

# Digital Documentation of the Saite Tombs in Saqqara

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This paper focuses on the digital documentation techniques employed in the recording of a number of Saite-Persian sarcophagus-tombs in the necropolis of Saqqara (Egypt). In this paper, we discuss pros and cons of different three-dimensional technologies for the documentation of a vast site as well as the process of ongoing excavation. We then delve into a discussion of the results and benefits of the employed techniques, particularly understanding the complex spatial relationships of archaeological features both aboveground and underground. Furthermore, we explain how we derive accurate scaled and ortho-rectified images of all inscribed walls and objects from the recorded 3D-information in order to produce digital facsimiles. The 3D-approach gives us the opportunity to create an exact digital copy of the morphology of the site, and to record all stages of the excavation. The produced 3D-models can be used in various virtual environments in order to give researchers and the general public the possibility to visit and to examine the site from a distance. Also, it is important to note that this paper presents a sustainable long-term data-archiving strategy, since saving the digitally born data for future generations is an integral part of our Saqqara Saite Tombs Project.

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## Key words:

Ancient Egypt, 3D-documentation, Saqqara, Laser scanning, Image-based modelling.

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## 1. INTRODUCTION

Digital tools offer innumerable possibilities in the documentation, visualization and analysis of enormous data sets. The application of this technology in the field of humanities, identified by the term Digital Humanities, has allowed more and more academic disciplines to integrate new approaches into their research process. On the one hand, we have text-based sciences editing fully annotated digital editions, allowing complex queries over thousands of pages in a few moments. On

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the other hand, we have archaeological disciplines documenting large sites and single artifacts in high-resolution 3D-models and combining them in new virtual realities.

Egyptology can profit from both worlds in the best possible way, as the relationship between texts, objects, and spaces is one of the discipline's general research questions. Egyptology is just starting to discover the new possibilities.

So far in Egyptology, the use of 3D models and reconstructions has been mostly confined to the visualization and presentation of content for a wider public. This paper will show how 3D information could be integrated into the research process itself, offering completely new possibilities in the visualization and the analysis of spaces and objects and their spatio-temporal relationships.

One of the main aims of the project described here was the generation of a digital 3D model of the whole site under examination within the Saite Tombs Project in order to understand the complex relationships of the features on and under the surface of the site. Besides the documentation of the structures, the complete process of the excavation was recorded in 3D, and excavation plans and ortho-images of inscribed walls were derived from the 3D data. To fulfill that task, different methods were chosen to address the different scales of the objects and features and the desired resolution of the digital datasets [Lowe 2018]. This makes the project the first archaeological undertaking in Egypt to be completely documented in 3D without producing any analog graphic documentation.

## 2. THE SAQQARA SAITE TOMBS PROJECT (SSTP)

The SSTP of the University of Tübingen was launched in March 2016 with a grant from the German Research Foundation (DFG). It focuses on the documentation, conservation, and publication of Saite-Persian sarcophagus-tombs (ca. 664-404 B.C.). Most of them were discovered between 1899-1948.

The tombs have substructures that uniformly consist of a main shaft, a secondary shaft, a passageway, and a burial chamber. On each, the main shaft, in all probability inspired by that of King Djoser's step pyramid, ranges in depth from 20-30 m. At its bottom lies a single burial chamber (ca. 5.5 m x 3.0 m) built with blocks of fine limestone in the shape of a large sarcophagus covered by a barrel vault, hence the designation "sarcophagus-tombs". The secondary shaft is inconsistently situated to the east, north or south of the main shaft. It leads to a passageway covered with a vaulted ceiling. This passageway ends at the entrance of the burial chamber.

The walls of the burial chambers of these tombs are extensively inscribed with compositions of religious texts interwoven together from revived selections from the corpora of the Pyramid Texts [Spiegel 1971 Sethe 2001], Coffin Texts [Faulkner 2004] and the Book of the Dead [Hornung 1997; Arbeitsstelle Totenbuch-Projekt 2019]. It should be noted that the text editors of the Saite-Persian Period worked within a framework that valued the revival of obsolete textual materials and encouraged the compilation of newer ones. Therefore, they integrated the revived texts with new ones (unparalleled texts) into meaningful compositions.

Our knowledge of the superstructures of the sarcophagus-tombs is, however, scarce. They were possibly lost because of intense quarrying and sebakh-digging activities by the local population from the 18th to the early 20th century. Consequently, the debate over the forms of their superstructures

is an ongoing one, with no clear consensus, since all theories are based either on sheer speculation or on fragmentary evidence. Conjectured forms for the superstructures include a mastaba, chapel, pyramid or truncated pyramid. Diethelm Eigner suggested that the superstructures were elaborately decorated cult chapels over the main shafts. He based his assumption on "... some remains of foundations" and "fragments of limestone blocks, and palmiform and composite capitals" [Diethelm Eigner 1999]. A similar suggestion was offered for the superstructure of the tomb of Tjananehbu by Edda Bresciani, who also sees another, smaller, chapel over the secondary shaft of this tomb [Bresciani et al. 1977]. These suggestions are along the same line of thinking presented by Jean Philippe Lauer, in his report on the tomb of Neferibresaniet [Drioton and Lauer 1951]. He construed a colonnaded cult chapel over its main shaft. Having exhaustively examined the remaining architectural fragments, Bareš concludes that the main shaft was topped with a 'central structure with battered walls' surrounded with a rounded-top enclosure wall. This is, however, different from the mastaba or truncated pyramid superstructure that was suggested for the shaft of Wdjahorresnet [Bareš et al. 1999]. However, the near complete absence of archaeological remains has driven some scholars to a rather extreme suggestion that the sarcophagus-tombs in general had no superstructures [Saddik 1984].

The goal of the Saqqara Saite Tombs Project is in essence a second round of excavation and epigraphical recording of six tombs that were discovered between 1899-1948, in order to apply state of the art documentation techniques.

The significance of accurately recording a monument, as well as the production of exact facsimiles of its decoration and texts, stems from the realization that "no amount of conservation or restoration can halt (a monument's) decay" [Jones 2008] and that "any monument will either disintegrate and become a ruin or be recycled." Working with limited resources and racing against factors of destruction, managers of cultural resources are obligated to set a priority list of monuments to be conserved. They face the dilemma of which monument should be saved and which one should be left to meet its fate. However, when it comes to documentation, such a dilemma does not exist, since the consensus is that accurate recording of the monument and the production of exact facsimiles is mandatory, and that that is the proper way to save the monument "for eternity" – admittedly in a different format. Recording was in fact once called "facsimile conservation" of monuments [Manuelian 1998], and most recently was referred to as "conservation by copying," in reference to the production of a replica of the tomb of Tutankhamun. The tombs' scenes were scanned, and a replica was made of it through a joint project between the Griffith Institute at Oxford University and Factum Arte [Factum Arte 2009]. Working within this intellectual framework, the project applied various digital documentation techniques, mainly 3D laser scanning and image-based modelling, in the documentation and mapping of the sarcophagus-tomb complexes of Padinist, Psamtek, and Amuntayefnakhet of Dynasty 26, located to the south and east of the pyramid of King Unas in Saqqara. It should not be concealed at this point that such a copy only shows the shape of a feature or a monument. Information about the material or the state of preservation cannot simply be captured in a 3D model. However, this information must also be recorded and linked to the model.

### 3. 3D DOCUMENTATION IN THE ARCHAEOLOGICAL EXCAVATION PROCESS

The use of 3D technologies in documenting archaeological excavations is becoming more and more common and, on many projects, has replaced traditional methods completely [Doneus et al. 2011; Verhoeven et al. 2013; Reu et al. 2014; Douglass et al. 2015; Galeazzi 2016; Historic England 2017, 2018]. This development is mostly driven by the availability of efficient, robust, and easy-to-use software-environments based on image-based algorithms like Structure-From-Motion and Multi-Stereo-View [Ma 2006; Howland et al. 2014; Hartley and Zisserman 2015]. While 3D laser scanning is extremely expensive, the described image-based approaches just need an overlapping dataset of digital images produced by commercially available digital cameras and a software that is suitable to derive 3D information [Doneus et al. 2011; Verhoeven et al. 2013; Davis et al. 2017]. While the heavy scanner needs to be mounted and leveled on a tripod for every scan, the image-set can usually be produced with a handheld camera under adequate lighting conditions. As the image-based approach is a passive method, a sufficient light-setting is always required to record a useful set of pictures. The scanner instead uses an active sensor and can be operated in complete darkness.

A laser-scanner just produces a dense point cloud describing the geometry of the scene which needs to be colorized in an additional step with an in-built camera of the device or an external setup. As a result, the data acquisition with the scanner is a complex, physically demanding and therefore a more time-consuming process compared to image-based data acquisition. The image-based software environments can mesh the point clouds directly and are able to texture those meshed 3D objects with high-resolution photo textures derived from the digital imagery already used for the reconstruction of the 3D-model directly in a combined workflow [Reu et al. 2013; Verhoeven et al. 2013; Davis et al. 2017].

While the resolution of the scanner is limited to the size of the laser beam used, typically between one and six mm, the resolution of the image-based approach is defined by the size and the resolution of the camera sensor, the focal length of the lens, and the distance to the recorded object [Historic England 2018]. With a high-resolution sensor and a dedicated macro-lens, a resolution in sub-mm precision can be obtained easily [Sapirstein 2018].

Besides those benefits, the approach has some downsides compared to the more complex laser scanning. Although image-based methods are able to combine several hundred digital pictures in order to derive a 3D-model, the processing of the data is time consuming and can easily take up to several hours or even days related to the image count and the available computing resources [Doneus et al. 2011; Verhoeven et al. 2013]. Therefore, it will always take some time to control the results of the data acquisition before the excavation process can proceed and previously documented features can be removed. Meanwhile, the data recorded by the laser-scanner are available directly after, or even during, the scanning process. The control of the derived models is of high importance, as not every recording is successful in the first attempt because of a lack of image overlap, especially in areas without adequate features, like plain plastered walls or areas with poor lighting [Verhoeven et al. 2013; Galeazzi 2016]. This might lead to holes in the models, or to highly interpolated, inaccurate areas, and in some cases the generation of the data set will fail partially or even completely. For this reason, the iterative recording of additional information to produce a sufficient model is not uncommon. While simple features, like small trenches or rooms, are easy to document with untrained staff, the

documentation of more complex structures, like architectural features, requires experienced specialists to produce an adequate set of images for the 3D reconstruction.

Furthermore, the image-based models are not scaled, and control points measured with a total station or a measuring tape are necessary to scale the object to its real size. However, the point clouds recorded by laser-scanner are always scaled in a metric system and no additional information to derive accurate measurements is required [Reu et al. 2013; Historic England 2018]

One of the biggest benefits of laser scanning is the ability to connect the scans accurately in a semi or fully automated registration process. This way, depending on the available computing resources, several hundred scans can be combined into a single scaled model. Image-based models cannot be connected in an automated approach and need to be aligned manually, never reaching the accuracy of the registered scans [Kersten et al. 2015].

As shown, both approaches have their benefits and their drawbacks, which leads to the conclusion that a combination of both methods might be the best solution to document all buildings, features and artifacts in a productive scale, resolution, level of detail, and quality of texture to answer any research question connected to the feature or object.

### 3.1 Laser scanning of the Sarcophagus-tombs and the Surface

One of the main aims of the project is the documentation of all structures on and under the surface of the investigated area in order to understand the spatial and temporal relationships between the single features and structures. Because of the size and complexity of the structures, laser scanning was chosen to document the whole site in order to produce a single model containing all available spatial information for further analysis [Wiese 2017; Lowe 2018].

To combine the data recorded by laser scanning and photogrammetry, an accurate georeferencing of all data is indispensable. First, a survey grid had to be established based on known coordinates distributed throughout the area by the Egyptian authorities in the UTM/WGS84 projection. All projects in Saqqara are obliged to carry out their measurements in this given grid. The use of a known, projected reference system is highly important because it connects the recorded data with legacy data or geo-data from external sources, and facilitates the reuse of the data in future research.

The known points we used for the layout of the grid are placed on top and on the southern slope of the pyramid of Unas. Using a Trimble M3 total station with the resection method based on the three known points, new standpoints could be derived with an accuracy of less than five mms. In conclusion, the best positional accuracy we could achieve for the resulting plans or 3D-models is equal or bigger than 2 cm. For an archaeological project and its questions, this is sufficient position accuracy.

While the survey grid could be set up easily and with high accuracy on the surface, the establishment of new points inside the shafts and subterranean corridors and hallways was more complicated, as there is no line of sight between the structures under and the known points on the surface. We decided to place three rotatable magnetic laser scanning targets on a heavy steel beam on the top of the shafts, and to measure them with the laser of the total station. Next, we used the resection method to station the surveying device on the bottom of the shaft using the center of the target as a

fixed point. Without a doubt, the geometrical distribution of the fixed points is insufficient and might easily lead to errors in the determination of the standpoint. To keep some control over the precision of the sub-surface coordinates, we remeasured the scanning targets again from the bottom of the shaft and the difference between the measurements from the surface and from the station in the shaft was less than three mms. For further control, we also used the targets on the beam on the top of the shaft for the combination of the scans made on and under the surface and compared them to photogrammetric models referenced with the coordinates of the survey grid. In this case, the margin of error was well controlled and, besides some erroneous cases, was also never bigger than five mms.

As a result, the described method of defining a sub-surface survey grid seems to be well suited for surveying such structures.

After establishing the survey-grid we started scanning the site using a Leica P40 time-of-flight scanner and an iSTAR 360 panoramic camera to gather high quality textures for colorizing the point cloud. The Leica scanner is an obvious choice due to its durability, high scanning speed and range. A full dome 360° scan with a range of 270 meters can be obtained in less than two minutes with a resolution of 6.3 mm at a distance of ten meters. Plans in a scale of 1:20 could thus be derived easily. We choose the resolution as a suitable compromise between speed, resolution and data-size, as we used an image-based approach for the more detailed models. With a higher resolution the size of the data and the scanning-time increases significantly and so does the time for registration and post-processing.

Although the Leica P40 has a built-in camera system, we choose an external device for the colorization of the point cloud as the camera lacks resolution and every scan station would require an additional five to seven minutes of data acquisition for recording the color information. We used an iSTAR 360 panoramic camera, which collects a fifty-megapixel HDR data set within a few seconds, depending on the light conditions. This accelerates the process significantly compared to the built-in solution. As the camera is always a passive sensor, the iStar needs sufficient light to collect the color-information. Since it was not always possible to illuminate every part of the structure, we decided to skip the collection of color information in some corridors and chambers.

In two campaigns, in 2017 and 2018, we had 240 scan stations and produced about 600 gigabytes of raw data to document the whole site. The following post-processing of the data has been carried out in Leica Cyclone, Leica Cyclone REGISTER 360 and Autodesk Recap. First, we combined the scans with the images collected with the iStar-camera in a semi-automated process and exported a colorized version of every scan-station. Second, we used the fully automated registration process, based on an Iterative-Closest-Point-algorithm (ICP) implemented in Leica Cyclone 360 REGISTER, to merge the single scans into one data set [Besl and McKay 1992; Holz et al. 2015]. The lack of overlapping features in the scans prevented them from combining automatically. Therefore, the connection between the scans made on and under the surface had to be executed manually by black and white targets. In a final step, the merged data set was exported into a standardized data format (E57) and imported into Autodesk Recap to clean the data set in a very time-consuming process. The resulting Recap data set could be directly opened in Autodesk AutoCAD or PointCab to derive highly accurate plans and sections (Fig. 1). The data exportation to a standardized open data format

guarantees their long-term utility and makes the data independent from Leica's proprietary, expensive, and not very user-friendly in-house software.

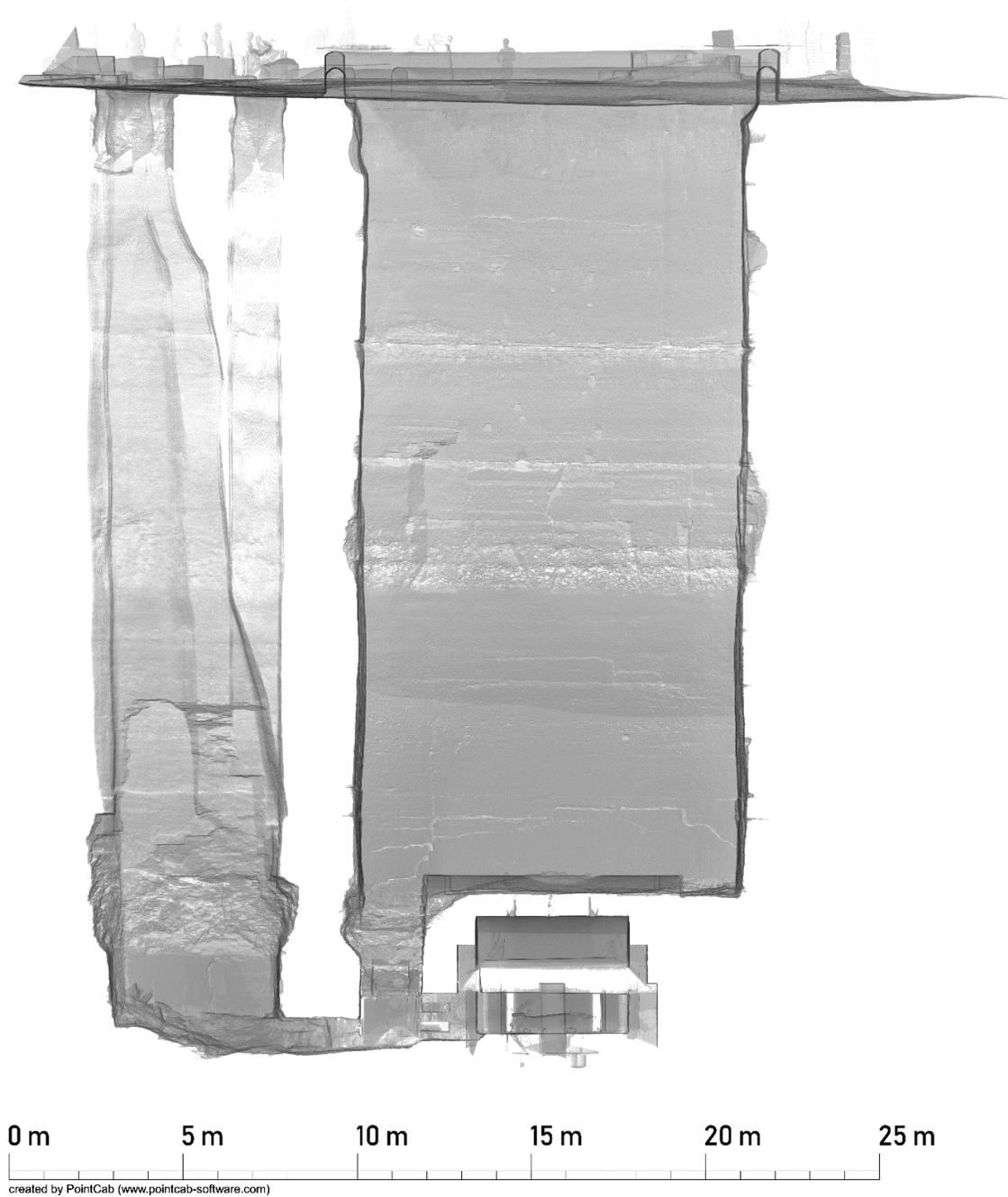


Figure 1. Section of the tomb of Amuntayefnakhhet derived from the point cloud.

## 3.2 Photogrammetric documentation

For the documentation of more detailed features, like the tombs and their walls, we supplemented the laser scanning with an image-based approach based on Structure-From-Motion and the Multi-Stereo-View algorithms. We chose the commercial tool Agisoft Metashape Pro (previously named Agisoft Photoscan) for the whole process, from the orientation of the images to the texturing of the meshed model. In recent years, Metashape has become the most widespread photogrammetric tool in cultural heritage and archaeology, due to its functionality, usability, stability, and moderate pricing compared to the competitors on the market.

One of the biggest challenges to the documentation of the tombs was the illumination of the chambers, as it is not possible to record information in the dark. We chose a handheld LED-light, which we tried to place parallel to the camera sensor to guarantee even lightning. Especially in narrow spaces, it was not always possible to shoot every image in similar lighting conditions. This led to spotty results. Another problem with unidirectional light is the strong shadows, leading to a large contrast between the brightest and the darkest parts of the picture. To face this problem, we chose a 24-megapixel Sony Alpha 7 II full-frame digital camera, offering a highly dynamic range, between the brightest light and the darkest shadow, to collect information both in the very bright and very dark areas of the captured scene. To facilitate the recording of an overlapping set of images of the general geometry, we chose a 21 mm Carl Zeiss Loxia Distagon wide-angle lens, offering high resolution and sharpness even in the edges of the frame. Furthermore, we recorded every single wall of the tombs in an additional high-resolution data set with a 50 mm Carl Zeiss Loxia Planar lens. Due to the lighting conditions, it was necessary to mount the camera on a stable tripod and use a remote control to prevent blurry images. In 2018, we experimented with a camera-mounted flash to operate in places where setting up a tripod was not possible. Compared to the LED-light and tripod setup, the color and the illumination of the images was better controlled and much more even. The sharpness of the pictures was also comparable. Therefore, we decided to change our workflow and use the camera-mounted flash for all areas without natural light. The approach accelerated the process drastically and the results are much more evenly illuminated and color controlled.

To scale and to georeference the models, we placed small markers in the scene and measured them with the total station in the coordinate system of the survey grid as described above. The georeferenced and scaled model allows the accurate extraction of metric information and orthorectified images and surface models [Reu et al. 2014]. The chosen ground sampling distance (GSD) was 5 mm for the bigger features like the chambers and up to 1.4 mm for the inscribed walls or objects.

As all images were shot in raw format, they needed to be processed in Adobe Photoshop Lightroom before their analysis in the photogrammetry software. Usually, we sharpened the images and adjusted their shadows and highlights, to keep as much information as possible for further processing and exported them as jpg-files.

The next step was to import all images into Agisoft Metashape Pro to generate 3D-models. This semi-automated process consisted of six consecutive steps, the image orientation (1) and sparse point cloud generation (2), dense 3D point cloud generation (3), meshing of the dense point cloud (4), texture mapping (5) and ortho-image generation (6) [Reu et al. 2014]. The basic principles and technologies

behind the 3Dmodel generation in archaeological contexts have been described and discussed frequently in recent years [Reu et al. 2013; Verhoeven et al. 2013; Reu et al. 2014; Historic England 2017; Zachar et al. 2017]. Besides the pictures, previously measured control-points can be imported into the software to combine them manually with the markers visible on the images in a semi-automated process in order to scale the 3D-model to its real size.

The final step was to export the scaled ortho-images and fully textured and meshed models for further processing (Fig. 2).



Figure 2. Textured model of the tomb of Padinist.

#### 4. DIGITAL EPIGRAPHY BASED ON 3D-MODELS

The production of detailed and accurate facsimiles is one of the most important steps in documenting and analyzing the hieroglyphic inscriptions and paintings on the walls of the tombs. In the last decade, digital methods based on image processing and digital inking [Manuelian 1998] have replaced traditional technologies nearly completely and the approach put forth by Chicago House in 2014 has become the standard [Vértes 2014; Vértes et al. 2020]. One of the major drawbacks of the proposed method is the use of digital images and scans as the basis for the facsimiles. They

do not contain any spatial information on the shape of the wall or objects comprising the hieroglyphs and scenes [Meyer et al. 2006]. Furthermore, the distortion of the image remains uncontrolled. Therefore, every facsimile based on pure digital imagery could never be an accurate depiction of the three-dimensional reality. Image-based modelling instead allows the generation of rectified and scaled high-resolution orthoimages based on the geometry of the scene and the accurately measured control points, and it can be used as a basis for the digital inking without further processing (Fig. 3).

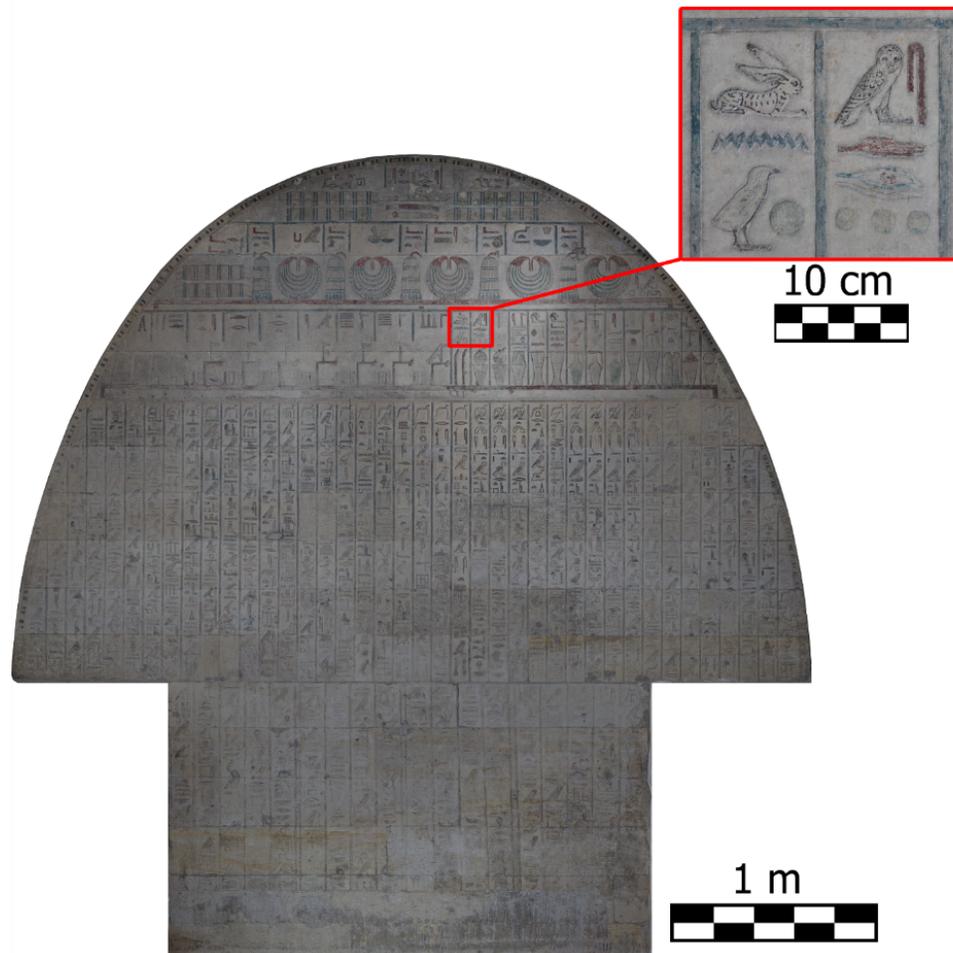


Figure 3. Orthorectified image of the north wall of the tomb of Padinis.

## 5. DATA MANAGEMENT

One of the problems we have encountered in the last two campaigns is the amount of data being produced. More than a terabyte of raw and processed data was accumulated by laser scanning and image-based modelling, which documented irrecoverable and unique features and structures that need to be preserved for the future [Koller et al. 2009; Richards-Rissetto and Schwerin 2017; Lowe

2018]. In the last two decades countless attempts have been made to develop new standards and infrastructures to save the data [Richards-Rissetto and Schwerin 2017]. We have decided to follow the guidelines of good practice published by the English Archaeology Data Service (ADS), which fully cover our requirements [Archaeology Data Service 2016]. This applies in particular to the extremely detailed metadata schema, which allows a meaningful description of the data in technical and in domain-specific aspects.

First of all, we transformed all data to open and sustainable formats like TIFF for the imagery and E57 and OBJ for the 3D-data. All data will be described with metadata according to the guidelines for depositors [Archaeology Data Service 2015] and stored in the research-data-portal FDAT provided by the University of Tübingen [eScience-Center 2018]. This process will begin after the processing of all data and the inking of all inscriptions. In the medium term, all data will be stored in a project-internal Nextcloud instance within the server infrastructure of the University of Tübingen, which allows the storage and exchange of even large amounts of data. The entire data set is backed up every night.

Meanwhile, the metadata will be published under an open-access policy, and the data itself will be locked until its publication is permitted by the Egyptian authorities.

## 6. RESULTS AND EXPERIENCES

One of the main results of the project is the high-resolution 3D plan of the whole site, combining all features derived from the laser scans (Figs. 4,5). The full model can be explored by researchers to reach a deeper understanding of the spatial relationships between the structures on and under the surface. We combined all scans into meaningful groups within Leica Register 360 and exported the single groups to PointCab to derive orthoplans and sections for further investigation. As every step of the excavation was documented in 3D, it is also possible to visualize the ongoing excavation process.

Besides the model of the whole site, high-resolution photogrammetric models have been produced of the tombs of Padinist, Psamtek and Amentayefnakht. First, we produced a fully textured 3D model of every tomb to document the rooms themselves and to visualize the spatial relationships between the inscriptions and scenes for further analysis with a GSD of 5 mm. Next, we used the images to generate high-resolution, orthorectified images of every wall to produce digitally inked facsimiles. The mean resolution we obtained was 0.14 mm per pixel, which also allowed us to capture even the finest details in the hieroglyphs and reliefs. While the generation of the orthoimages of the plain walls could be done directly within Metashape just based on the geometry and the coordinates of the control points, curved scenes, like the ceilings of the tombs, required the generation of a cylinder to describe the curve of the ceiling within Autodesk AutoCAD so we could roll out the scene in Metashape based on this cylinder without distortion (Fig. 6).

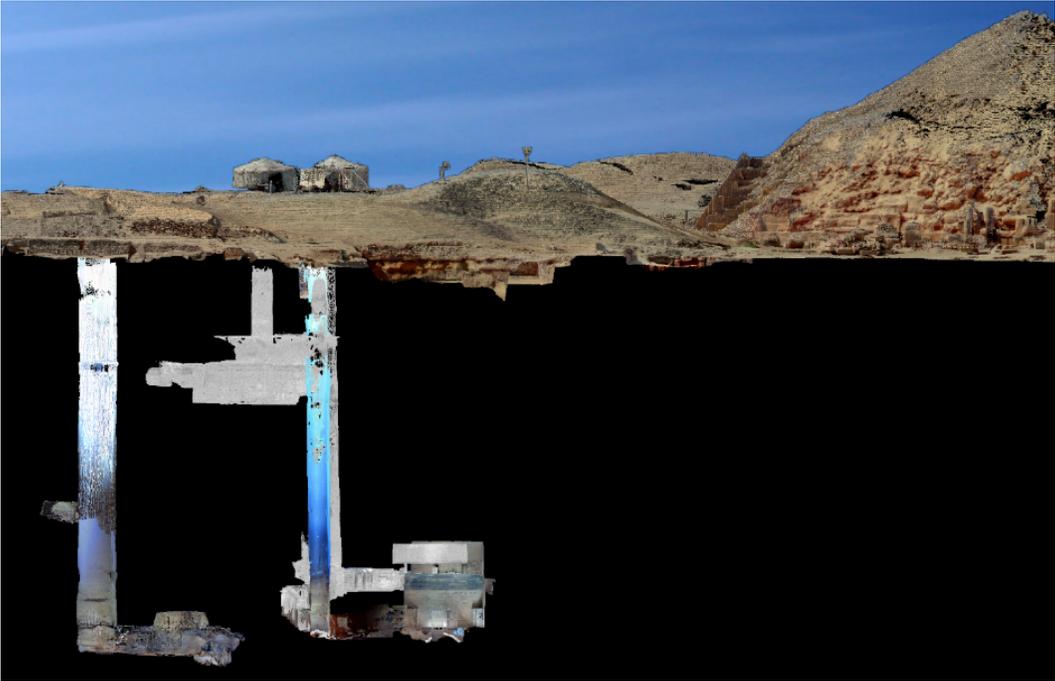


Figure 4. 3D-model of the whole site showing the surface and the shafts

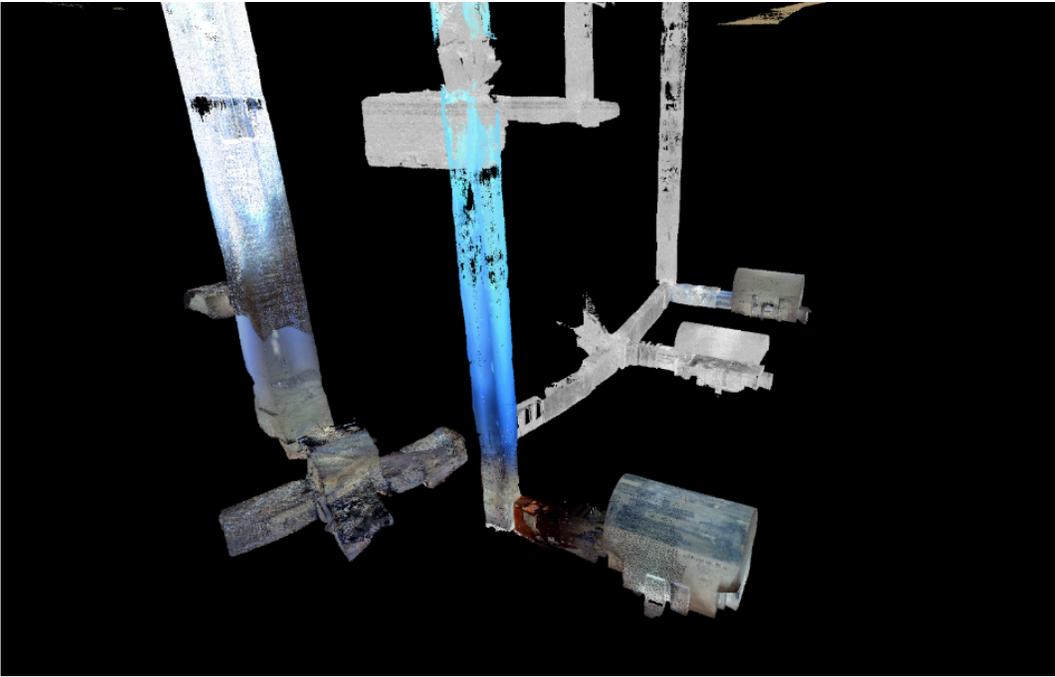


Figure 5. 3D-model showing the spatial relation of the shafts and tombs

Afterwards, the lower straight and the upper curved part of the wall were stitched together in Adobe Photoshop. The application of orthorectified high-resolution images, instead of oblique digital images, sped up the digital inking process significantly and led to much more accurate results.

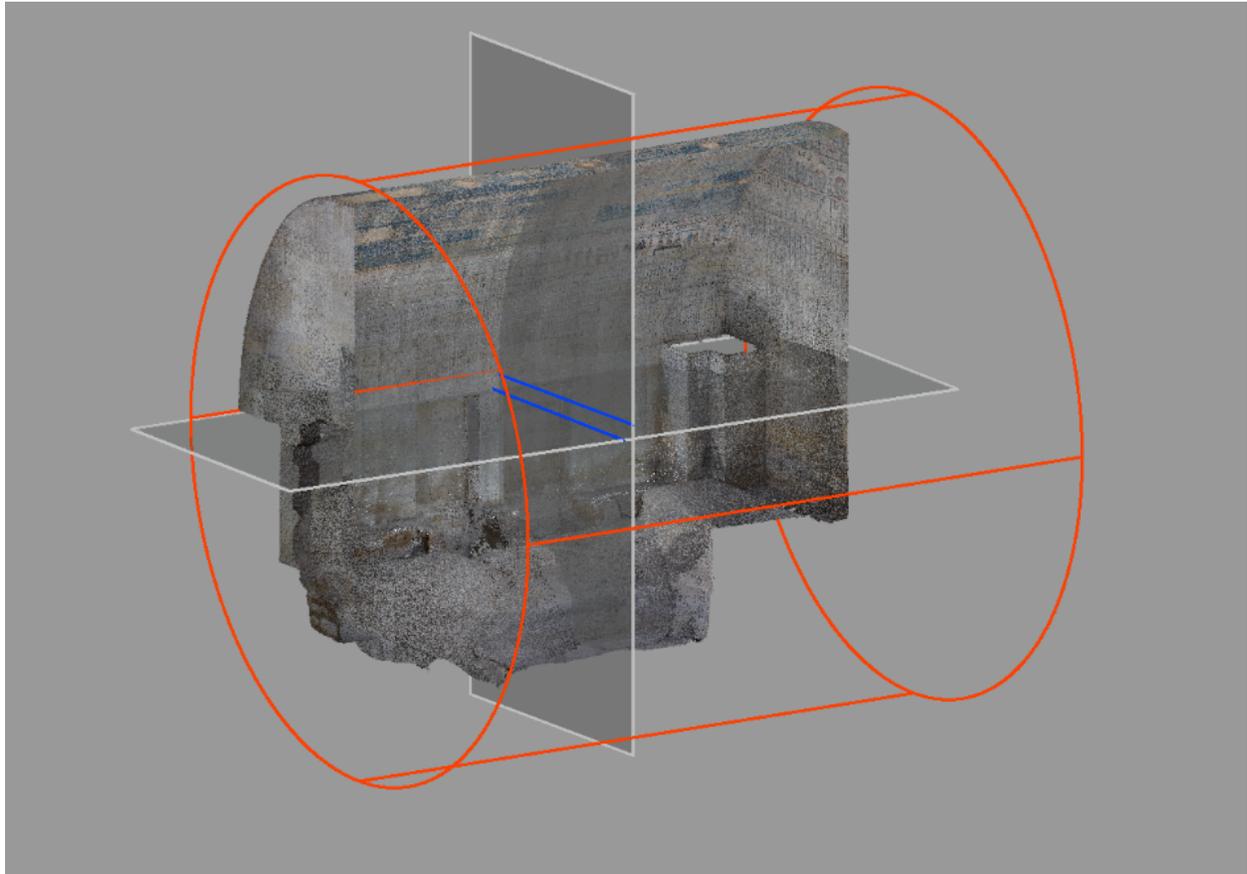


Figure 6. Generation of an orthorectified image based on a cylinder

Furthermore, all the features and tombs from the ongoing excavation have been documented in high-resolution photogrammetric 3D-models, to document all features carefully before the excavation continued. Next, we derived orthoimages from all scenes and imported them into a geoinformation system (GIS) based on QGIS to get a detailed planimetry of the site for a better overview of the data processing progress.

Compared to a conventional documentation strategy, the 3D approach is technically demanding. Aside from the necessary devices and computing resources, a trained staff that can use a wide range of 3D and survey technologies is required. The use of a GIS clearly demonstrates that traditional two-dimensional documentation is not sufficient for sites like the shaft tombs in Saqqara. Only a fully digital and three-dimensional approach makes it possible to visualize and to understand the complex spatial relationships of the area and its features. The 3D-approach gives us the opportunity to create a digital copy of the morphology of the site in the desired scale and resolution, preserving

all stages of the excavation. This copy can be used in various virtual environments in the future to give researchers and the public the possibility to visit and to examine the site from everywhere in the world, while the site itself can be reserved for a small group of specialists. Particularly with the burial chambers, with their irrecoverable and unique features and artifacts made of extremely fragile ephemeral materials like wood, plaster and linen, the 3D model is the only way to document and preserve them adequately.

In addition, the 3D-models can always be combined and visualized in new ways. For example, it was possible to record the sarcophagus of Padinist in the National Museum in Cairo and then place it virtually at its original location. It is to be hoped that we can also virtually recontextualize the sarcophagus of the Psamtek, which is now kept in Berkeley. It was recently captured in 3D as part of the "Book of the Dead" project [Lucarelli 2019b, 2019a].

As 3D technology, like virtual or augmented reality, is still in its infancy, the importance of careful archiving and curation of the raw data cannot be emphasized enough. This is the closest representation we have of the reality and we can save the information for future generations and integrate it into emerging technologies to analyze it to answer new research questions.

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