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GROUND AND AERIAL PHOTOGRAMMETRIC DOCUMENTATION IN JIYEH (PORPHYREON)

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Abstract: The article presents methods and results of aerial photographic documentation during two seasons of excavation by a Polish team from the Polish Centre of Mediterranean Archaeology of the University of Warsaw at the site of Jiyeh in Lebanon. The photographs and photogrammetric processing was carried out in 2009 with some follow-up work in 2010. All the ground and aerial photographs were made by the author. The aerial views were taken with a remote-controlled photo camera mounted on a frame under a kite.

Keywords: photogrammetry, kite aerial photography, aerial archaeology, Lebanon, Jiyeh

The photogrammetric documentation of the excavation project in Jiyeh, specifically linked with the exploration of an extensive Roman and Byzantine habitation quarter, was carried out in the 2009 season and completed in 2010. Documentation work of this kind was undertaken also on the site of Chhîm excavated by the PCMA archaeological team, and the monastery in Kaftun in northern Lebanon, the latter in connection with a conservation project of the Fine Arts Academy in Warsaw. Photogrammetric processing made use of both ground and kite photography. It should be noted that photogrammetry has seen modest application in the archaeology of Lebanon (see, e.g., Grussenmeyer, Yasmine 2004) despite early use of photogrammetric studies in ancient Baalbek (Albertz 2002: 22).

The most important task at the archaeological site in Jiyeh was aerial low-altitude photography of the excavations in the habitation quarter. It was accomplished using a special kite photography set constructed previously for fieldwork in Libya and Peru (Bogacki *et alii* 2007; Bogacki *et alii* 2008; 2010: 123–127). The equipment consisted of three different-size flowform kites with mounted remote-controlled frame with photo camera, kite line and apparatus for radio-steering of the camera and ground monitoring of photo takes. A Canon 5D camera with Canon 35mm f.2.0 and Canon 17-40L f.4.0 lenses was used. The camera was mounted on a self-leveling, remote-controlled frame suspended a dozen or so meters below the kite. Photos were taken at different heights, from 10 to 100 meters.

Weather and field conditions at Jiyeh were favorable. Winds, mainly from the southwest, were strong enough to carry the camera. Four photo sessions were carried out in 2009 and an additional two in 2010. Different parts of the day were

chosen for the different sessions, in order to obtain the fullest possible picture of the site. Afternoon photographs show areas of the excavated site that were in the shade in the morning photos. Altogether hundreds of vertical and angled shots were taken by the kite-photography crew. They will be used in further archaeological analysis of the site. Moreover, they can be used for promotional and information purposes.

Processing of the photos with photogrammetric software was the next stage of the operation. To obtain a high-exactitude 3D model and photomap of the site it was necessary first to calibrate the camera and the lenses used, using the Image Master 2007 manual and Image Master Calib. Software. The Canon 17-40L lens was calibrated at focal length 22mm. The excavation area was covered with two vertical photos overlapping from 70 to 90%. To scale the photos for photogrammetric processing crosses were marked first with red paint on the site; they served as photopoints, set in an irregular grid, their three-dimensional coordinates measured with a Leica TCR 407 Power laser theodolite. These coordinates were assigned to the photopoints seen in the photos, forming so-called stereo-pairs used subsequently for the 3D model and orthophotomap. Total station measurements were approximately 2 cm exact. Orthophotomap error did not exceed 3 cm.

In effect, digital surface models of the excavated site were developed [***Fig. 1a–c;*** for the plan, see Fig. 2 on page 426 in this volume]. Each one is composed of a triangular network with a resolution of 0.5 m. Orthophotomaps of the site were also made, applying different degrees of exactitude and different resolution. Ortophotographs do not present any of the optical faults of lenses or perspective distortions. Two- and three-dimensional data are recorded in popular file formats: DXF, VRML, OBJ, and GeoTIFF. This permits importing by both graphic and GIS software for further interpretation and processing. Contour maps can be made, sections of different extent and altitude views. The data are oriented according to the grid coordinates of a given site, hence they can be supplemented by new data from the site at any time.

In the second stage of work at Jiyeh a 3D model [***Fig. 3***] and orthophoto of the basilica were made, using photos from a Canon 5d mk2 camera with Canon 50mm f.1.8 lens. A laser theodolite was used to scale these photos. Measurements were taken without the mirror, which made it easier to measure specific markers. The photopoints were distributed in an irregular grid. Measurement error of the 3D model did not exceed a maximum of 3 cm, while the orthophotomap of the facade had a resolution of 2540 x 619 pixels, the resolution of the triangular network of the model being set at 3 cm. Similarly as in the case of the excavation area, the data was recorded in different digital file formats.

Individual finds were also documented photogrammetrically in the 2009 season. The first to be completed was a stele with the image of a falcon [***Fig. 2***; for a photo of the stele, see Fig. 12 on page 436 in this volume]. The three-dimensional model was created based on a network of triangles with 1 mm resolution. The orthophotograph was recorded in 3723 x 4479 pixel resolution. A Canon 5D Mk2 camera with Canon 50mm f.1.8 lens was used to take the photographs.

Summing up the work, it should be noted that digital photogrammetry has

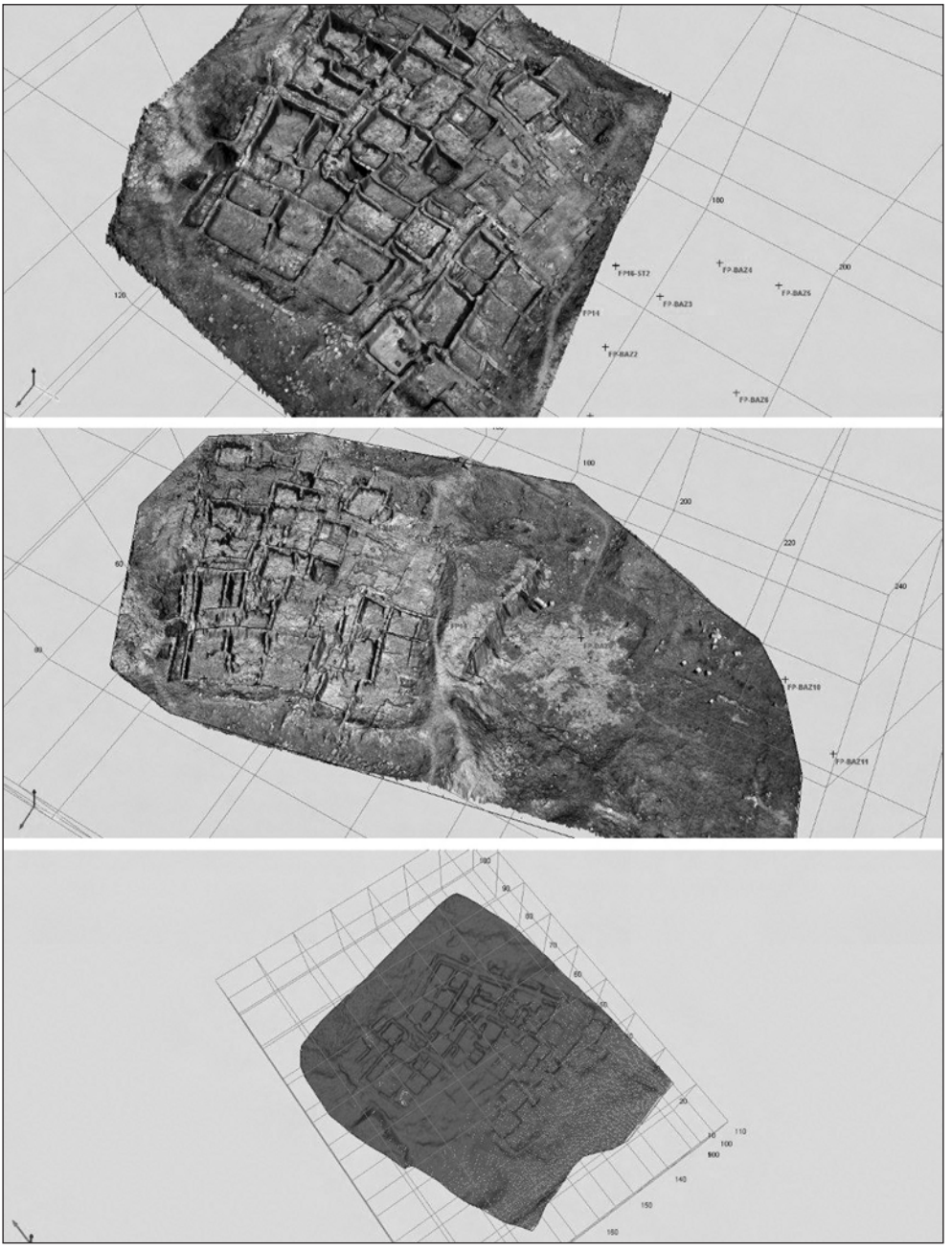

Fig. 1. Three different digital surface models of the excavation area in the Roman-Byzantine habitation area in Jiyeh (Photo and processing M. Bogacki)

proved to be an extremely universal and comprehensive documentation method. The same software could be used for processing large area photographed from the air as well as small finds just a few centimeters in length or width. The method works well with kite photography sets. The software and laptop do not pose the same problems with air transport to and from site as 3D scanners, for example. Rapid results in the field is another unquestioned strength of this method. The exactitude of the photogrammetric documentation can be considered sufficient for the needs of archaeologists. The resolution is dependent primarily on the method, technique and quality of the photographs. Weaknesses include a worse quality of depth and height measurements compared to planar measurements and the long time spent on generating data.

Three weeks of work were sufficient to document the excavation area and objects, a task which would have taken months by the traditional excavation methods. Extant drawing documentation was also verified. Digital data is easy to transport, store, analyze and process. It also permits an effective and friendly form of presentation of research results to a broadly understood scientific community.

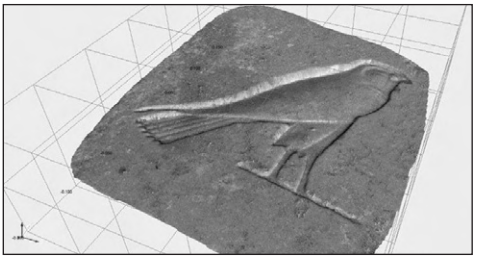

Fig. 2. Stele with representation of Horus (Photo and processing M. Bogacki)

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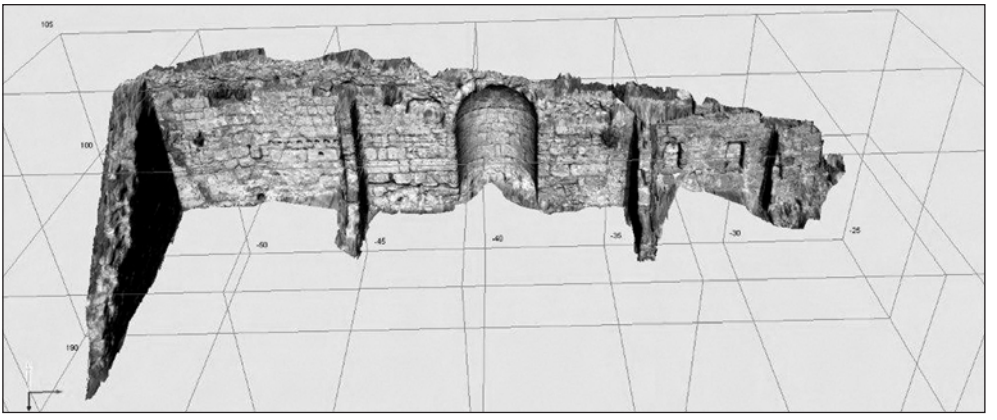

Fig. 3. Three-dimensional model of the eastern part of the Byzantine basilica in Jiyeh (Photo and processing M. Bogacki)

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