UNIVERSITY OF WARSAW | Polish Centre of Mediterranean Archaeology

Title: **Polish Epigraphical Mission in the Tomb of Ramesses VI (KV 9) in the Valley of the Kings in 2010**

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Journal: *Polish Archaeology in the Mediterranean 22 (Research 2010)*

Year: 2013

Pages: 161-170

ISSN: 1234–5415 (Print), ISSN 2083–537X (Online)

Publisher: Polish Centre of Mediterranean Archaeology, University of Warsaw (PCMA UW), Wydawnictwa Uniwersytetu Warszawskiego (WUW)

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Revised: Author added on pages 161 and 165 (title/author) and in the captions of Figures 5 and 6 on page 167; additional author's name and address added in credentials on page 170

POLISH EPIGRAPHICAL MISSION IN THE TOMB OF RAMESSES VI (KV 9) IN THE VALLEY OF THE KINGS IN 2010

Adam Łukaszewicz[1]

with appendix by Wiesław Małkowski,[2] Miron Bogacki,[3] and Jakub Kaniszewski[4]

[1,2,3] Institute of Archaeology, University of Warsaw, [4] independent

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The study of the Greek and Latin graffiti in the Tomb of Ramesses VI (KV 9) in the Valley of the Kings (*Theban Mapping Project* online) is the prime objective of a team from the Polish Centre of Mediterranean Archaeology, University of Warsaw, which has been working on and off in the tomb since 1996 (Łukaszewicz 2000a). A preliminary survey of the graffiti was completed during several visits to the tomb preceding 2010. Some general conclusions have been published by A. Łukaszewicz (2000b; 2007; 2010a; 2010b; 2013a; 2013b; 2013c). The results of the first period of research will appear in a prospective study by the author, *The Son of the Dawn and the Greeks. The tomb of Memnon* (*Ramesses VI*) *revisited* (Warsaw).

The overall examination of the epigraphic material from the tomb has been accompanied by an intensive program of measurements and photographic documentation of the graffiti, which is designed to facilitate the reading and interpretation of the inscriptions. The choice of documentation methods in places like a rock-cut tomb with a regular flow of tourist visitors must be cost- and time-efficient simultaneously, while interfering as little as possible with daily sightseeing routines. The following detailed description of the measurement and documentation methodology is given in order to share ideas as to how quality results can be achieved with low-cost and easily available methods.

EPIGRAPHIC STUDIES

Interest has focused so far on graffiti belonging chiefly to the Roman period and written in Greek by visitors from diverse parts of Egypt and the Mediterranean. Rare graffiti in Latin, Demotic and Coptic accompanied the majority of inscriptions in Greek, which was the international language of the time. Graffiti occur in substantial numbers on the tomb walls regardless of whether they had been decorated or not. They are the most frequent in the upper part of the tomb and cover virtually the entire wall space in the sections of the corridor near the entrance. For the most part a sharp tool was used to scratch them in the plaster. In the lower part of the tomb and in the pillared hall, the graffiti are concentrated in a zone corresponding approximately to the modern walking level. In the lower corridors and in the burial chamber there are some graffiti painted in red. A considerable number of graffiti in the whole tomb are written in black ink.

A diversity of graffiti patterns has been identified. Most graffiti contain only the name of the visitor, many mention the visitor's function or origin. There are expressions of admiration for the beauty of the tomb or words indicating the religious character of the visit (*proskynema*). There

Fig. 1. A series of graffiti from the Roman period, including the inscription of a comes of Thebaid of the 4th century AD (All photos M. Bogacki)

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Explicit dates are rare, but it is hoped that the date of some of the graffiti can be established based on the palaeography to some extent, but primarily on the data provided by the prosopography. The time span covered by the graffiti appears to extend from the 3rd century BC to the 7th century AD, rather than the 6th century as previously believed.

Visitors to the tomb included philosophers, doctors, high-ranking officials both civilian and military. They considered their visit to the tomb of Ramesses VI important, an expression of piety rather than mere curiosity. The tomb was believed to be that of Memnon erroneously identified with the king represented on the famous colossi of Amenhotep III. The reason for that error was not only the epithet Mery-Amun used by Ramesses VI (an appellation of Ramesside kings confused with the Greek Memnon), but also the presence of signs for Nebmaatre both in the name of Amenhotep III and of Ramesses VI.

Fig. 2. Graffiti of the Roman period between the figures of Isis and Nephthys

DOCUMENTATION METHODS

Photographic documentation is obviously essential and an effort was made to document as many graffiti as possible, especially in the upper part of the tomb. More time is needed to complete a full dossier of the graffiti found in the tomb.

One should note, however, the advantages of photography combined with photogrammetric software and tachymetry for documenting features like tomb KV 9. It should be stated that the effect was comparable to that obtained through three-dimensional scanning, while our method was less expensive and more ergonomic, hardly interfering with the circulation of tourists visiting the tomb.

Additional advantages of this method include simplicity and negligible failure, as well as no cross-border transportation problems. The outcome is positive in most cases, assuring the best results.

Measurements within the tomb were made with an optical device without touching the walls. Digital processing of the data

Fig. 3. Inscription of one Nemesas (Roman period)

combined with photographic documentation will locate individual graffiti precisely within the tomb. The end result will be a map of the graffiti found on the walls.

A study of the measurements taken this season should help to establish the walking level within the tomb in different periods of its accessibility. Jules Baillet's 1926 edition and commentary on research carried out in the late 19th and early 20th century is in need of revision and updating.

APPENDIX

THREE-DIMENSIONAL SPATIAL INFORMATION SYSTEM FOR THE GRAFFITI INSIDE THE TOMB OF RAMESSES VI (KV 9) IN THE VALLEY OF THE KINGS

Wiesław Małkowski,[1] Miron Bogacki[2] and Jakub Kaniszewski[3]
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1. TACHYMETRIC MEASUREMENTS

A Leica TCR407 Power electronic total station was used to take measurements inside the tomb of Ramesses VI in the Valley of the Kings, enabling a noninvasive reflectorless measuring of points with an electronic distance meter (EDM). The instrument uses a visible red laser (wavelength 0.670 mm) working in a 100 MHz 1.5m frequency. The visible laser spot size does not exceed 5 mm in short-distance measurements (10 m) aimed at angles of up to 45 degrees from the perpendicular to the wall. Accuracy according to technical specifications of the instrument is 3mm + 2ppm (distance), 7 " = 2mgon (read angles), instrument leveling precision 2 "= 0.7 mgon. The dual axis oil compensator was activated for measuring, correcting the tilt of the instrument in the range of ± 4 ' (0.07 gon).

Reference points inside the tomb were based on a linear point set inventoried by the tachymetric method using a mirror GMP111 (constant 17.5 mm) [*Fig. 4*]. They were stabilized on a wooden floor, parallel to the walls of the tomb, taking into account that the collapse of the axes of the tomb is not collinear. Height positioning and the planar coordinate system were defined as a local coordinate system. Measurements of slope distances to each point took into account vertical angle values. Polar coordinates were converted into Cartesian coordinates (x, y, h). Cartesian coordinates (x, y, h) were calculated on the basis of all the necessary information: station coordinates and back sight points, height of instrument over the station, height of pole with reflector, values of vertical and horizontal angles and slope distances. The set of points (processed into three-dimensional space) corresponds to real geometry of the measured tomb and is ready for processing as digital data and ultimately for spatial modeling.

All further measurements were performed with reference to these basic points. Data for specific points of tomb geometry were collected for all the recorded rooms:

edges of wall surfaces, irregular elements (curves) and control planes. Sets of recorded data (geodetic observation) were transmitted to a geodetic calculation program.

2. PROCESSING DATA INTO THREE-DIMENSIONAL MODEL

Constructing a spatial model requires a set of points from direct measurement (by the tachymetric method) to be processed into a model mesh. A triangulated irregular network (TIN) is constructed, the vertices of the triangles constituting the measured points [*Fig. 5*]. Constructing the grid in a 3D Max Studio environment is partly automatic; the grid is optimized and errors reduced by manual selection of grid nodes.

The grid is an essential element of three-dimensional data processing, supporting modeling of edges as well as building faces. It is also the base for modeling surfaces, which operates on the principle of algorithmic distribution of a regular grid mesh that optimizes the three dimensional surface by smoothing and averaging inheritance-curves. Interpolation of the TIN grid affects the final result, which is a realistic model of the object.

Assuming that all the necessary elements of the model were identified during measurements and documented as nodes of the grid-mesh, one can optimize the process of drafting of surfaces between adjoining irregular triangles in order to avoid artificial breaks of the surface visible to the eye of the observer.

The resultant model is divided into a number of modules representing ele-

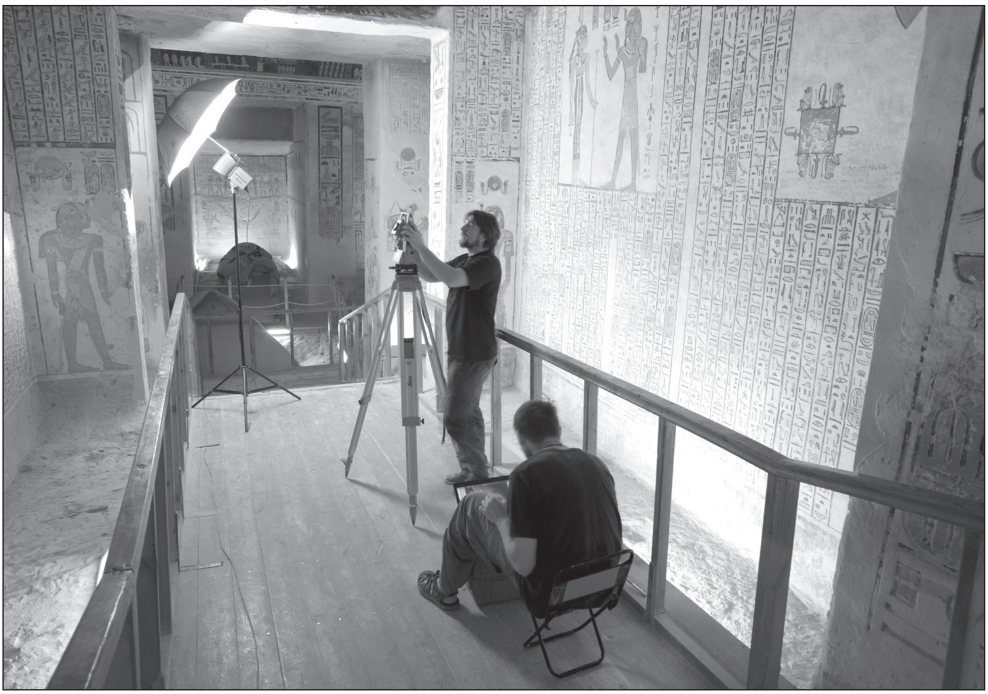

Fig. 4. Documentation in progress inside the tomb

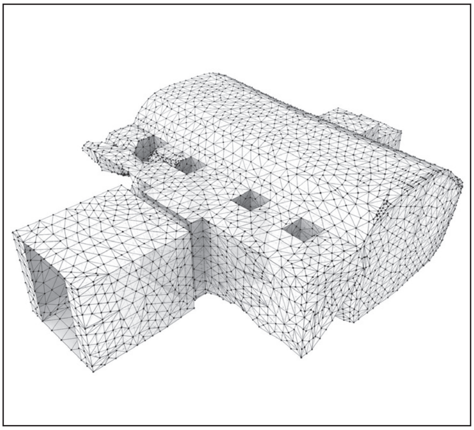

Fig. 5. Three-dimensional TIN model of the chamber (Processing J. Kaniszewski)

ments of the geometry of the feature. In the case of the tomb of Ramesses VI, every wall will be treated as a separate element and placed in a defined coordinate system. This will allow work on the level of the whole model as well as of particular selected elements (i.e., objects). Each module thus has a separate name and a set of characteristics to determine its shape, dimensions and position [***Fig. 6***].

3. PROCESSING PHOTOGRAPHS INTO CARTOMETRIC IMAGES

Using the wide capabilities of Photogrammetric Image Master Pro software, a properly taken image can be transformed

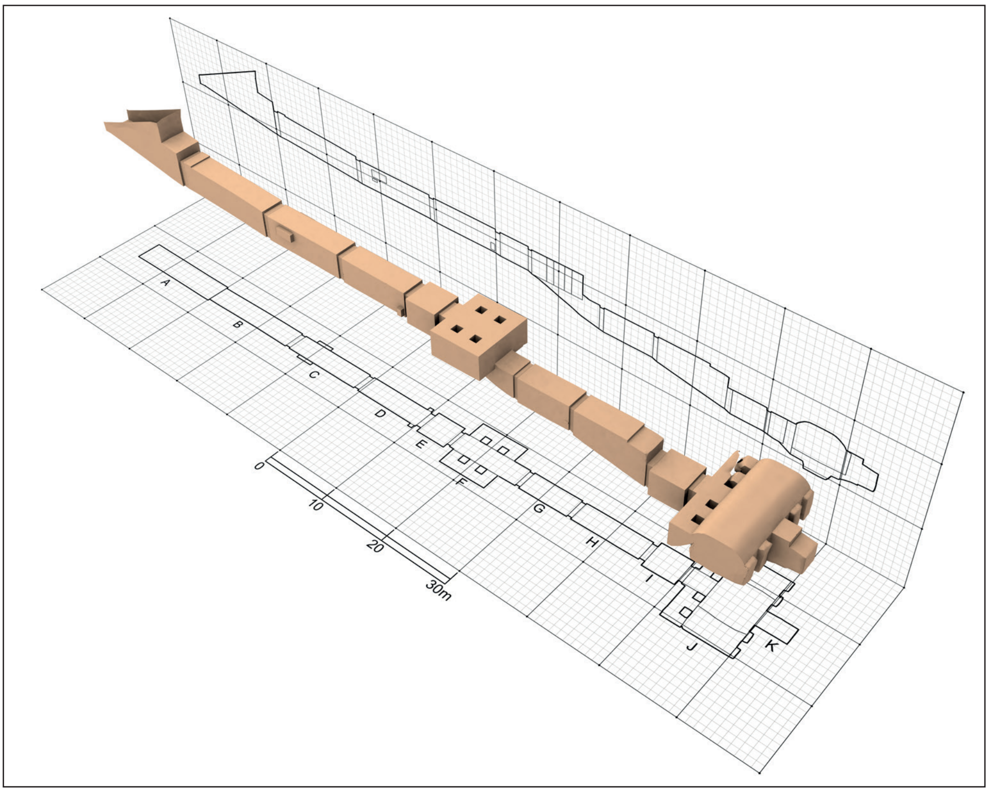

Fig. 6. Spatial model of the geometry of the tomb (Processing J. Kaniszewski)

into distortion-free photo- and orthophotomaps and then recalculated as a three-dimensional surface model based on a TIN grid of triangles. In order for this to be successful, the camera and lenses have to be calibrated so that there are separate profiles for each camera lens; this reduces optical and perspective defects, which are the lot of most photographs. It is crucial to all further processing that the photos be taken with a scale, for example, two points with known distance between them. Calculations are more precise when a grid of control points is established on the photographed surface. In our case, these control points, so called photo-points, were measured by the tachimetric method. Georeferencing for each photograph was based on measurements and coordinate calculation of the photo-points.

Measured photo-points were an integral part of the recorded graffiti, e.g., edges of letters or other distinctive features. The number of control points for each photographed graffiti ranged from a few to several units (depending on the dimensions of the scene with the inscription and the state of its preservation). Photo-points were measured in an irregular grid.

The photographed graffiti were successively transformed to prepare a model grid (DEM Digital Elevation Model) and orthophotomaps. The final effect – an example of the effect can be seen in ***Fig. 7*** – depends on a number of factors. First of all, each pair of images should cover from 70% to 90% of the scene (=graffiti) in question, this being a prerequisite condition for constructing stereo-pairs which permit surfaces to be developed into three dimensional space based on stereoscopic calculation. In practice, this requires the software operator to indicate each photo-point visible on a raster/bitmap image and match it with appropriate, measured coordinates (X, Y, Z). The pixel bitmap image is then transformed by automatic calculation into a defined system of coordinates (X, Y, Z).

Fig. 7. Photogrammetric 3D model (DEM) of part of Room B

The system generates stereo-pairs allowing a three-dimensional digital model of the surface to be created. Areas selected by the user were processed into a triangulated irregular network, filled with a textured surface, and finally formed as a photorealistic three dimensional surface.

Grids made for all documented areas can be analyzed independently or in the context of another model located in the same coordinate system. The idea ultimately is to combine the data in one file, presenting a larger test area. Elements important from the epigraphic point of view can be separated out in the course of the processing. These can then be selected, allowing further work on each "graffiti area" using edition and measuring tools.

Flat photomaps documenting scenes with graffiti from the walls of the tomb were also made and saved in GeoTiif format, ready to use on a GIS (Geographic Information System) platform using georeferenced data on file.

The advantage of working with a total station inside the tomb is that it does not interfere with the regular tourist cycle. Measurements were taken during tourist opening hours with large numbers of visitors streaming through the tomb while the work was in progress.

4. METHOD ASSESSMENT

The method of photography combined with photogrametric software and tachimetry used in the circumstances of the tomb of Ramesses VI proved to have several advantages. The effect was similar or even better than 3D scanning while using a cheaper and more ergonomic method and not interfering with tourist flow inside the tomb. Compared to the three dimensional scanner, which could ideally be used for the task at hand, but which collects data automatically without selection, the method described above gives the opportunity to collect only characteristic points, required to create the geometry of a measured feature. A relatively limited number of points (about 5000), measured within a couple of days, sufficed in this case to achieve a result similar in effect to the process of scanning and processing data with a scanner. Moreover, photos are better documentation of graffiti than the colored cloudpoint from a scanner, especially when using professional reflex cameras and adequate lighting for good photography. They hold more graphic information, are scalable and after transformation to orthophotomaps with coordinates can provide useful and highly accurate data. The same technique of taking pictures is useful for small areas 5–50 cm and for bigger areas 1–5 m. In the documentation process, taking pictures is not as time-consuming as their processing in photogrammetric software. Nearly all the graffiti from the tomb were photographed within two weeks of work in the tomb. Software processing of photographic data will take months, but it can be done locally in Poland.

In summary, this combination of photogrammetric, geodesic and 3D modeling methods gives researchers the following:

– a full 3D model of the tomb created from geodesic measurements;
– two-dimensional plans of all parts of the tomb extracted from the 3D model;
– 3D models of paintings with graffiti created by photogrammetric methods;
– detailed orthophotographs of graffiti scaled and localized in space with a high degree of accuracy.

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Fig. 4. Documentation in progress inside the tomb

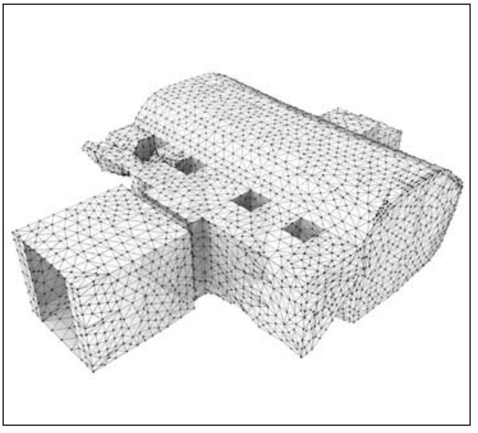

Fig. 5. Three-dimensional TIN model of the tomb chamber

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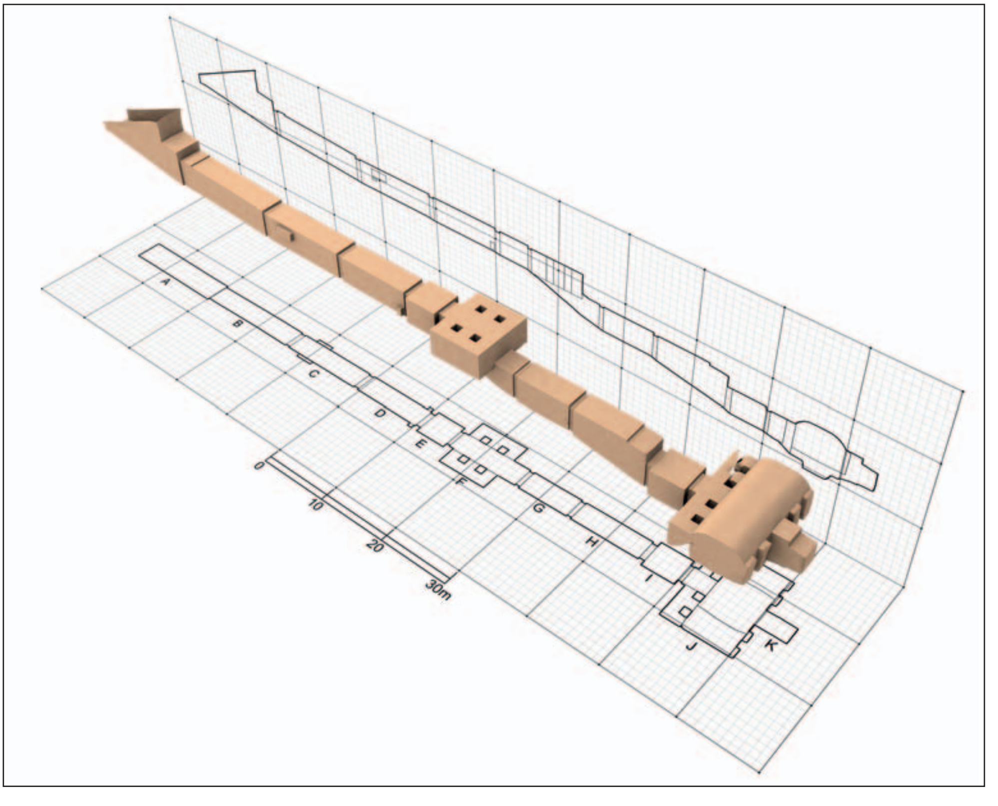

Fig. 6. Spatial model of the geometry of the tomb

into distortion-free photo- and orthophotomaps and then recalculated as a three-dimensional surface model based on a TIN grid of triangles. In order for this to be successful, the camera and lenses have to be calibrated so that there are separate profiles for each camera lens; this reduces optical and perspective defects, which are the lot of most photographs. It is crucial to all further processing that the photos be taken with a scale, for example, two points with known distance between them. Calculations are more precise when a grid of control points is established on the photographed surface. In our case, these control points, so called photo-points, were measured by the tachimetric method. Georeferencing for each photograph was based on measurements and coordinate calculation of the photo-points.

Measured photo-points were an integral part of the recorded graffiti, e.g., edges of letters or other distinctive features. The number of control points for each photographed graffiti ranged from a few to several units (depending on the dimensions of the scene with the inscription and the state of its preservation). Photo-points were measured in an irregular grid.

The photographed graffiti were successively transformed to prepare a model grid (DEM Digital Elevation Model) and orthophotomaps. The final effect – an example of the effect can be seen in ***Fig. 7*** – depends on a number of factors. First of all, each pair of images should cover from 70% to 90% of the scene (=graffiti) in question, this being a prerequisite condition for constructing stereo-pairs which permit surfaces to be developed into three dimensional space based on stereoscopic calculation. In practice, this requires the software operator to indicate each photo-point visible on a raster/bitmap image and match it with appropriate, measured coordinates (X, Y, Z). The pixel bitmap image is then transformed by automatic calculation into a defined system of coordinates (X, Y, Z).

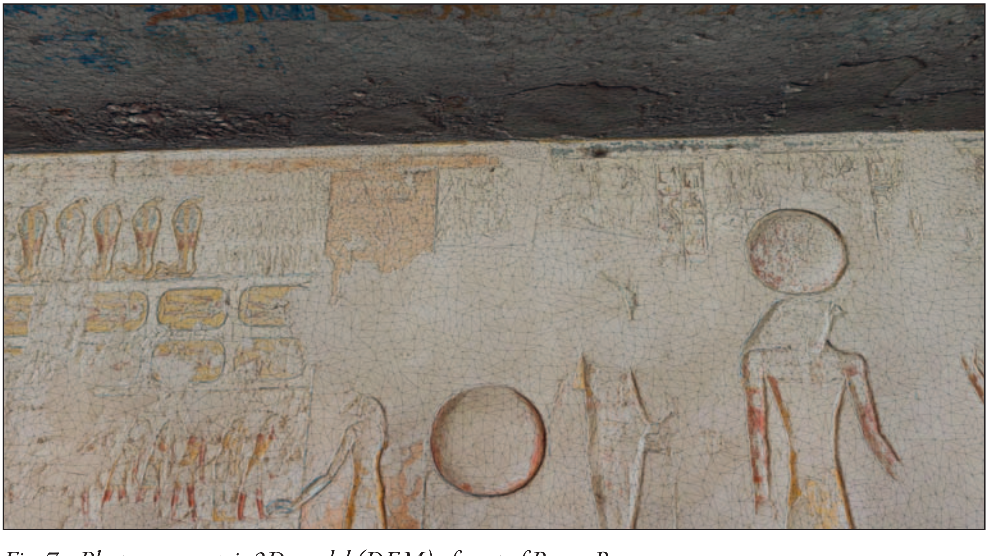

Fig. 7. Photogrammetric 3D model (DEM) of part of Room B

The system generates stereo-pairs allowing a three-dimensional digital model of the surface to be created. Areas selected by the user were processed into a triangulated irregular network, filled with a textured surface, and finally formed as a photorealistic three dimensional surface.

Grids made for all documented areas can be analyzed independently or in the context of another model located in the same coordinate system. The idea ultimately is to combine the data in one file, presenting a larger test area. Elements important from the epigraphic point of view can be separated out in the course of the processing. These can then be selected, allowing further work on each "graffiti area" using edition and measuring tools.

Flat photomaps documenting scenes with graffiti from the walls of the tomb were also made and saved in GeoTiif format, ready to use on a GIS (Geographic Information System) platform using georeferenced data on file.

The advantage of working with a total station inside the tomb is that it does not interfere with the regular tourist cycle. Measurements were taken during tourist opening hours with large numbers of visitors streaming through the tomb while the work was in progress.

4. METHOD ASSESSMENT

The method of photography combined with photogrametric software and tachimetry used in the circumstances of the tomb of Ramesses VI proved to have several advantages. The effect was similar or even better than 3D scanning while using a cheaper and more ergonomic method and not interfering with tourist flow inside the tomb. Compared to the three dimensional scanner, which could ideally be used for the task at hand, but which collects data automatically without selection, the method described above gives the opportunity to collect only characteristic points, required to create the geometry of a measured feature. A relatively limited number of points (about 5000), measured within a couple of days, sufficed in this case to achieve a result similar in effect to the process of scanning and processing data with a scanner. Moreover, photos are better documentation of graffiti than the colored cloudpoint from a scanner, especially when using professional reflex cameras and adequate lighting for good photography. They hold more graphic information, are scalable and after transformation to orthophotomaps with coordinates can provide useful and highly accurate data. The same technique of taking pictures is useful for small areas 5–50 cm and for bigger areas 1–5 m. In the documentation process, taking pictures is not as time-consuming as their processing in photogrammetric software. Nearly all the graffiti from the tomb were photographed within two weeks of work in the tomb. Software processing of photographic data will take months, but it can be done locally in Poland.

In summary, this combination of photogrammetric, geodesic and 3D modeling methods gives researchers the following:

– a full 3D model of the tomb created from geodesic measurements;
– two-dimensional plans of all parts of the tomb extracted from the 3D model;
– 3D models of paintings with graffiti created by photogrammetric methods;
– detailed orthophotographs of graffiti scaled and localized in space with a high degree of accuracy.

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POLISH ARCHAEOLOGY IN THE MEDITERRANEAN

XXII

RESEARCH 2010

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