correct geographical coordinates, it was possible to geo-reference the monument and visualize it in a simulated landscape in order to check the orientation of the temple and connect it with any astronomical investigation. Last but not least, it was possible to simulate and evaluate other natural phenomena, such as rainfall and wind or the effect on the monument of earthquakes. The overlapping of these features on the surrounding landscape, even if modern, eventually also allowed to better understand the artificial terrace systems carried out for the foundation of the temple<sup>3</sup>.

As it is logical to imagine, not all issues have been so far tested and solved by means of this new BIM approach. However, BIM has undoubtedly demonstrated to be a fundamental tool for a clear and accurate 3D reconstruction of the monument as well as for its final presentation and verification in the scientific milieu. Additionally, to the traditional 3D techniques, addressed to the geometrical reconstruction of a monument, the ABIM adds the potentiality of a 3D tool provided with the taxonomy of each construction element, that gives us, at the end of the process, a transparent archaeological model. Of course, the lack of automatic and/or semi-automatic procedures to transform the point-clouds in parametric objects and the absence of standardised libraries does not facilitate the implementation of the ABIM, which thus still presents criticalities in its construction and implementation. Nevertheless, the case-study of the sun temple of Niuserra demonstrated that the creation in the future of shared semantic and parametric libraries will encourage the development of ABIM, especially in terms of designing specific libraries and identifying adequate level of reliability, as the transformation of archaeological data into digital objects will involve always an high and intrinsic level of uncertainty.

<sup>3</sup> For a more detailed analysis of this part of the BIM investigation and reconstruction, with all future potentialities for the site, see Nuzzolo et alii 2018, 51-56.

#### SEASON 2018-19 (M. Nuzzolo)

The Italian Mission at the sun temple of Niuserra in Abu Ghurab conducted its sixth and seventh season's work in the time span December 2018 - March 2019<sup>4</sup>. In a line of continuity with the previous seasons, and especially with the 2017 season (Nuzzolo et alii 2018), the main goal of the 2018-19 campaign was to complete the study, documentation and drawing of the temple architecture and archaeology, in order to finalize the new general plan and 3D reconstruction of the temple's complex started in 2010. For this reason, attention was focused on three specific areas of the temple, which have never been re-investigated since Borchartd's time:

1. the South-eastern corridor, which leads from the main entrance of the temple to the “obelisk structure” (Nuzzolo 2018, 214-222);
2. the so-called “Room of the Seasons”;
3. the North-eastern sector of the complex, namely the area characterized by the presence of the secondary entrance of the temple and the alabaster basins of the so-called “slaughterhouse” or “purification area” (Nuzzolo 2018, 234-242).

At the same time, during this campaign we also began the investigation of two completely new avenues of research:

- A. the survey, study and documentation of the material culture, especially pottery, accumulated since Borchartd's excavation, both inside and outside of the main enclosure wall of the temple, and never investigated before;
- B. the topographical survey and geo-magnetic investigation of the area immediately to the South of the enclosure wall of the temple and of the valley area to the South-East of the temple complex.

Methodologically, a crucial aspect of the 2018-19 season was the use of the reference numbers (squares) introduced by Borchartd in his ground plan of the temple (Borchartd 1905, Bl. 6.) besides the more standard geo-topographical and/or contextual definitions of the temple spaces employed so far (e.g. entrance gate, southern corridor, room of the seasons, etc, see pl. 1). This was done with the primary purpose of creating a link, and a clear overlap, between the past investigation (and the plan) of the German scholar and our new research and plan. As we shall see below, this link eventually revealed useful not only for the precise contextualization of the material

<sup>4</sup> The first season was conducted only for one week in early December (2-9) 2018 for the late concession of the permission of work and security clearance. The second longer season, instead, was carried out from February 16 to March 14, 2019.

culture - for which it has been originally introduced by us given that the material culture had been completely neglected by Borchardt - but also for a better contextualization and mapping of the whole archaeological - architectural dataset of the sun temple, especially of the newly discovered one, that had so far no mention in the old (Borchardt's) documentation/map. In a GIS-based environment, as the one we are working with, this finally creates what is usually defined as the historical GIS, which acts on both a horizontal (maps and plans) and vertical (stratigraphy and contexts) levels.

#### ARCHAEOLOGICAL INVESTIGATION OF THE SOUTH-EASTERN CORRIDOR (M. Nuzzolo, P. Zanfagna)

During this campaign we carried out the cleaning and archaeological - architectural study of the South-eastern corridor which leads from the main entrance of the temple to the "obelisk structure". This area, about 60m long and 3m large, has never been investigated since Borchardt's time. Accumulation of wind blow sand in some sectors of the corridor, especially the South-eastern corner, was considerable so as to require an accurate cleaning to allow us to complete the study of the architecture of the area and the drawing of both the walls and the slabs of the floor pavement.

Moving from the temple entrance southwards, we investigated the corridor in two phases: the first one was devoted to the analysis of the eastern branch of this corridor, up to the South-eastern corner. In this area, in fact, based on Borchardt's plan and publication, we expected to find extensive and well-preserved traces of the temple structure in both elevation and plan, particularly the temple pavement. Also, the accumulation of wind-blow sand in this sector of the corridor was not as extensive as in the rest of the corridor. We thus did not expect to discover here significant architectural remains hidden below sand and/or abundant traces of the temple material culture.

The second investigation phase was instead reserved for the rest of the southern corridor, up to the entrance of the so-called "Room of the Seasons". In this part of the corridor, according to Borchardt's plan and publication, the deterioration of the temple structures (esp. the pavement) was more systematic, leading us to imagine here a significant accumulation of the original material culture of the temple. Additionally, in some parts of this area, the accumulation of wind blow sand over the last 100 years had reached the significant level of about 2m above the central courtyard level. Therefore, particularly in this second area, we moved slowly, with a systematic sieving of the sand seeking for

both architectural - decorative remains and/or ceramic finds.

As to the first area (eastern branch of the corridor and South-eastern corner), we could investigate and better understand the structure of the wall masonry which, in this area, similarly to what we have in other spaces of the temple (e.g. the storerooms, already largely investigated in the past), is built up with the so-called *emplekton* technique: large slabs of white and high quality (probably Turah) limestone (20cm large and 60cm high) which embedded a central core masonry (about 1.5m in width), composed of yellowish limestone slabs of minor quality, probably coming from local quarries (Fig. 9).

In this area the slabs of the pavement were almost all still in situ and this allowed us to verify the presence of traces of later occupation of the temple. Small fire places, which left intense black colour traces on the pavement slabs, were in fact found in the South-eastern corner, as well as traces of small rounded holes inset into the slabs of the pavement and only 1-2cm deep, which had been probably used as crushing areas for grain or other material consumed on the spot (Fig. 10). These archaeological remains would lead us to imagine that domestic activities of burning and cooking had taken place here, possibly connected with temporary dwellings created in this corner area of the temple. Being set in the corner, this area was in fact evidently more protected by the atmospheric agents and the action of the wind than the rest of the temple and, thus, possibly, more suitable for any sort of domestic activities. Similar traces of later occupation were found also at the end of the southern corridor, immediately before the entrance of the "Room of the Seasons", again in an angular area, more protected than the rest of the temple spaces. In both cases, however, it is impossible to establish a precise date for these domestic activities, considering that only a few pot sherds have been found here, in a fully disturbed context, and they range from the typical Fifth Dynasty beer jars to much later (even Roman) pottery.

One further piece of evidence also deserves a mention here, namely the accumulation of pot sherds - all of small dimensions and very fragmentary - in two small gaps [context unit 1009 and 1012] of the pavement slabs (square M14) next to the South-eastern corner of the southern corridor (Fig. 11). The kind of material accumulated here, mostly late Fifth and early Sixth Dynasty beer jars, seems to demonstrate that ritual (but maybe also domestic) activities were still going on during the above period, but also that the temple structures were undergoing a process of abandonment, deterioration

and eventually re-occupation quite early, probably already one or two generations after the reign of Niuserra. This seems to indirectly confirm what we knew already after the textual sources, e.g. the biographic texts of priests and officials working at the sun temple, who are mostly dated from Niuserra's time and up to, at the latest, the early reign of Teti (Nuzzolo 2018, chapter V, tabs. 1-3).

As to the second area of investigation (the true southern corridor), we have got quite new and unexpected results. In fact, as recorded in Borchardt's plan, the central part of the southern corridor was very badly preserved, with most of the fine white limestone slabs of the pavement already removed in the antiquity, evidently for the reusing of the material (Fig. 12). Fragments of some of these crashed slabs are still visible in the corridor, usually laying along the western part of the wall masonry. Besides these limestone slabs, some large fragments of granite and quartzite were also found in this structural collapse although it is hardly imaginable that these pieces did belong to the original architecture of the corridor. Rather they might be pieces originally standing in the adjacent "Room of Seasons", which is about 20m to the East of the area where the granite/quartzite pieces were found. As we could ascertain already during the previous campaigns, the "Room of Seasons" was in fact endowed with a large decorative program, which also included the use of valuable construction stones, some of which - especially granite - are still lying in their original spot (see below).

The archaeological evidence would thus lead us to conclude that the southern corridor was used already in the antiquity to move construction stones from the "Room of Seasons" - and from the "obelisk structure" - to the outside of the temple to be cut and reused. In some occasions, as the one we are discussing here, these stones might have got broken (weather intentionally or unintentionally it is not possible to say) and then left on the spot where we found them.

In terms of architectural comprehension of the temple construction, the absence of the limestone slabs of the pavement has allowed us to investigate the structure of the preparatory foundation level of the corridor which is not visible elsewhere in the temple. This is extremely interesting to understand how the whole temple's structure was set out by the ancient architects. This foundation level (square M9-10) is composed of a number of slabs of yellowish local limestone set up irregularly to support the main enclosure walls of the temple as well as the inner wall of the corridor [context unit 1039]. In several cases these slabs are not perfectly adjoining and the gap is filled with crushed pieces of limestone or,

more frequently with mud, either unshaped or as full bricks.

In the centre of the southern corridor (squares M9-10), at approx. 13.5m from the entrance of the "Room of the Seasons", we also found the remains of a completely different structure made of mudbricks [context unit 1038] (Figs. 13-14). The preserved part of this structure is composed, in plan, of 9 courses of mudbricks, arranged according to a pattern of one stretcher and 2 headers<sup>5</sup>. This is a bonding structure which can be also found in the North-eastern sector of the sun temple (see also Borchardt 1905, 67, Abb. 53), as well as in other contemporary royal monuments in the Abusir necropolis (Verner 2006, 113-137). The preserved part of the wall has an overall dimension of 3.32×0.63m and is perfectly aligned along the main temple enclosure wall (East - West). Only two layers of this brick wall are preserved; the average size of the bricks is 40×20×8cm - which is also very similar to the size of the mudbricks of the building found in the North-eastern sector of the temple (see further below) - but often these bricks were not perfectly rectangular, having dimensions of 36×18cm and 37×16cm.

From an architectural standpoint, it is certainly of some interest to note that, adjoining this mudbrick structure [context unit 1038], to the South, we found a part of the foundation layer of the southern corridor [context unit 1039] characterized by a different composition with respect to the same layer in the rest of the southern corridor. In fact, this layer was composed of small slabs of whitish limestone (instead of the previously-mentioned big slabs of yellowish limestone) mixed with chops of crushed limestone, dark sand and unshaped mud, the latter evidently put in place to level the space between the stone part of the foundation layer itself and the mudbricks structure [context unit 1038] described above.

Finally, what is particularly noteworthy here is the presence of a small pit filled with miniature bowls and ashes (Fig. 15) at the edge (South-western corner) of this mudbricks structure [context unit 1038]. Notably, eight intact miniature bowls were found, as well as fragments of two or possibly three more bowls, all produced in a rough red clay and not plastered. Together with them, remains of a rough beer jar were also found. As shown by the archaeological evidence, the position of this pottery is not a matter of chance, or the output of a later

<sup>5</sup> Given that only 2 layers of bricks are currently preserved it is not possible to specify which kind of bond was used here. The three types of A2, A4 and A5 are equally plausible based exclusively on their plan. See also Spencer 1979, 136-139 and pls. 1-4.

occupation of the temple (as it is instead the case of the South-eastern corridor described above), but clearly the result of an intentional ritual/ceremonial activity, which should be certainly connected to a specific moment of the temple construction, possibly to be identified, according to the present writer, as the end of the use of the mud bricks structure followed by its ritual burial below the new stone temple pavement.

Similar pottery findings, with ritual accumulation of miniature bowls, are quite common throughout the Memphite necropolis - including tombs in South Abusir, contemporary with the sun temple<sup>6</sup> - and peculiar examples can also be found in the other so far known sun temple of Userkaf (see Kaiser 1969, 75). In the latter case, however, the pottery (esp. these miniature bowls) has not been found in an intact context, as in our case, and no context analysis - or picture - of this kind of findings has been published. This makes the material collected in Niuserra's sun temple extremely interesting because for the first time we have not only a very valuable term of comparison with the other sun temple but also a first-hand archaeological context and a primary source for the understanding of the cultic activities performed in the solar sanctuaries.

What the function of this mudbrick structure [context unit 1038] was, remains unclear. Given the size of the mudbricks, which is the same as those of the mudbrick structure or "Pre-temple" (see below for this definition) investigated in the North-eastern sector, the first hypothesis that comes to mind is that this mudbrick structure [context unit 1038] may be one of the walls of the "Pre-temple". However, we have to notice that what remains of the mudbricks structure [context unit 1038], in at least one point, seems to lean on the limestone slabs of the foundation layer and not *vice versa*. This would seem to indicate that this structure [context unit 1038] was later than the stone foundation layer [context unit 1039], although a definitive answer to this question might come only from a more in-depth excavation of the area.

For the moment, therefore, the most suitable option is that this brickwork is what remains of a construction ramp for the transportation of the heavy blocks of limestone and granite towards the "obelisk structure". Traces of other similar ramps are visible all over the central courtyard as well as in the already mentioned mudbrick structure or "Pre-

temple" (see further below), although we have to notice that these ramps are always transversal (North-East - South-West) with respect to the temple orientation (East-West), whereas the mudbrick structure [context unit 1038] located in the southern corridor is perfectly aligned with the main stone enclosure wall of the temple along the East-West axis. We can thus only hypothesize that part of the mudbricks structure or "Pre-temple" of the North-eastern sector of the temple was at a certain moment dismantled, and its bricks reused for the construction of this ramp in the southern corridor.

Whatever the interpretation we provide of this still enigmatic brickwork [context unit 1038], what is more important to remark here is that Borchardt did not record at all its existence, either in the main text of his publication or in the general plan of the temple. This opens several questions on the accuracy of the work carried out by Borchardt in this area of the temple when we consider that, as already recalled above, in other areas of the temple (e.g. the central courtyard and the area around the alabaster basins) he did in fact document the existence of the mudbrick structures.

#### ARCHAEOLOGICAL INVESTIGATION OF THE "ROOM OF THE SEASONS" (M. Nuzzolo, P. Zanfagna)

The so-called "Room of the Seasons" is the last chamber before approaching the "obelisk structure" on the southern side. This elongated room, 12×3m, oriented North - South, is directly connected to the southern corridor, from which it can be accessed on its eastern side. The "Room of the Seasons" thus represents a natural extension of the southern corridor, directly interconnecting it with the sacred space of the "obelisk structure", the primary element of the temple architecture.

The "Room of the Seasons" had already been superficially cleaned in the 2014 campaign, when we carried out the first laser scanner documentation, with textures features, of the whole temple (see above). In 2018, however, within the framework of the new project carried out in Charles University, we started the photogrammetric documentation of all the decorated slabs and fragments once adorning this room's walls. In July 2018 we documented the material kept in the Berlin museum whereas in October 2018 we proceeded with the Cairo museum material. In order to be able to put this decoration back on its original walls by means of a 3D virtual reconstruction and anastylosis of the decorated blocks, we then decided to carry out, in 2019, another cleaning of the "Room of the Seasons", followed by a new photographic/photogrammetric documentation campaign. Additionally, we planned to have a more in-depth investigation of the

<sup>6</sup> In the tombs of South Abusir, contemporary with the sun temple of Niuserra, these miniatures bowls are even more remarkable, in terms of manufacture, being very often done in stone (mostly limestone and/or alabaster).

architecture of the room, especially of its northern end (i.e., the approach to the “obelisk structure”) where no traces of the pavement are preserved and where Borhardt’s reconstruction is not fully clear. Last but not least, by means of this new photogrammetric campaign of the room, we would have been to get a single dataset, with equal textual features and resolution, of the ensemble “entrance gate-southern corridor-room of the seasons”, something which presents undoubted advantages in terms of construction of the final 3D model.

The complete results of the photogrammetry carried out in this room, as well as its architectural analysis and the reconstruction of the original temple decoration are still a work-in-progress<sup>7</sup>. In this article, however, we wish to briefly present the discovery of a group of so far unknown decorated blocks which were found in this room.

During the cleaning of the final (northern) part of the southern corridor, in fact, we found 15 decorated pieces of variable dimensions. These pieces were inset in a gap of the pavement slabs measuring 120×70cm [context unit 1010] which was characterized by dark and compact sand but also directly covered with a subtle layer of wind blow sand [context unit 1000] of 10cm (Figs. 16-17). The area is thus not a primary, and completely untouched, archaeological context, though offering nevertheless several important information. These pieces were completely missed by Borhardt’s exploration of the room and this is even more remarkable when considering the huge amount of decorated blocks (those in the museums of Cairo, Berlin and Munich that we have mentioned above) that he found in this room as well as at the entrance of the obelisk, which is only 3.5m to the North.

All the pieces we found are small in dimensions (average size 20×20×5cm h/w/d) but characterized by exquisite manufacture, as undoubtedly testified by the gorgeous colours preserved on them, including, among others, the rare Egyptian blue. In the context of the present article, two decorated fragments are particularly interesting.

The first one (Fig. 18: exc. no. ST-C1010/12/2019) is the biggest fragment we found: it measures 46.5×33.5×12cm w/h/d and presents two decorated registers separated by a starry sky. On the first (bottom) register, a part of Niuserra’s cartouche is visible, preceded (on the left of the image) by the sign of the bee (*bity*) and below it the phonetic sign “*r*”, both evidently a part of the “*nesut bity*” title now

lost. To the right of the cartouche the remains of what seems to be a “*nesut*” sign and a phonetic “*r*”, with below the top of another not clearly readable hieroglyphic sign. On the second (top) register, the remains of 5 human legs belonging to at least 3 different (probably male) figures moving leftwards. Traces of the original colours are still visible everywhere on the fragment, with a particular concentration on the legs of the upper register and the background of the bottom register, as well as on the starry sky separating them.

The second fragment (Fig. 19: exc. no. ST-C1010/13/2019), measuring 17.5×17.5×12cm w/h/d, represents the face of a king, very likely Niuserra, looking leftwards and bearing a decorated head band, the *ureaus* and what seems to be the remain of one of the ram’s horns of the *atef* crown. In this case, too, traces of the original (esp. black and red) colours of the decorated piece are preserved.

Considering the archaeological context in which these decorated pieces were uncovered, the lack of clear information on the context in which the early blocks were found by Borhardt in the years 1898-1901, and the general state of disrepair of the area, it is difficult to say where these newly discovered pieces were originally located. Two are the most plausible hypotheses.

The first one is that these pieces may feature a similar royal iconography to what we can see in another block, once kept in Berlin (cat. no. ÄM 20052: see Fig. 20 here) and nowadays lost (Kees 1928, 41, Bl. 22). On this latter block, too, the king, facing leftwards, is represented with the *ureaus*, the ram’s horns and the *atef* crown, and his cartouche is preceded, on the left, by the “*nesut bity*” title. At the same time, we may notice that, on the right of the king’s figure, the decorative framework is different, being engraved here with the standard formula “*dj ankh djed was neb*” (given all life, stability and power) which is missing on our newly discovered fragment. The top register of the Berlin block is also decorated by some legs belonging to walking human figures (only a couple of legs in this case is still visible), which are separated by the register underneath by means of a starry sky. Unfortunately, the original location of the Berlin block is unknown, for it was found next to the South-western corner of the obelisk among the debris of the collapsed structure, and together with other decorated blocks, all evidently not *in situ*<sup>8</sup>. Nevertheless, it cannot be ruled out that both our newly discovered fragments and the Berlin one were once a part of a single decorative pattern or even of a single decorative

<sup>7</sup> Some preliminary results of this work have been recently presented in an exhibition on the Fifth Dynasty currently going on (at the time of writing the article) at the National Museum of Prague: see Krejčí, Nuzzolo 2020, 116-122.

<sup>8</sup> For wider discussion on the possible original location of the piece and its meaning see Nuzzolo 2018, 199-200.

register on one of the temple's walls, most likely the entrance corridor of the obelisk structure.

The second hypothesis is that our newly discovered fragments belonged to the decoration of the "Room of the Seasons" itself (where they were actually found) and notably to the North wall. Here, above the entrance to the obelisk, there was almost certainly a decorated block, once kept in the Berlin museum (cat. no. ÄM 20061: see Fig. 21 here) and nowadays lost, depicting Niuserra leading a procession of fecundity figures and *nomoi* (Egyptian provinces) to the sun god Ra-Harakhty, who is represented, for the first time in Egyptian history, with anthropomorphic features (Edel, Wenig 1974, taf. 24). For wider discussion on this decorated block see also Nuzzolo 2018, 195-196). On this block, only part of Niuserra's cartouche and titles survive, whereas his figure is not preserved. It has thus been suggested that the king's figure was not represented in this decorative scene (Seyfried 2019, 43-47, Abb. 10). Now, however, we can suppose that the two blocks recently discovered by the mission may in fact have originally adjoined the block kept in the Berlin museum (piece in Fig. 21), being located, respectively, above (piece in Fig. 18) and below (piece in Fig. 19) it.

#### ARCHAEOLOGICAL INVESTIGATION OF THE AREA TO THE NORTH-WEST OF THE SECONDARY ENTRANCE OF THE TEMPLE (M. Osman, M. Nuzzolo)

This area is characterized by the presence of the secondary entrance to the temple and the so-called "slaughterhouse" or "purification area" (see above for definitions of the areas), but also by the existence, underneath, of a mudbricks structure already partially excavated by Borchardt and interpreted as an earlier building phase of the later stone temple of Niuserra (pl. 1). According to what was uncovered by Borchardt, the main part of this mudbrick building appears to be aligned with the secondary entrance of the current stone temple of Niuserra (Borchardt 1905, 66-71 and Bl. 6).

When we first started our investigation of the sun temple in 2010, the remains of this mudbrick structure - that we shall call here, conventionally, the "Pre-temple", on account of its still unclear nature and significance - were already visible, on the surface, in several parts of the courtyard, especially along the eastern side of the obelisk, to the South of the central alabaster altar, and in the area around the alabaster basins of the "purification area". From what it was visible on the surface, however, it was not possible to understand either the plan of this building - that in the only picture published by Borchardt appeared to be a quite extensive structure (Borchardt 1905, 67, Abb. 54) - or the monumental

limestone threshold of its entrance, also only briefly mentioned and sketched in his book (Borchardt 1905, 66, Abb. 52). However, as it became clear especially in 2017, on the occasion of a heavy rain storm that affected the site for more than half an hour, the entire mudbricks construction was covered only by a subtle layer of yellow and fresh wind blow sand, certainly not deeper than a few centimetres.

For these reasons, in the 2019 season, we decided to start cleaning all the mudbrick structures inside the stone temple enclosure wall, in order to re-locate these remains on the new plan we are elaborating and, at the same time, clarify its real extension, something on which Borchardt did not provide clear data on his plan. Additionally, our main objective was to start the documentation and study of the material culture - esp. the pottery - associated with this area, that Borchardt, as already specified in the introduction to this article, had never studied or even collected. Last but not least, we also wished to understand the architectural and historical relation of this mudbrick structure with both the visible stone temple of Niuserra and the other mudbrick remains/structures found in other parts of the temple.

To reach these goals the investigation and documentation technology depended mainly on the systematic and mechanic cleaning process, namely in removing all the wind blow sand accumulated over the last 120 years. Once such task was completed, minor investigations and sondages took place where there was uncertainty about the spatial-architectural relationship among the diverse components. These micro investigations aimed at contextualizing what has been decontextualized by Borchardt. During this phase of the investigation, we produced drawings of the different areas by means of the SfM technology combined with photogrammetry, and we finally inserted all the acquired data in the general GIS database of the temple (see pl. 1), elaborated starting from the very first 2010 campaign (for more details on these methodological and technological aspects, see also the above paragraphs by Bosco, D'Andrea and Zanfagna).

As in the case of the southern corridor, the so-called "purification area", too, completely lacks the slabs of the original pavement. Therefore, after the removal of a thin layer of superficial wind blow sand (average depth of this layer 10cm), the old mudbrick building immediately emerged.

The features of this "Pre-Temple" are quite complex (Figs. 22-23). The building is characterized by a L-shaped entrance which leads to a courtyard of which we could ascertain only the eastern and southern limits. This L-shaped entrance space was

paved with mud on a preparatory pavement foundation, that had been found also in the courtyard area. Two more rooms on the southern side (Room-1 and Room-2) already briefly described by Borchardt and interpreted as magazines, have also been uncovered, re-drawn and added to the general plan of the temple we are elaborating. Both rooms had neither floors nor floor foundations, and were originally filled with collapse rubble, which can be seen in their eastern profile (North-South section).

The outer walls of this “Pre-Temple”, preserved up to a height of 20cm, show traces of the original yellowish mud plaster, which should have characterized the façade of the building. Traces of white mortar are also visible in some cases on the inner walls. The monumental threshold described and drawn by Borchardt at the entrance of this L-shaped passageway has also been re-found and re-documented (Fig. 24). This threshold - made in fine white limestone and measuring 2.6×3.5m, with a depth of 50cm - is still well preserved, including the big hole for the door post on its southern side.

The preserved floors of the investigated building spaces (i.e., the niched entrance portico, the L-shaped corridor and the partially explored courtyard), were constructed out with a 20cm thick foundation layer, consisting of construction materials wastes. On top of this irregular layer, a compressed and somehow irregular layer of sand, about 10cm deep, was laid down in order to level the horizontal slope of the floor. The latter was finally plastered with a 2cm thin layer of mud, which had been whitewashed.

In the northern part of the L-shaped corridor we found some surprises, in terms of the plan, with respect to what documented by Borchardt. In fact, the L-shaped entrance corridor not only leads to the courtyard, westwards, as described by Borchardt, but also opens, eastwards, to another, newly discovered, space (Ent-to-Room-3) not included in Borchardt’s plan. Although its function is still unclear, this space is likely to be a passageway, which turns to the North and leads to another space (Room-3), likely a secondary room or another storage room like those (Rooms-1-2) on the southern side. Unfortunately we could not investigate this newly identified area further to the North, for it continues below the stone foundations of the current sun temple.

Above a considerable part of this newly identified area (Ent-to-Room-3 and Room-3) of the “Pre-Temple”, a large, transversal brickwork [Wall-5] was also found. This had likely been used as a construction ramp to move the heavy limestone and granite blocks employed for the later stone temple. Borchardt already saw and drew this structure/ramp, but, surprisingly, he did not notice the presence of

the new room(s)/space(s) that we identified. Additionally, and most importantly, he completely skipped the abundant material culture associated with the entire area (see further below); nor his text presents any discussion/description of the original mud floors/walls of the “Pre-temple”, that sometimes preserved even clear traces of their original colours. As a final result, we are therefore now able to reconstruct more precisely the stratigraphical relations among the “Pre-temple”, the later construction ramp [Wall-5] and the stone foundations of the pavement of the visible sun temple.

The main surprise, however, came to us from the cleaning of the area in front of the entrance of this mudbrick structure. Here, a niche-shaped rectangular entrance was uncovered, characterized by two walls, on the northern and the southern side of the main entrance [Wall-8 and Wall-10], adjoining the frontal walls [Wall-1 and Wall-4] on the West. These two walls [Wall-8 and Wall-10] are supposed to turn northwards and southwards, respectively, to join the other walls we discovered on both the northern [Wall-13] and southern [Wall-7] sides and eventually form two big shoulders around the main entrance [Wall-14 and Wall-15]. It must be noticed, however, that the precise features of these two shoulders, on the eastern side, could not be ascertained because of the presence, in this area, of the stone temple foundations and pavement (Fig. 17). Particularly on the North-eastern sector, the temple may have in fact a quite different planimetric development, being eventually not symmetrical to the South-eastern sector, as it is the case, e.g., of the pyramid temple of queen Khenkaus II (see further below).

The most important feature of this newly discovered area was the round limestone column base that was found 1.12m east of the threshold, and 1.5m North from [Wall-10]. The column base was found almost entirely beneath a big limestone pavement block from the sun temple pavement, and only one-third of it was accessible for investigation in 2019. From the curvature of the base, it is possible to reconstruct its original diameter in around 95cm (Fig. 25). The base was embedded into the floor pavement surrounding it. The position of the base almost aligned to the southern edge of the entrance’s threshold suggests another opposite column aligned with the northern edge. This other column base was not accessible because of the later sun temple stone pavement that covers this area. According to this new feature, it is most likely to recognise a columned entrance portico as part of the façade of the “Pre-temple” (preliminary 3D reconstruction in Fig. 26).

Moreover, another wall was discovered between the column base and the main southern shoulder of the niche-shaped entrance portico [Wall-10]. This brickwork [Wall-12] was uncovered enough to recognise that it was built with smaller bricks (dim. 27×15×8cm) than those used in the rest of the “Pre-temple” (dim. 39×20×13cm). The wall was plastered and whitewashed exactly as the rest of the other walls of the “Pre-temple”. The thickness of the wall, unfortunately, could not be determined, for it partially lies under the pavement of the stone temple. It is clear, however, that it is a later addition, which had the aim to connect the column base and the portico’s southern wall in a second building phase of the “Pre-temple”.

Last but not least, it is worth noticing that the entire niche-shaped entrance area presented a compact mud floor (still visible in a few spots), laying on a solid mud foundation, which had been flattened at the same level as the entrance limestone threshold, the column base and the internal room floors of the “Pre-temple”. This constructive remark seems to eventually indicate that all the components of this complex or “Pre-temple” analysed so far did belong to a single architectural plot and building phase.

To the South of this “Pre-temple”, other unknown - and so far still unclear - archaeological evidence were also found (see Fig. 22-23). The most interesting one is a platform-like structure (foundation?) made of chops of limestone of medium size, bound together with mud. This structure [context unit 1033] takes an elongated shape with a half-rounded northern end and runs below the last three (southernmost) basins of the “purification area”. To the West of this structure, another mudbricks wall [context unit 1020] was also found - also not documented at all by Borchardt - whose function is still not clear. A dense layer of collapsed bricks and rubble [context unit 1025] was found attached to it and seems to continue further to the East, but could not be investigated for the presence of the alabaster basins above. This brickwork is made of the same size as that of the “Pre-temple” components. However, one cannot find any architectural connection between this wall and the main mudbrick structure. Finally, further to the South, at the border of the investigated area, we found the remains of another structure [context unit 1026], probably to be identified as a construction ramp, which had already been found and drawn by Borchardt.

The overall understanding of the functional relation among the different mudbrick components so far described, as well as their individual date, is still undergoing. A crucial contribution in this

regard, esp. for the understanding of the chronology and nature of the “Pre-temple”, will hopefully come from the study of the mudbrick size and bonding, as well as by the analysis of the abundant pottery associated with the whole complex, although, for the sake of completeness, we have to say that a large part of this pottery was not found in its original context (see next paragraph).

One of the main difficulties in clarifying the nature of these newly discovered buildings, both the “Pre-temple” and the other associated structures, lays in the fact that we were able to investigate only a small portion of this area. As already specified above, at the beginning of our work we did not expect to find the extraordinary and huge amount of findings that we had concerning both the architecture of the area (mudbrick structures) and its material culture (pottery). This has slowed down the scheduled work dramatically and resulted in the fact that, at the end of the work season, we finished to clean only the area immediately connected to the alabaster basins of the “purification area” (see also pl. 1), for an overall extensions of 22×11m (North-South/East-West).

For the moment, based on the new and only partially explored plan, the pyramid temples of queen Khentkaus II and king Neferefra, in Abusir, seem to offer the closest comparison, as far as the Fifth Dynasty architecture is concerned (Fig. 27). The similarities between the outer (mudbricks) part of the queen’s temple and the Abu Ghurab mudbricks building or “Pre-temple” are particularly considerable in terms of spatial arrangement, for the former temple is also characterized by the three main components that we have found in Abu Ghurab<sup>9</sup>:

1. A niched entrance portico with two columns;
2. An L-shaped corridor, oriented South-North and giving access to a wider courtyard, westwards, and subsidiary rooms northwards;
3. A side room, of uncertain function, immediately located to the South of the main entrance, which gives access to other rooms (storerooms) southwards;

The main difference of our building with respect to the pyramid temple of Khentkaus II so far seems to be that the latter is featured, at the entrance, as a pillared (and not columned) portico. This part of the temple of Khentkaus II has been somehow dated between the late years of life of the queen and the late years of reign of Niuserra<sup>10</sup>.

<sup>9</sup> For the analysis of the main architectural components of this part of the temple see Verner 1995, 161-162.

<sup>10</sup> Verner 1995, 38-41. In this publication Miroslav Verner dates the completion of this mudbricks building to the late reign of Niuserra. However, by reading the archaeological evidence

The comparison of the Abu Ghurab building or “Pre-temple” with the inner part of the pyramid temple of Neferefra - somehow dated between the reign of Neferefra and the early years of reign of Niuserra - is also interesting, first and foremost for the presence in both cases of a niched entrance portico with two columns. However, crucial differences between the two buildings also emerge, such as the absence of the L-shaped entrance corridor in the pyramid temple of Neferefra and the fact that the small subsidiary rooms (storage rooms?), that in Abu Ghurab are located immediately to the south of the entrance gate, are instead all located to the North of the entranceway in the case of the pyramid temple of Neferefra (Verner 2006, 29-41).

Only further exploration of the Abu Ghurab structure will provide new ground for a full understanding of the situation, in terms of both architecture and chronology. For the moment, the similarity between the mudbrick building (Pre-temple) that we have partially re-investigated underneath Niuserra’s sun temple and the ground plans of the two above-mentioned pyramid temples in Abusir (esp. that of Khentkaus II) would seem to indicate that the Abu Ghurab structure might not necessarily be an earlier building phase of the sun temple of Niuserra, as proposed by Borchardt, but a previous Fifth Dynasty building (one of the four missing sun temples?).

Finally, and for the sake of completeness, we cannot rule out also the possibility that this mudbrick building below the sun temple of Niuserra might be dated to a much earlier period. In fact, and although with important due differences, such as the absence of columns/pillars at the entrance, the tradition of a niched entrance portico that gives access to an elongated L-shaped corridor, flanked by small side rooms, can be traced back to the Early Dynastic Period - as shown, e.g., by the so-called “funerary enclosures” of Djer, Peribsen and Khasekhemwy in Abydos and Hierakonpolis (O’Connor 1989, 51-86) - and goes up to the early Fourth Dynasty (Snefru), when we find it attested in the plan of the small funerary temple/chapel of the Meidum pyramid (Stadelmann 1985, 83-84, fig. 22). This hypothesis may also explain the presence of the Early Dynastic tombs found at the edge of the cultivated area in the 1990s (Radwan 2001, 509-514), only a few hundreds meters to the North of the sun temple itself, tombs with which the mudbricks

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provided by him, this chronology does not appear to be supported by any direct element. In fact, not even a date to Niuserra is sure. What seems clear, in his report, is only that the temple was completed after the death of the queen.

structure below the sun temple might be somehow connected.

#### SURVEY, STUDY AND DOCUMENTATION OF THE POTTERY (K. Arias)

One of the main goals of this 2018-19 season was also the start of the documentation, analysis and drawing of the wide material culture, esp. pottery, left by Borchardt inside and outside the temple. Final aim of this investigation will be of course the insertion of all data into the final database on the sun temple that we are creating.

Given the huge extension of the data to be studied, we decided to adopt a precise strategy of documentation, based on the context significance: in the case of high priority finds, these were fully documented, including statistical and metric analysis. Diagnostic pieces were drawn 1:1, described in detail and photographed. Furthermore, the ceramic context was, as a rule, photographed as a group. The rest of the pottery, usually a quite abundant bulk of material, was instead packed and stored in the Saqqara magazine waiting for further analysis during the next campaigns. What is provided here is of course only a preliminary analysis of the material given that, due to its consistency, the material will require further documentation and analysis.

The pottery surveying was concentrated on the wider area of the so-called spoil heaps made by Borchardt during his excavation in the early 20<sup>th</sup> century. We undertook approximate mapping and identification of individual heaps, specifying their outlook as well as the number and nature of finds (general character of the heap, quantity, quality and typological sequence of ceramic finds, presence of other finds such as stone vessel fragments, stone tools, etc.). From the point of pottery, it could be ascertained that some areas contained exclusively Old Kingdom wares (such as, e.g., the dumps near the North-East part of the upper temple) while others included also much later pieces (e.g., numerous Late Period fragments in the extensive South-West heaps). On the basis of this preliminary survey, several smaller and spatially well-defined spoil heaps (designated as BD, i.e. Borchardt’s Dumps) were selected for a detailed analysis, especially those immediately North and East of the temple. The heaps were photographed and mapped, and the main diagnostic sherds from their whole surface were collected.

Out of the analysed dumps, BD-N3 proved to be the most interesting, as it contained a rather homogenous ceramic material, consisting of several representatives of the same type, namely rough beer jar with a flat base resembling *hes* jars (J-1i in

Abusir classification) (Arias 2017, fig. 5.4). This type is limited for the period of the middle to late Fifth Dynasty and was so far attested only in the region of Abusir South, Centre (e.g. in the mortuary complexes of Queen Khentkaus II and Neferefra; mastabas of Khentkaus III, Kakaibaef and Ptahhotep) (Krejčí *et alii* 2015, fig. 11; Arias 2017, figs. 4.69a, 4.71) and in the neighbouring sun temple of Userkaf in Abu Ghurab (Kaiser 1969, Gruppe X), thus providing us with very valuable chronological comparison. Moreover, this particular spoil heap was situated immediately North of the magazines, thus possibly composed by the material coming from the excavation of this area. Another partially documented spoil heap BD-E3 (Fig. 28) from the area North-East of the temple also yielded mostly Old Kingdom pottery, including Fifth Dynasty beer jar rims (Abusir types J-1aI and J-1aII)<sup>11</sup> and bases, bread form rims and fragments of finer vessels of the Fifth Dynasty.

In the area of the upper temple itself, the whole surface layer consisting predominantly of yellow wind-blown sand and partially eroded ceramic pieces was designated as context [context unit 1000], specified according to Borchart's original square designation. Despite its undoubtedly secondary nature, several remarks can be observed.

In almost all the squares, there was a considerable percentage of later (even though non-diagnostic) pottery that was kept for later analysis. All of the explored squares had also a large presence of Old Kingdom pottery mixed with later wares. Particular was the presence of some miniature vessels (Fig. 29) in squares M8 [context unit 1000], M13-14 [context unit 1009] and especially M10 [context unit 1038], the only area, in the whole temple, where the concentration of miniature bowls was considerable (see Figs. 14-15 above). All of them were of the typical middle to late Fifth Dynasty date, being rather small and casually made (Reisner, Smith 1955, fig. 127; Kaiser 1969, Gruppe XLVIII; Arias Kytarová 2014a, fig. 4.89).

Among the exceptions, in terms of manufacture, we can count square K8 [context unit 1018], containing three larger miniature bowls covered with a red slip (Abusir type MB-4). This points to a production that was most common during the Fourth Dynasty and the earlier part of the Fifth Dynasty and ceased at the latest during the reign of Djedkara. Red-slipped miniature vessels are usually attested in Abusir in the tombs of the members of the royal family or high officials, such as prince Werkaure, princess Sheretnebt, count Kakaibaef

(see type MB-4 in Arias Kytarová 2014a, fig. 4.90; Arias 2017, fig. 5.19). Context K8 [context unit 1018] is furthermore interesting due to the presence of above-mentioned beer jar type with a flat base (J-1i), as well as several fine storage jars and bowls, all characteristic of ca. mid-Fifth Dynasty.

A large amount of ceramic finds came from the cleaning of the area of the alabaster basins. Several subsequent structures consisting of walls, floors and various levels of debris and collapse were identified in this area. Old Kingdom pottery was prevailing in all analysed contexts, with later pottery coming only from some clusters. Among the contexts, jars were the most frequent class, with a clear predominance of beer jars in both diagnostic and non-diagnostic sherds, followed by the class of bread forms in diverse types. Such contexts include fill layer [context unit 1002] that contained a variety of late Fifth Dynasty beer jars, bread forms, a bread tray as well as a few pieces of finer pottery such as a large bent-sided bowl (type B-2). As a rule, the most important contexts, such as e.g. [context unit 1003] in the entrance corridor had only two small Old Kingdom rim fragments, namely of a beer jar and bread form that did not allow any precise dating within the Fifth Dynasty. Beer jars enable us to delimitate the dating between specific dynasties relatively easily even from smaller diagnostic sherds, but for a more exact dating within a dynasty, a whole vessel is required in order to compare its morphometric properties (e.g. relation of complete height to width, or its volume) with available well-dated parallels (see discussion of chronological markers of beer jars in Arias 2017, 225-234). Other floor contexts, e.g. [context unit 1007] in the portico, contained only non-diagnostic sherds that included the usual combination of beer jars, bread forms and bowls which enabled only a very rough dating to the late Old Kingdom.

On the other hand, some pottery remained in relatively well preserved state, as it probably was of only minimum interest during the excavations in the beginning of the Twentieth Century. In the South-West corner of the Entrance Corridor, in the layer above the floor [context unit 1004], an originally intact but collapsed storage jar was found, possibly related to one of the pits dug into the floor (Fig. 30A). From the fill, all the fragments could be collected and the vessel was reconstructed fully. It was relatively large, with a height of 37.50cm and maximum diameter of 20cm. The jar had a low neck and ovoid body with a rounded base, and was thoroughly white-washed after firing, horizontally on the upper body and vertically on the lower body. It was made of Nile silt B2 and its technique of manufacture was of higher quality than that of

<sup>11</sup> For parallels see Reisner, Smith 1955, fig. 85; Kaiser 1969, Gruppe VIII; Arias 2017, fig. 5.1.

common beer jars, especially seen in the relatively thin and regular sherd break and in the execution of the base (see Fig. 30B). As far as the analogies are concerned, similar rougher storage jars or beer jars that were well smoothed and exhibited a relatively low thickness of body sherd are known from a few tombs of officials of the middle to late Fifth Dynasty in Giza (e.g. the tomb of Medunefér, G4630)<sup>12</sup> and from Abusir (e.g. the tomb of priest Neferinpu, AS 37) (Arias Kytarová 2014b, figs. 7.9-7.10).

The richest ceramic contexts were those coming from upper levels or collapse layers of the newly excavated mudbricks structure. As an example, the layer of debris on top of Wall-4 [context unit 1008] contained some Sixth Dynasty pottery, namely tall flat-bottomed bread trays (F-4b), carinated (Meidum) bowls with a groove under the rim (B-1bIV) and shallow bowls of type B-6 with an angular rim underlined from inside, with parallels known e.g. from the complex of the tombs of vizier Qar and his sons Inti and Senedjemib in Abusir South (Bárta *et alii* 2009, figs. 6.3.139-6.3.142; Arias 2017, figs. 4.44 left; 4.51 middle) or from the late Old Kingdom contexts in Saqqara West (Rzeuska 2006, 417-422, pl. 89; 641-643, pl. 127).

Among the investigated contexts, two are particularly noteworthy due to a relatively large presence of Middle Kingdom pottery sherds. In context [1010], at the end of the “Room of the Seasons”, before approaching the “obelisk structure”, rim fragments of a number of small hemispherical cups and bowls were discovered (Fig. 31), belonging to at least five or six individual vessels. They were rather small, cups with rim diameters between 11-13cm and bowls with 15-17cm. None were preserved in full profile, but the angle of the rim and body shows that they were all relatively wide, with direct open rims (Schiestl, Seiler 2012, 58-59, form I.A.1.b; 92-94, form I.A.10). These are all features pointing to an earlier Middle Kingdom date, possibly early Twelfth Dynasty (Schiestl, Seiler 2012, fig. 21, I.A.10) and thus highlighting the existence of activity in this area of the Upper Temple during this particular period. Several bore traces of exposure to fire on inner or outer surface in accordance with the context itself. Fragments of at least three hemispherical cups and two hemispherical bowls were discovered also in square L8 [context unit 1022], some with evidence of burning on inner and outer surfaces (Fig. 32). These are slightly larger than the examples from the “Room of the Seasons”, with rim diameters of 12-14cm, in the case of cups, and 18-19cm, in the case

of bowls, but the shape corresponds to the above-mentioned parallels.

To conclude, the analysed ceramic finds from the cleaning inside the two main areas of the temple belong mainly to the Fifth Dynasty, with a high predominance of rough wares such as beer jars and bread forms. Some beer jars had traces of white-washing on their outer surface pointing to their particular use in a cult. Further analysis of the remaining contexts will be required to specify dating for individual structures within the temple. So far, the oldest pottery found can be dated to the mid-Fifth Dynasty, while the youngest Old Kingdom pottery belonged to the reign of Pepy I and Merenre, possibly demonstrating the interruption of the activities connected with the sun cultic in the temple after this period. However, the Middle Kingdom and later pottery lets us assume that the temple remained visible and was visited even during much later times.

#### TOPOGRAPHICAL AND GEO-MAGNETIC INVESTIGATION OF THE AREA TO THE SOUTH AND SOUTH-EAST OF THE TEMPLE (E. Brienza, P. Zanfagna)

The final part of our mission was dedicated to the accomplishment of a wider topographical and geo-magnetic investigation of the areas to the South and South-East of the temple to check the possible presence of so far unknown archaeological remains, including a second solar bark immediately outside of the enclosure walls of the temple. Other investigations have been carried out also along the causeway to verify where and if some remains of this structure are still *in situ*, under the sand.

As is widely known in the field of the geo-magnetic, the accuracy of the investigation depends on a number of diversified factors, including primarily:

1. the nature of the soil to be explored;
2. the conformation of the terrain (flat versus hill-shaped);
3. the possible presence and nature of the archaeological artefacts (kind of material, such as, e.g., limestone or mudbricks) (for different results in various soil types in different archaeological contexts, see Piro, Campana 2012).

For this reason, and in order to carry out an accurate investigation of this zone, which may provide us with reliable results, we decided to use the GPR Loza V-200 (50-400 MHz) Bistatic Antenna, which allows a ground penetration included between ca. 2 to 10m. A specific feature of LOZA-V, compared with other similar devices, is the high energy potential allowing to probe highly

<sup>12</sup> See <http://giza.fas.harvard.edu/objects/17814/full/>: Vessel 14-1-20 (last accessed on 18.2.2021).

conductive soils, such as wet clay, inaccessible for standard GPR. This is highly indicated for our case-study since mudbricks are expected to be found in the investigated area.

The investigated zones have been set up using different principles based on:

- A. Previous knowledge and supposed presence of archaeological evidence;
- B. Need to test the type of antenna, depth, offset and gap between profiles;
- C. Logistic based on available time and main targets to achieve.

Following these guidelines, the areas of investigation were set up with different measures and shapes, using a gap of surveyed profiles varying from 7 to 5m in case of more accurate investigation. This was made to provide us with a different screening of the investigated areas in comparison with other parts of the site which are closer to the temple and better known archaeologically. At the same time, this methodology offered us a useful point of reference to calibrate the possible future investigation of other sectors of the site so far not explored yet.

The final result is a series of grids and profiles (*b-scans*) associated to the investigated areas which record the anomalies of the terrain and its main morphological features (Fig. 33). From the combined elaboration of the previous elements, it is then possible to obtain 3D scans (*c-scans*) of the underground and extract *time-slices* related to a selected depth range.

All the investigated areas and all the strips surveyed by GPR have been georeferenced by total station using the excavation topographic network set in this area during the past years and directly imported in our intra-site GIS (Nuzzolo et alii 2018, 59-61).

We started with the survey of the area outside the temple gate (Area 1) to verify the presence of underneath structures related to the causeway which have already been explored and documented by Borchardt (Borchardt 1905, Bl. 1 and 6). This area has been prioritized to calibrate a correct and functional procedure and to get useful indications to cross-check with the evidence coming from other unexplored areas, first and foremost the area where remains of the solar bark might be located.

We thus planned two different areas to survey, following the orientation of the ramp: the first one, closer to the temple, measures 30×20m (Fig. 34, A1a); the second one, a bit further, measures 50×20m (Fig. 34, A1b). Both areas are oriented North-East / South-West. Here 20 profiles have been taken, with a gap of 5×7m, in order to verify if the equipment and related procedures could be adequate

to the specific situation and add some other information on the causeway. This geo-magnetic investigation eventually confirmed the presence of anomalies approximately oriented along the North-East / South-West axis which should correspond to the already investigated causeway of the temple.

In a second sector (Area 2) we have set up two areas with a West-East orientation, running along the southern enclosure wall of the temple: the first one, measuring 27×20m, corresponds to the area where Borchardt found the so far known solar bark (Fig. 34, A2a). The second area, measuring 50×20m, and adjoining the previous one to the West, is the area where we wanted to verify the possible presence of a second sun boat (Fig. 34, A2a).

In this latter case, where 23 profiles were surveyed with a gap of 5×7m, the anomalies in the terrain recorded by the geo-magnetic investigation are not uniform. This may probably signify that the archaeological evidence hidden below sand is not featuring a regular structure (i.e., a structure that can be associated to a specific plan), but rather that they may represent some destroyed (or irregular) evidence. This may fit the idea of the presence of a second solar bark which, being made of mudbricks and having a considerable shape as the one already found by Borchardt, can generate a waves reflection which is distorted and heterogeneous. However, these anomalies might be also and simply due to the presence of irregular formations of the natural bedrock, which in this area should not be very deep. A third hypothesis could be the presence of a not homogeneous filling of a previous robbery pit, made during previous decades and later covered by sand dunes.

Finally, we can discuss about our main research area (Area 3), which was examined following a more accurate procedure. This area is located about 450m South-east of the sun temple, in a zone that, from what we know, has never been investigated in the past and therefore the previous archaeological record is too little to address our analysis (Fig. 34, A3).

Most of this sector shows an abundant presence of material and structural evidence on the surface, which would seem to demonstrate the existence of archaeological structures underneath. The analysis and cross-comparison of modern satellite imagery with the historical cartography of the area seems to further confirm the existence of hidden and so far unknown structures here, though not clarifying much, *per se*, of both their nature and ground plan (Nuzzolo, Zanfagna 2018, 113-142). We had also to take into consideration that this zone - as we know from previous information from surface survey and analysis - is characterized in

several points by a high-level ground water, which could somehow affect the reflectivity of waves and the following interpretation and post-processing of the data.

The area, measuring 65×50m, was surveyed by a grid of 25 profiles, with a distance of 5m from one another. At the end we produce 11 profiles with a West-East direction and 15 with a North-South orientation (Fig. 35). A little shift westward was also adopted during the survey, in order not to be excessively conditioned by the morphology of the actual surface of the terrain.

The outcome of the investigation of this area is composed of a considerable number of anomalies that feature the underground presence of abundant archaeological evidence, most of which located at a depth of about 1.5 meters from the lowest point of the actual surface. This point has been fixed by a topographic benchmark used as level 0 reference for every profile level calculation (we must take in considerations that the area is characterized by many bumps of different height and it was necessary to have a unique reference for all levels).

From these profiles we have elaborated a *time-slice* and outlined a general map, with a depth range from 1.1 to 1.6m, where most of the anomalies were targeted (Fig. 35)<sup>13</sup>. The disposition of these features at this level testifies the existence of regular alignments with a South-West / North-East orientation, together with some orthogonal axes which allow us to assume the presence of ancient archaeological structures.

According to our analysis of waves reflection, most of the material that composed the hidden structures should be mudbricks and its extension is quite considerable; in addition, the orientation of the buried structures, legible also in our high-definition satellite image, is the same that distinguishes the valley temple not only of Niuserra but also of Userkaf, the other so far known sun temple, located about 300m to the South-West the investigated area (Nuzzolo 2018, 74-99).

The presence of a valley temple here, already suggested on the base of the reading of the SAR images (Nuzzolo, Zanfagna 2018, 93, fig. 8), would therefore seem confirmed. We have to notice, however, that the evidence found by the GPR survey, though presenting the same direction and shape as those hypothesized after the analysis of the SAR images, show a shift of about 35m to the South-West.

To better define the latter issue as well as to verify the other hypotheses postulated above, it

would be thus fundamental to carry out another geomagnetic campaign, with the use of different depth antennas as well as with the help of a geomagnetometer, in order to combine and cross-check data coming from two different types of geomagnetic investigation (for a recent combined use of these tools in Egypt see Ahmed *et alii* 2020).

After this step, ideally, archaeological campaigns, or at least some sondages in targeted spot of the areas, should be conducted to finally have to chance to ground-truth the hypotheses generated so far. In Area 3, where spots of mudbricks emerge from the ground, it would be very useful to dig some preliminary shovel texts, in order to verify the consistency of the stratigraphic basin and get some reliable information for the planning of a future excavation.

#### CONCLUSIONS AND PERSPECTIVES (M. Nuzzolo, R. Pirelli, A. D'Andrea)

The 2018-19 campaign in the sun temple of Niuserra has provided us with new and interesting results that can be resumed as follows:

1. The cleaning of both the South-eastern corridor and the area of the secondary entrance to the temple has revealed so far unknown archaeological evidence, especially the presence of big mudbricks structures, only partially documented by Borchardt, all around the alabaster basin, in the so-called “purification area”. In particular, the discovery, in the latter area, of a monumental and columned entrance portico to the main mudbricks structure described above would seem to indicate that this building may not be simply an early building phase of the later stone temple but a completely different - and so far, unknown - building. This once more confirms that Borchardt’s investigation of the area was not accurate and complete enough to be fully reliable, and that its plan, though precise in the general outline, is certainly to be amended and updated in many important points. The continuation of this investigation, especially of the mudbricks structures, will be thus one a primary target of our next campaigns.
2. The cleaning and documentation of the “Room of the Seasons”, especially of its last part before approaching the obelisk, has revealed wonderful, and so far undocumented, decorated reliefs, some of them with a unique royal iconography. This prompts for further and more accurate cleaning of this area and the entrance of the “obelisk structure” that were evidently not well explored by Borchardt and may reserve new discoveries. Moreover, in order to better understand the development of the overall decoration of the

<sup>13</sup> Only seven anomalies were recorded at depths greater than 1.6m: five from 1.7 to 1.9m and two at 2.5 and 2.9m.

- “Room of the Seasons” and the corridor running into the “obelisk structure”, it will be important to re-explore the whole western sector of the temple, at the bottom of the “obelisk structure” itself. This area has not been investigated by Borchart and is characterized, at the moment, by a considerable accumulation of debris from the “obelisk structure” and wind-blow sand, which may hide other unknown decorated blocks.
3. The survey, collection and study of the material culture, just started this year in some targeted areas of the temple, has revealed a so far unexpected chronological horizon of the pottery repertoire, which testify of the wide use of the temple (not only Old Kingdom pottery but also Middle Kingdom and later periods). This is a situation which is not documented for the other known sun temple (Userkaf’s) and is thus of primary importance to deepen our knowledge of the temple history and occupation. Given the discovery of untouched pottery contexts in several areas of the temple, one of the targets of our next seasons will be to analyse, chemically, wherever possible, some samples in order to have more precise chronological information.
  4. The brief geo-magnetic survey of some areas outside of the temple enclosure walls demonstrate the presence of so far unknown archaeological evidence hidden below sand. The tools employed this year, however, have not given us a clear result in terms of identification of the plan and consistency of these structures. It will be thus our goal, for the next campaigns, to use other types/devices for the geo-magnetic investigation, whose results might be then crossed with the 2019 results, and hopefully give us a more reliable picture of the situation. This would be ideally the base for the planning of a proper archaeological excavation of the area which, only, can allow us to verify the nature and extension of the evidence identified so far.

We hope that the continuation of this field-work can eventually receive further benefit and scientific contribution by means of a new research project, just launched, under the auspices of the Polish National Science Centre, at the Institute for Mediterranean and Oriental Cultures, Academy of Sciences in Warsaw. The project, led by one of the present writers and involving a wider international research team, intends, among others, to prompt our quest for the lost sun temples<sup>14</sup>.

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<sup>14</sup> Project title: “Sun Temples Project. Religious spaces, ideological patterns and social dynamics of constructing the sacred landscape in Third Millennium BC Egypt”. Project director: Massimiliano Nuzzolo. The project has been granted within the framework of the Sonata Bis-9 Call - project no. 2019/34/E/HS3/00438 - duration 2020-2024): <http://iksiopan.pl/index.php/en/scientific-activity/research-projects/84-research-projects/830-sun-temples-project-religious-spaces-ideological-patterns-and-social-dynamics-of-constructing-the-sacred-landscape-in-third-millennium-bc-egypt>.

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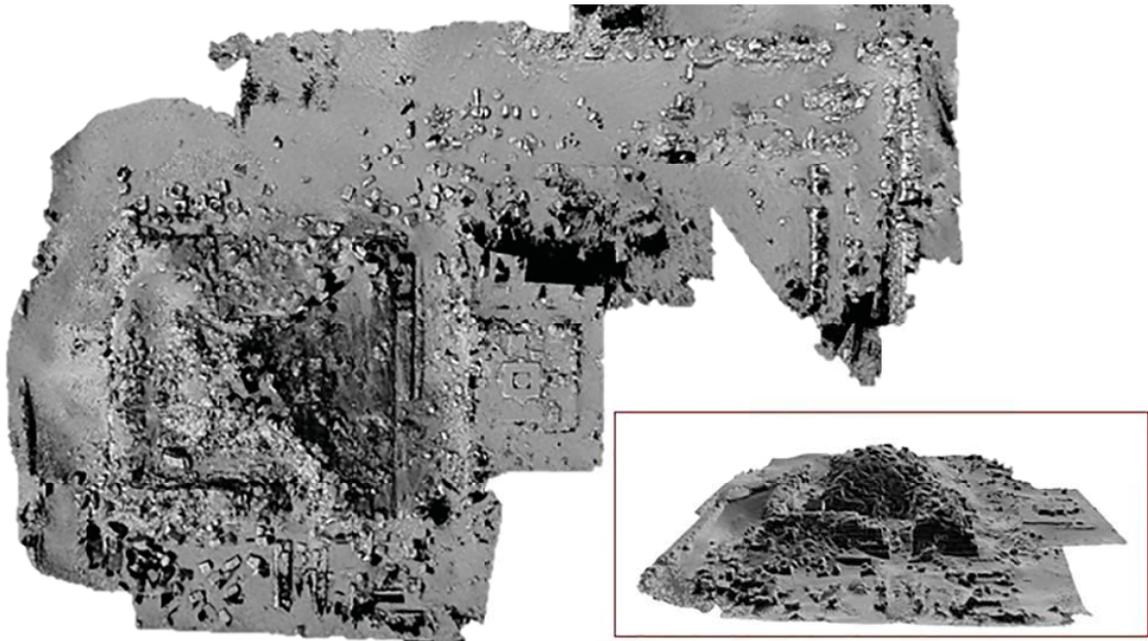


Fig. 1 - Two views (from top and South) of the 3D model of the temple generated by Zoller & Frohlich laser scanner during the 2010 campaign (elaboration: A. Bosco, after original laser scanner files produced by G. Iannone)

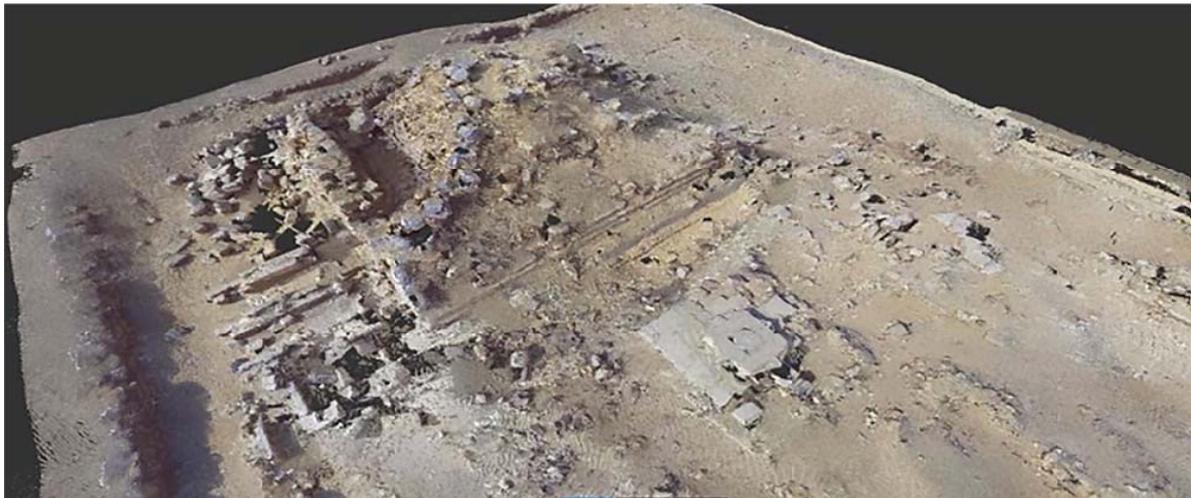


Fig. 2 - Bird eye view of the point cloud generated by FARO Focus laser scanner during the 2014 campaign (acquisition and elaboration: A. Bosco)



Fig. 3 - The 3D model of the alabaster basins after terrestrial photogrammetry (elaboration: A. Bosco)



Fig. 4 - Survey of the sun temple causeway by means of Osmo Dji device and tablet mounted on telescopic pole (photo acquisition: A. D'Andrea; elaboration: A. Bosco)



Fig. 5 - 3D restitution of the area of the storerooms after acquisition by Osmo Dji device (photo acquisition and elaboration: A. Bosco)



Fig. 6 - Acquisition phase and final 3D model of a granite inscribed block (photo: A. D'Andrea; elaboration: A. Bosco)

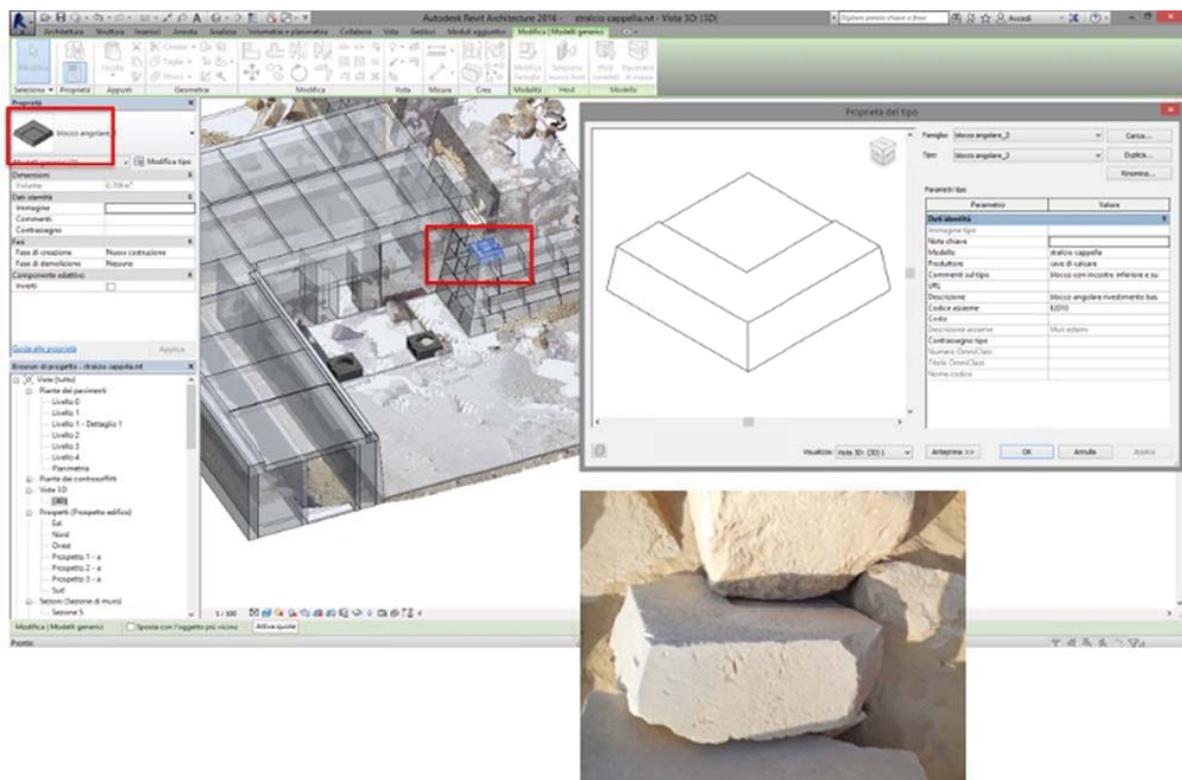


Fig. 7 - BIM implementation of a specific archaeological library of elements. Example of a temple corner block with its own table of attributes (elaboration: P. Zanfagna)

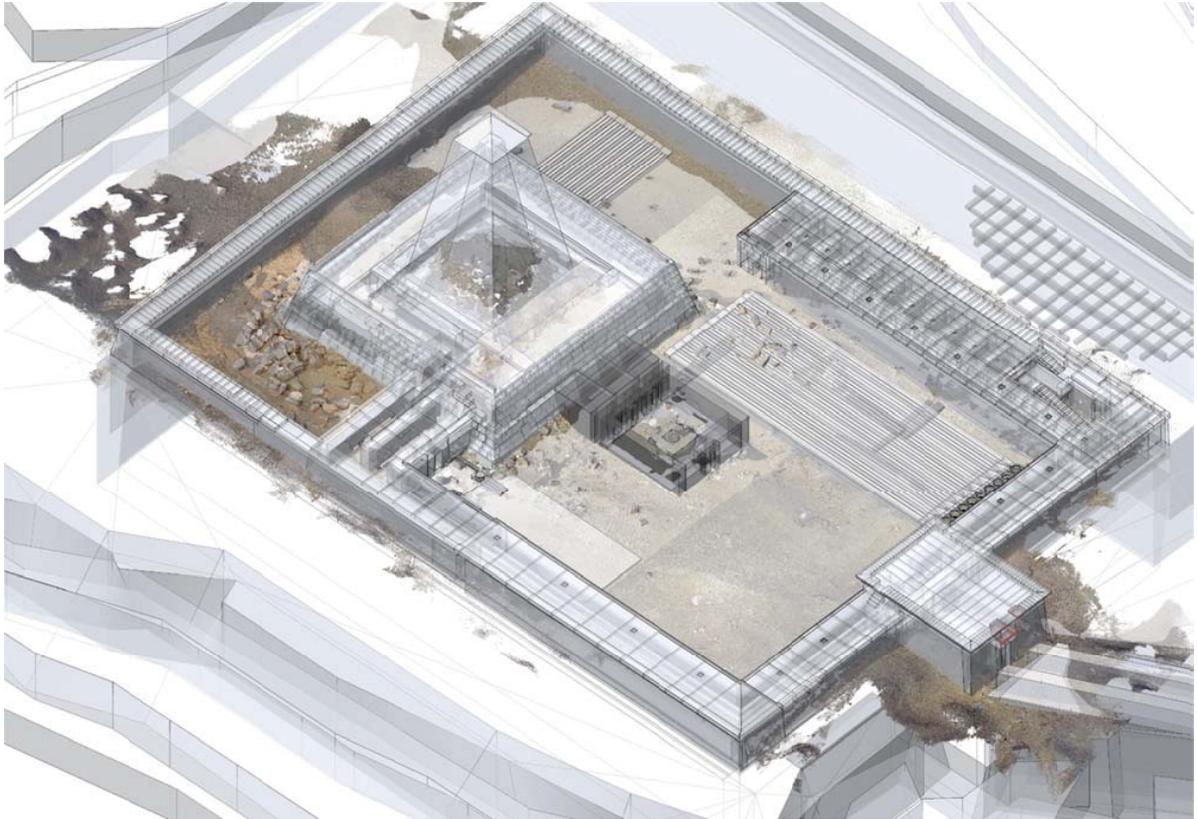


Fig. 8 - View of the BIM reconstructive model overlapped on the laser scanner point cloud (elaboration: P. Zanfagna)



Fig. 9 - Southern corridor: view (from the North) of a portion of the inner wall, at the South-eastern corner. The photo shows the *emplekton* technique used for the wall building (photo: M. Nuzzolo)



Fig. 10 - Southern corridor: view of the South-eastern corner with traces (fireplaces) of later domestic activities (photo: M. Nuzzolo)



Fig. 11 - Southern corridor: one of the pit [context unit 1012], inset into the limestone pavement slabs, filled with Fifth-Sixth Dynasty potsherds (photo: M. Nuzzolo)



Fig. 12 - Southern corridor, central sector, seen from West. The photo shows the building components [context unit 1039] of the foundation layers (photo: M. Nuzzolo)



Fig. 13 - Southern corridor, central sector, seen from West. The photo shows the presence of the brickwork [context unit 1038] to be possibly identified as a later construction ramp (photo: M. Nuzzolo)

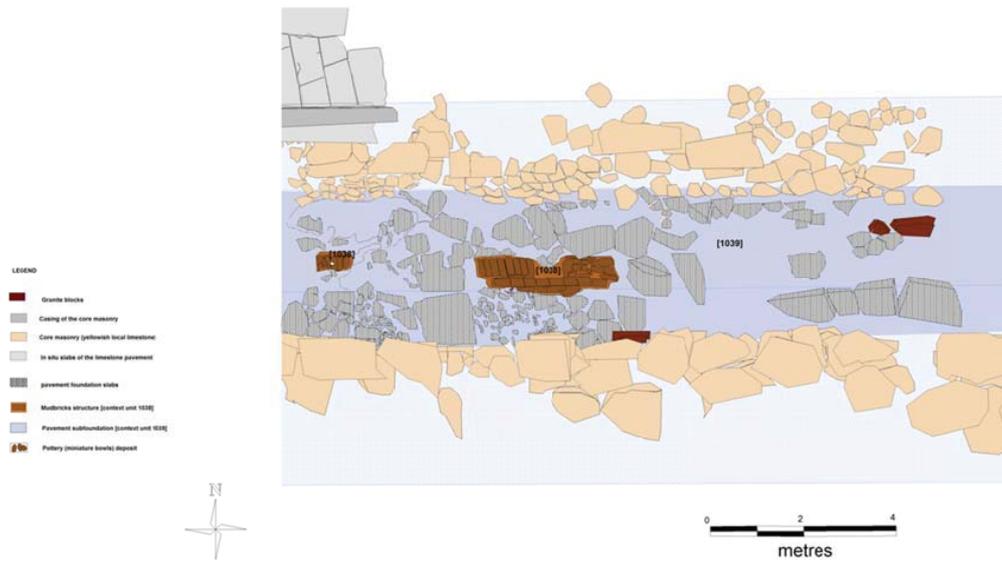


Fig. 14 - Southern corridor, central sector: general plan of the area (drawing: P. Zanfagna)



Fig. 15 - Southern corridor, central sector: the pit with accumulation of Fifth Dynasty miniature bowls inset into the newly identified mudbrick [context unit 1038]. Detail photos of (A) the pottery *in situ* and (B) after cleaning (photos: M. Nuzzolo)



Fig. 16 - Room of the Seasons, northern sector: photogrammetric view of the area. In the center of the picture, the pavement gap where the decorated fragments were found

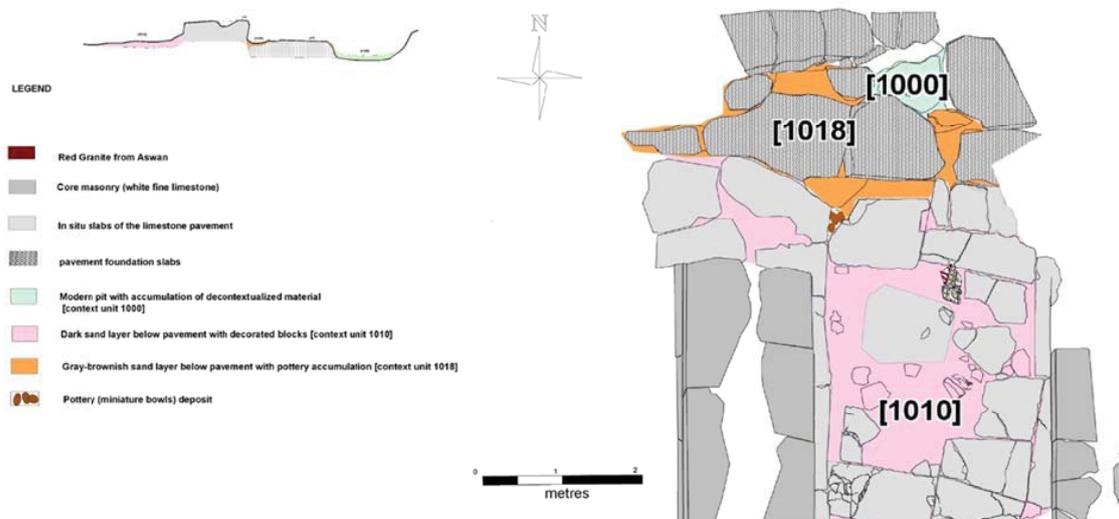


Fig. 17 - Room of the Seasons, northern sector: plan and section of the area (drawing: P. Zanfagna)



Fig. 18 - One of the newly discovered decorated fragments (exc. nr. ST-C1010/12/2019) engraved with the cartouche of king Niuserra (photos: M. Nuzzolo)

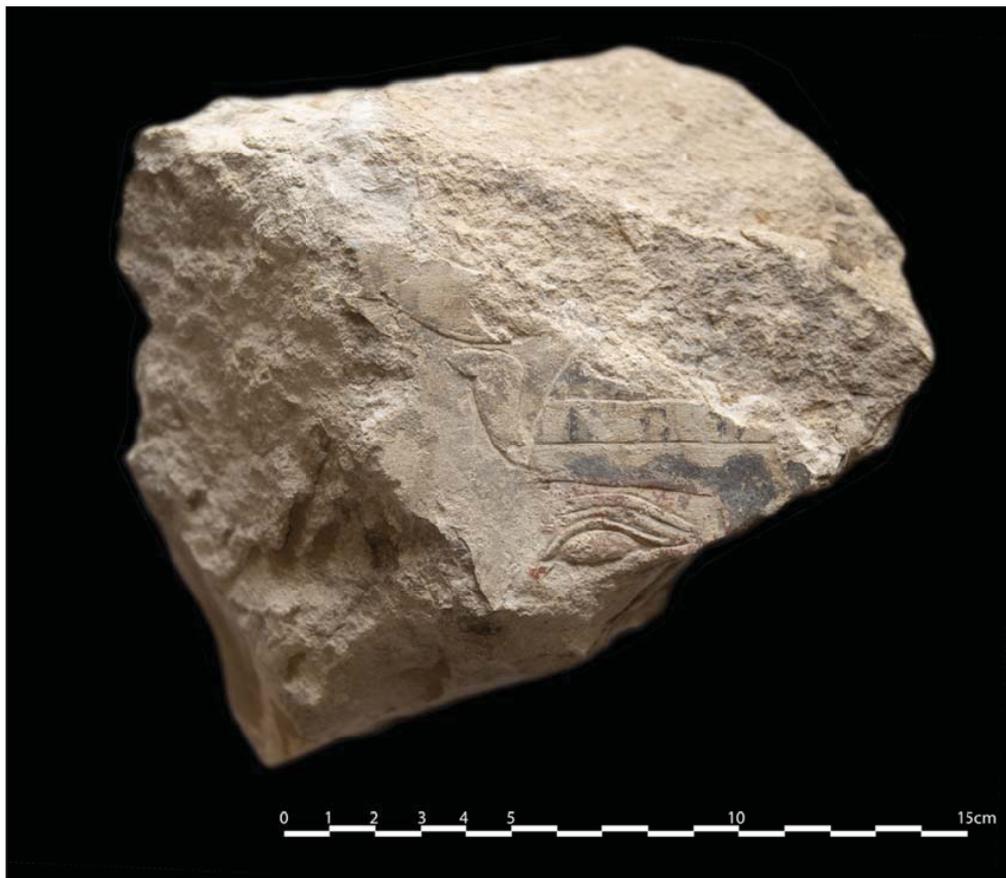


Fig. 19 - One of the newly discovered decorated fragments (exc. nr. ST-C1010/13/2019) with the face a king (likely Niuserra) bearing the *ureaus* and one of the ram's horns of the *atef* crown (photos: M. Nuzzolo)

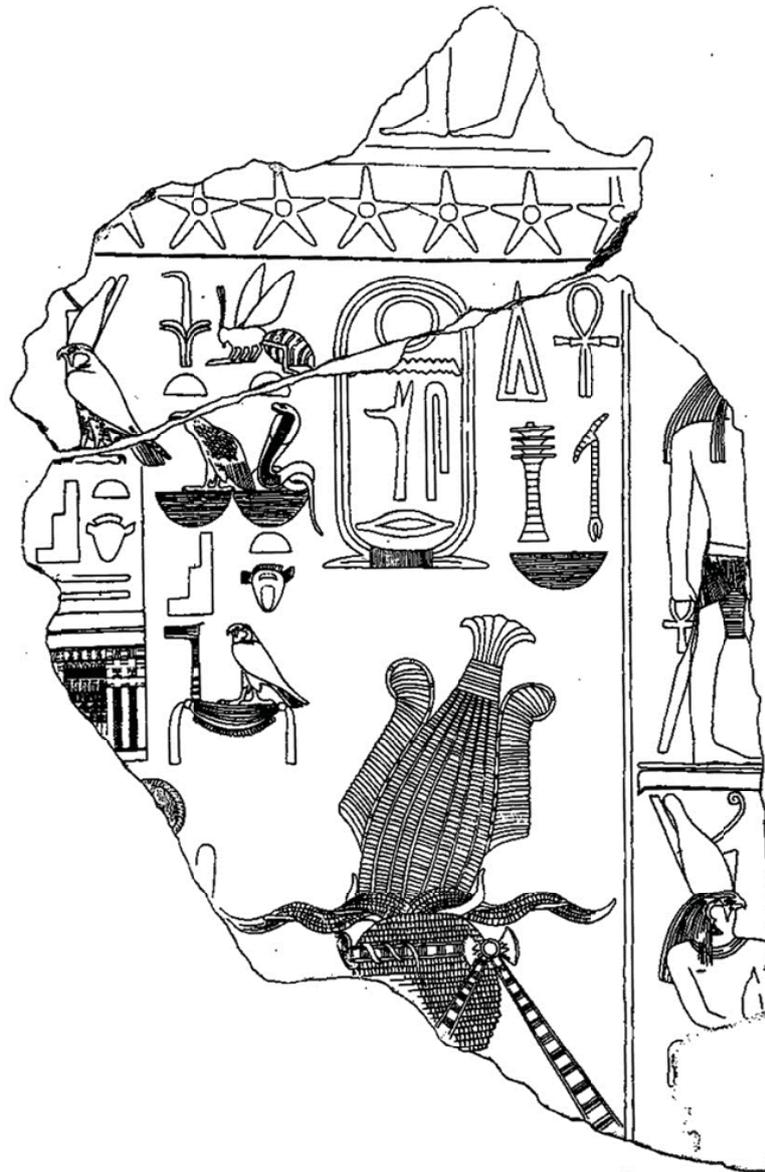


Fig. 20 - Relief fragment found by Borchardt in the year 1900 to the West of the obelisk structure (Berlin Museum: cat. no. ÄM 20052, now lost). The block represents king Niuserra with the *ureaus*, the ram's horns and the *atef* crown (after Kees 1928, Bl. 22)



Fig. 21 - Relief fragment found by Borchardt in the year 1900 in the Room of the Seasons (Berlin Museum: cat. no. ÄM 20061, now lost). The block represents king Niuserra leading a procession of fecundity figures and *nomoi* (Egyptian provinces) to the sun god Ra-Harakhty (after Edel, Wenig 1974, taf. 24)

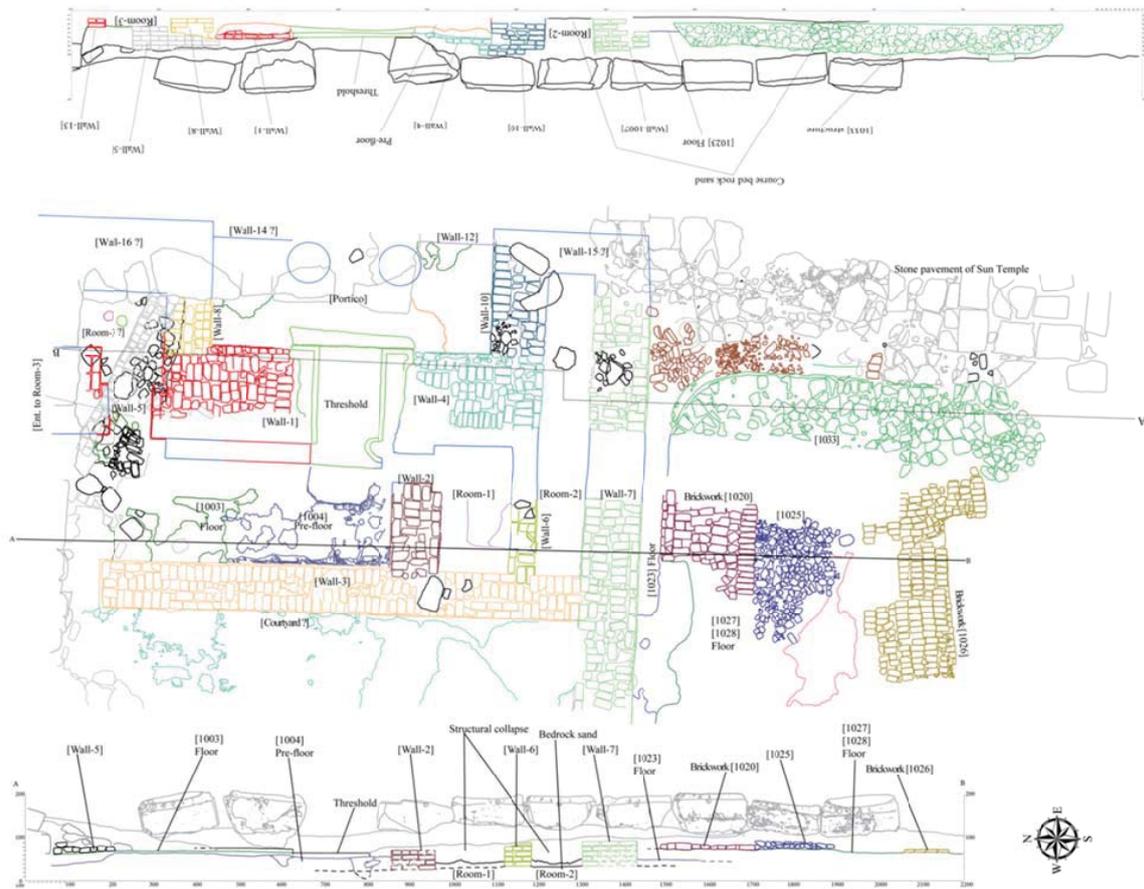


Fig. 22 - Area of the alabaster basins: general plan and section of the “Pre-temple” and the associated structures (drawing: M. Osman)

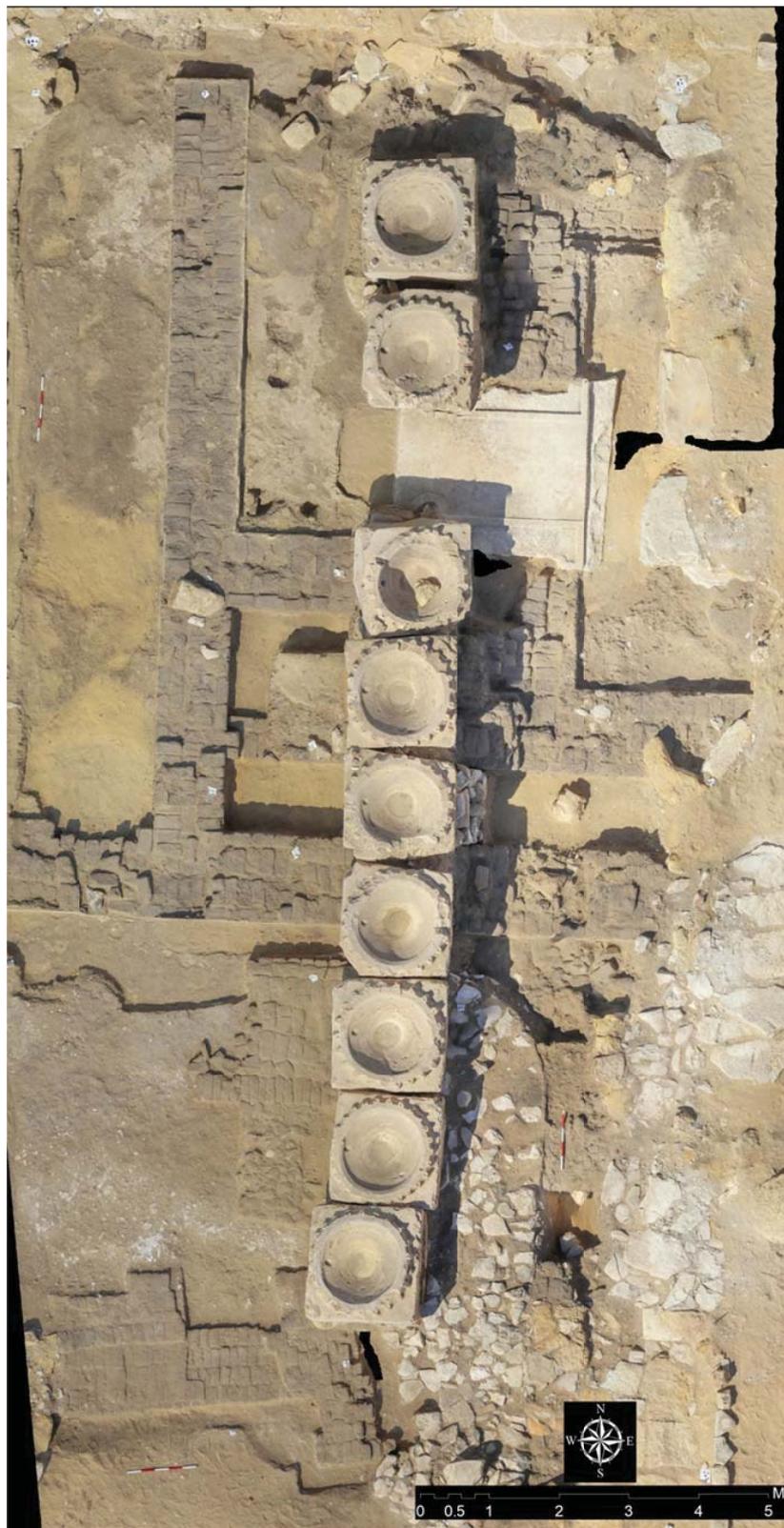


Fig. 23 - Area of the alabaster basins: Orthophoto of the "Pre-temple" and the associated structures (photos and photogrammetric elaboration: M. Osman)



Fig. 24 - Area of the alabaster basins: the fine white limestone threshold of the “Pre-temple” already discovered by Borchardt in 1901 (photo: M. Osman)



Fig. 25 - Area of the alabaster basins: view of “Pre-temple” (from the South). In the central part, on the right, the newly discovered column base in front of the limestone threshold (photo: M. Osman)



Fig. 26 - Area of the alabaster basins: 3D reconstruction of the entrance portico of the “Pre-temple” (graphic elaboration: P. Zanfagna)

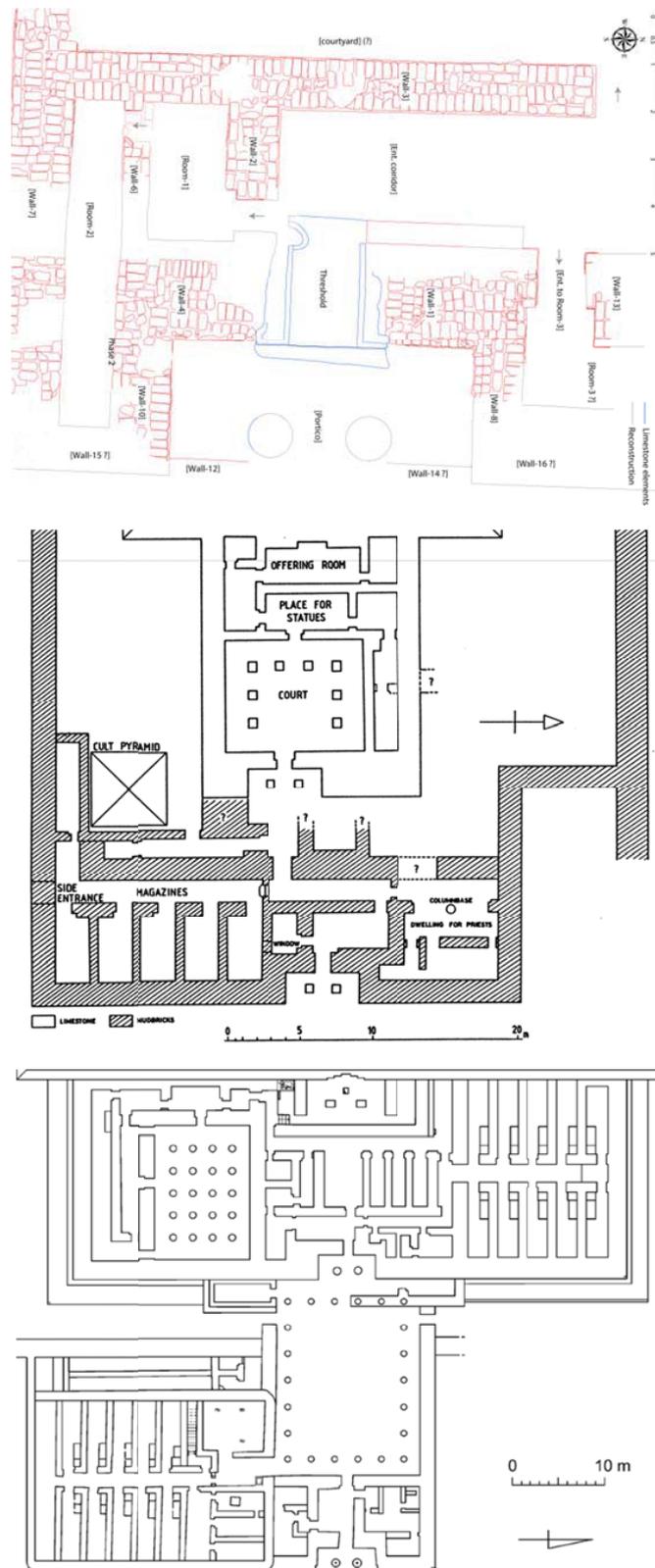


Fig. 27 - From top downwards: plan of the investigated portion of the “Pre-temple” (drawing: M. Osman) in comparison with the plans of the pyramid temples of queen Khentkaus II and king Neferefra (latter two plans respectively after Verner 1995, fig. 75; Verner 2006, fig. 1.7.3)



Fig. 28 - Diagnostic pottery fragments from the dump left by Borchardt (BD-E3) outside the enclosure wall of the temple, on the North-eastern side (photo: K. Arias)



Fig. 29 - Fifth Dynasty miniature bowl from square M8 [context unit 1000] (photo: K. Arias)



Fig. 30 - Area of the alabaster basins: two images of the large white-washed jar found near the entrance of the “Pre-temple” [context unit 1004]: (A) photo of the jar after final assemblage of the fragments; (B) photo of the jar in fracture. In the latter picture we can notice the manufacture of the inner base (photos: K. Arias)



Fig. 31 - Room of the Seasons, northern sector: Fragments of small hemispherical bowls and cups discovered in context unit [1010] (photo: K. Arias)



Fig. 32 - Area of the alabaster basins: rims of hemispherical bowls and cups from the context unit [1022] (upper row). The two heavily burned examples belong to two different bowls, based on diverse fabrics (photo: K. Arias)

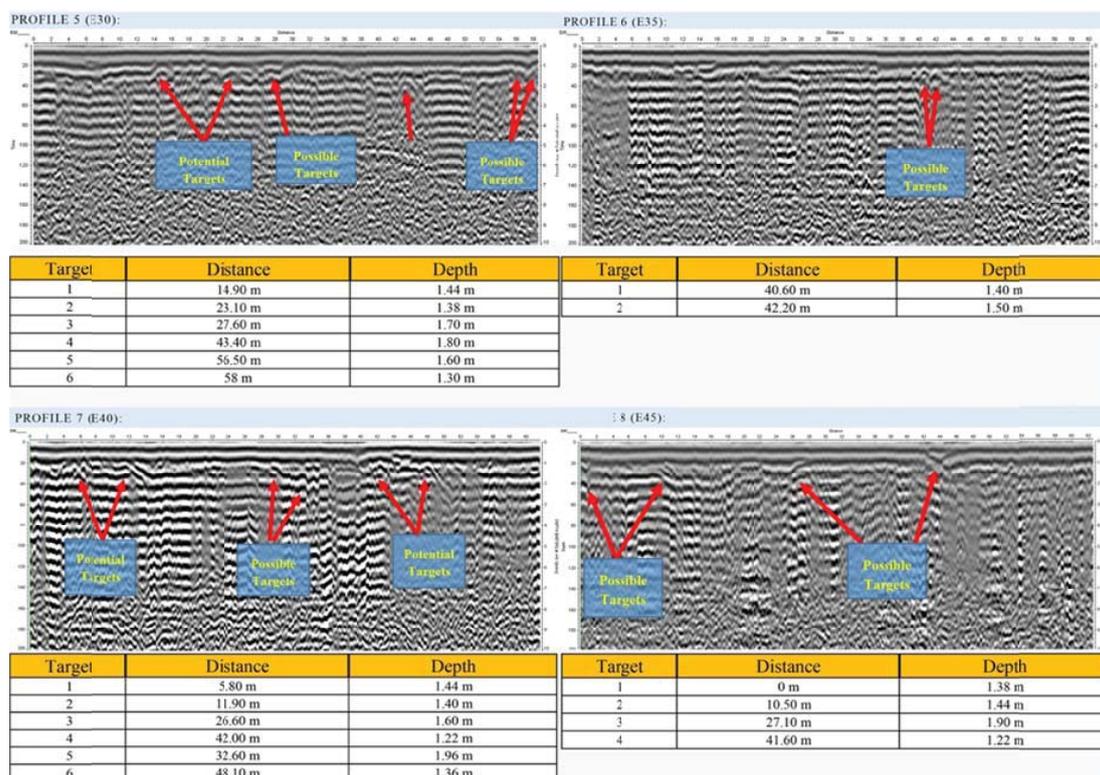


Fig. 33 - Some examples of the profiles (b-scans) surveyed in the investigated areas by means of GPR Loza V-200 (50-400 MHz) Bistatic Antenna (elaboration and courtesy of the Egyptian Company for Space Applications and Remote Sensing)



Fig. 34 - General map of the 2019 geo-magnetic survey in the site of Abu Ghurab overlapped with satellite view (elaboration: E. Brienza)

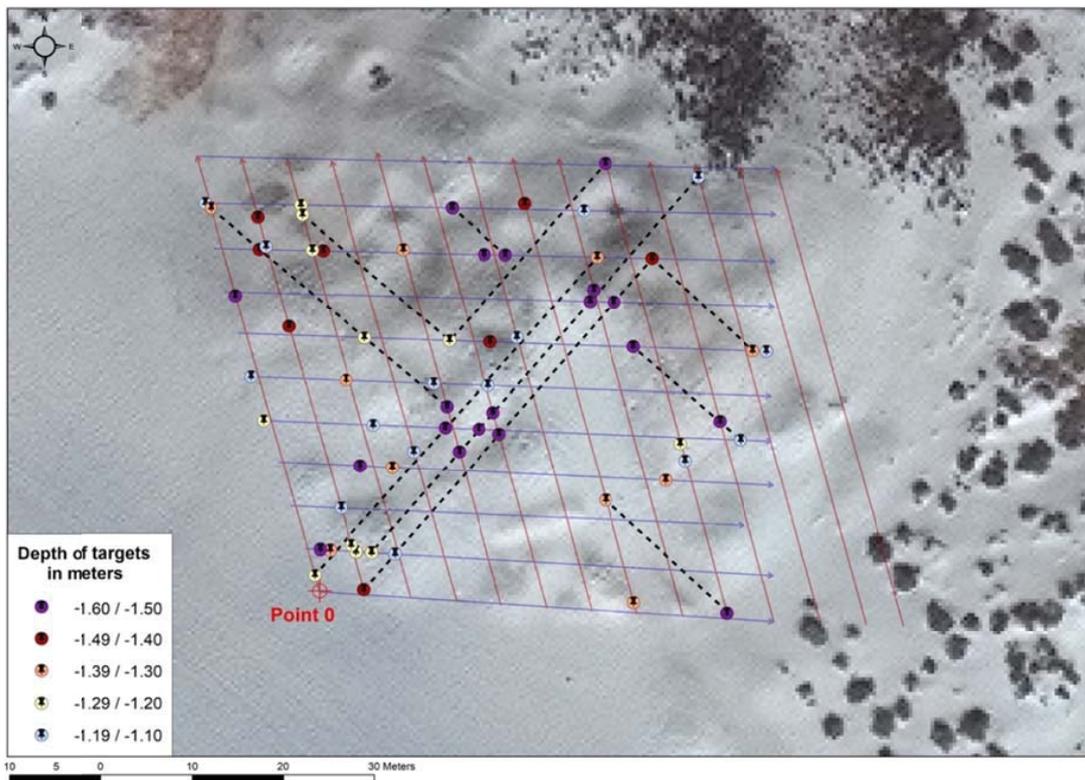
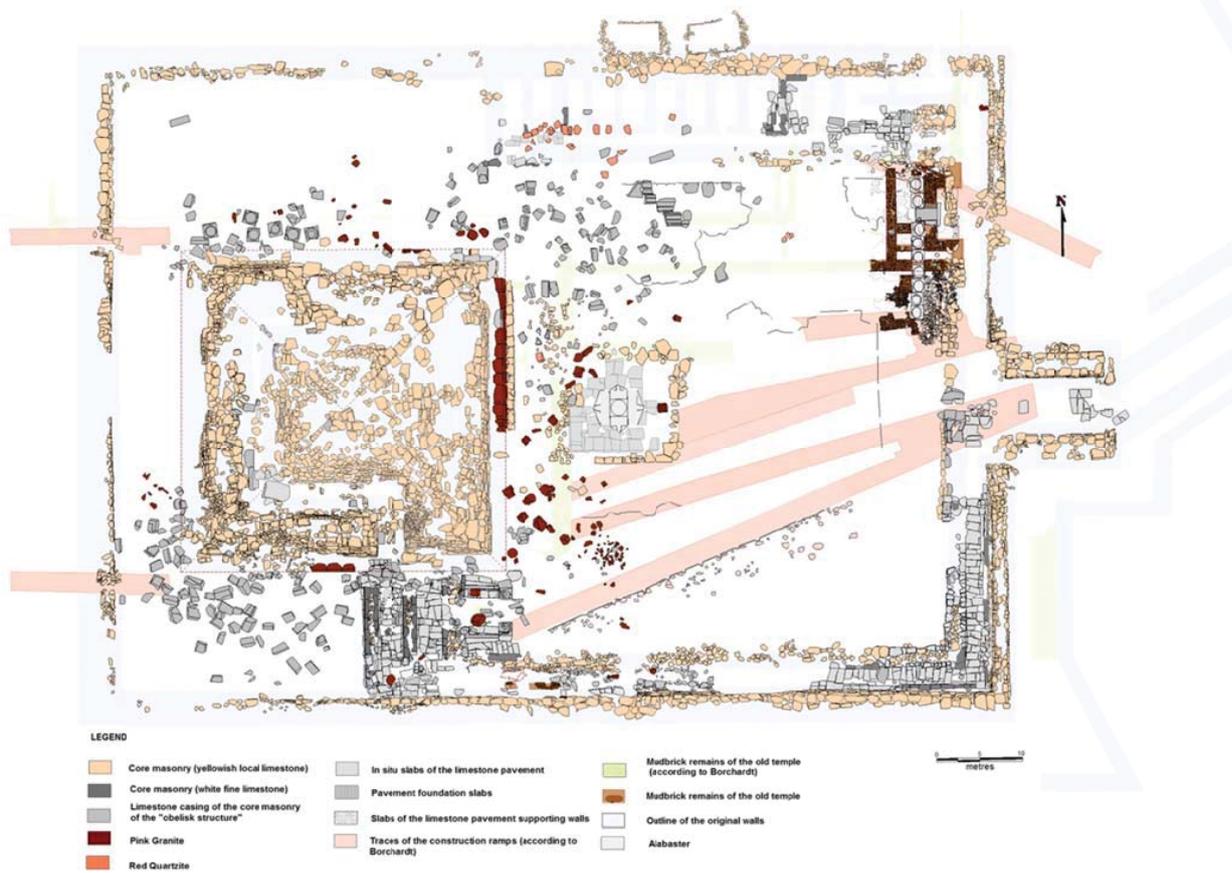


Fig. 35 - Detailed view of the anomalies found in one of the areas (area A3 - depth range -1.1/-1.6) investigated during the 2019 geo-magnetic survey in Abu Ghurab overlapped with satellite view (elaboration: E. Brienza)



Pl. 1 - General plan of the sun temple of Niuserra, updated as of February 2021 (drawing: P. Zanfagna)