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Documentation and computer reconstruction strategies in the study of architecture at the sanctuary of Poseidon at Kalaureia, Greece

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Abstract: In the recording of the progress of the excavations and architectural features at the sanctuary of Poseidon at Kalaureia special emphasis has been placed on the use of current digital technologies. Three-dimensional site scanning was ruled out due to high costs and it has been largely replaced by extensive use of up to three total stations. In the recording of architecture the total stations are used to directly ‘draw’ the features with laser beam. Effective use of the laser requires frequent changes in the position of the instrument which is made possible by an extensive network of fixed points over the large site. Recording the architecture principally as lines has the added benefit of making the production of site plans and 3D reconstructions quicker. Due to the detailed measurements of the archaeological features it is also possible to present 3D digital elevation models (DEMs) of the various stages of the excavations. Further details can be added to the 3D models by draping actual photographs over the DEMs. The terrain models and recorded ancient features can be integrated with the reconstructions to display the basis of the architectural interpretations.

Keywords: Greek architecture – Kalaureia, Greece – Sanctuary of Poseidon – digital documentation – three-dimensional reconstruction

Introduction

The Kalaureia Research Program – the Sea, the City and the God is a multi-disciplinary project hosted by the Swedish Archaeological Institute at Athens and funded by the National Bank of Sweden Tercentenary Foundation (2007–2012).[1] The project combines three different strands of inquiry into an important sanctuary of ancient Greece: archaeological investigation, study of the local religion and its contribution to understanding Greek religion in general, and exploration of the impact of the archaeological remains on the local community. The specific responsibility of the author of this paper is to conduct research on the architectural remains of the sanctuary, and besides basic publication of the buildings, also to produce a computer model of the site (for an overview of the project, see www.kalaureia.org; PENTTINEN *et al.* forthcoming). The new research programme is directly linked to the Swedish excavations carried out at the site since 1997 (WELLS *et al.* 2003; WELLS *et al.* 2005; WELLS *et al.* 2006–2007).

Poros is located in the south of the Saronic Gulf, and it comprises two separate islands: Spheria in the south, where also the modern town and harbour of Poros are located, and Kalaureia, the larger northern island with the homonymous archaeological site. The sanctuary is located on the saddle between the hills of Vigla and Agios Ilias at the height of some 190 m above the sea level. The ancient harbour was located in the Bay of Vayonia to the north of the site.

With a temple and five major subsidiary buildings, the site is among the most important sanctuaries in the Saronic Gulf (Figs. 1 & 2). As to its architectural importance it is on par with other large sanctuaries of Greece. The sanctuary is best known as the death-place of the orator Demosthenes, who sought asylum

Fig. 1 – General view of the sanctuary from southwest in 2008. Attica is faintly visible in the background (J. Pakkanen).

Fig. 2 – General plan of the archaeological site with named buildings inside the sanctuary (J. Pakkanen & E. Savini).

there in 322 BC. He was pursued by the Macedonians after the capture of Athens, and with nowhere to escape he committed suicide by taking poison (STRABO 8.6.14; PLUTARCH, *Vit. Dem.* 28–30).

The foundations of the buildings are mostly what remains of the temple, stoas and the entrance propylon: there is very little standing higher up than the ground level (Fig. 1). The fragmentary nature of the architectural remains provides a very interesting scholarly and methodological challenge: how is it possible to study the ancient built environment in a case where the majority of the building material has been systematically dismantled and reused away from its original context? One way of answering the question is to carry out a thorough comparative study of related buildings and sanctuaries in the neighbouring regions, and the new excavations are already bringing into light large numbers of fragments and also some more complete architectural blocks.

Since there are no standing structures, the site has attracted little attention from scholars of Greek architecture. As part of the excavation campaign in 1894 by Wide and Kjellberg their architect, Sven Kristenson, recorded plans of the buildings, and in 1930s the German scholar Gabriel Welter carried some further studies on the architectural remains. Despite the use of the sanctuary as a quarry for building material, previous studies at the site have managed to establish the majority of the principal features and dimensions of the building plans (WIDE & KJELLBERG 1895; WELTER 1941).

Documentation strategies

Current digital survey technologies have been widely employed in the recording of archaeological material from the start of the excavations at the site in 1997: the employed surveying, global positioning system (GPS), photogrammetry and geographical information system (GIS) strategies are described in detail by Emmanuel Savini in WELLS *et al.* 2003, 129–135. The role of current technologies has been further emphasised in the new research programme started in 2007, though three-dimensional site scanning was ruled out at the planning stage of the project due to high costs.

One of the principal aims of this paper is to demonstrate that detailed surveying of the architectural remains with a total station can still be used as a cost-effective alternative for building precise 3D models of both the *in situ* and displaced building blocks and fragments. Perhaps the main advantage of surveying with a reflectorless laser total station is that the interpretation of what is recorded and how it is done is made directly in the field and not in the post-processing phase (Fig. 3).

H. Eiteljorg has criticised the use of laser in archaeological surveying as follows: “Modern total stations no longer require the use of a target; they can take a direct reading from nearly any surface. This can reduce the surveying “crew” to [a] single person. Note the trade-off, however, when using a total station without a target. The operator is obliged to pick points to be surveyed by looking through the instrument telescope from some distance. Very fine discriminations simply cannot be made from ten or twenty meters away” (EITELJORG 2007, 199). However, these problems are easy to avoid by keeping the instrument close to the observed blocks and in normal circumstances using the laser pointer instead of looking through the telescope. Nearly all the points at Kalaureia have been recorded within five meters of the total station and with some practice it is possible to learn to read where the centre of the laser pointer is in relation to the intended measurement target on the building block without checking the crosshairs of the telescope (Figs. 3 and 4). Wearing laser enhancement glasses increases the visibility of the pointer so that it is well perceptible also in the strong midday sun, and the major benefit of working mainly with the pointer is that the time needed to adjust

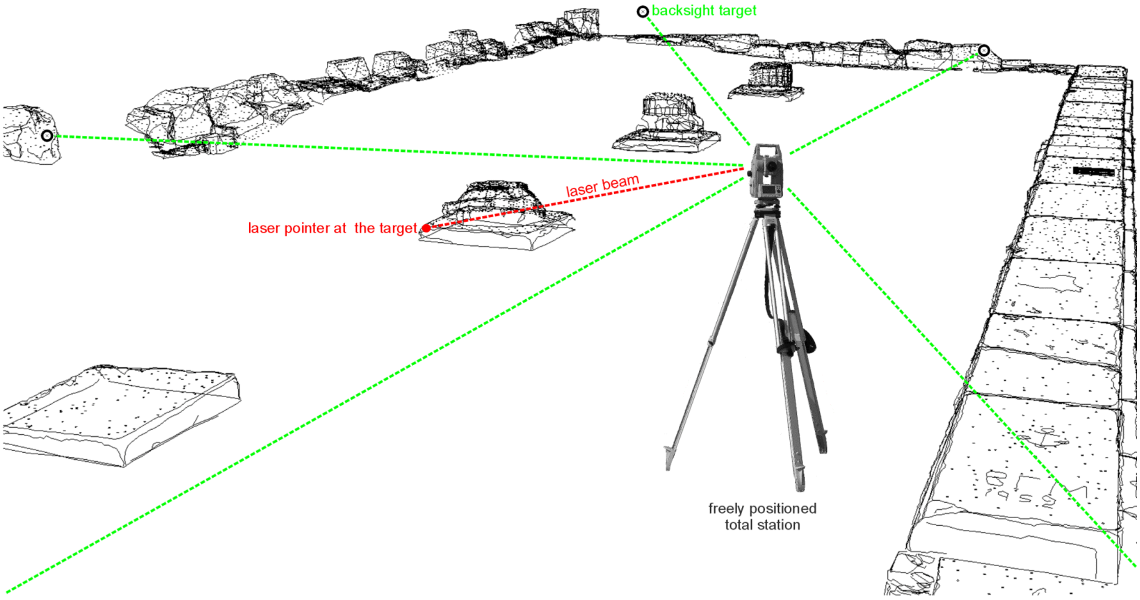

Fig. 3 – Schematic representation of survey principles and terminology using reflectorless laser total stations (J. Pakkanen).

Fig. 4 – Total station survey of Building A in October 2008 (J. Pakkanen).

the telescope is entirely eliminated allowing clearly faster rate of shooting points. Keeping the distance between the architecture and the total station as small as possible does require several changes in the position of the instrument during the day. An extensive network of laser targets over the large site has made it possible to freely relocate the total station with minimal loss of working time and also into an optimal place in relation to the documented blocks without being tied to a limited number of fixed station points (Fig. 5). A typical change of instrument location takes now less than fifteen minutes, and the standard deviations in the instrument co-ordinate position using five laser backsights is normally

1 mm or less. We have been able to obtain a usual rate of 300–500 points per hour at Kalaureia using this method varying mainly due to the type of documented object.

Fig. 5 – Network of fixed points used as backsights for free positioning of the total stations (J. Pakkanen).

The architectural features are principally recorded as lines (Fig. 6). The preserved surfaces of the blocks are documented in detail, and the surveyor makes the decision how precisely to shoot the broken surfaces and modern graffiti: we have opted to do rather precise recording also of the cracked edges and centre lines of the graffiti. The method can effectively be described as directly ‘drawing’ the blocks in 3D with the total station. Recording the blocks principally as lines makes the production of architectural plans straightforward: Fig. 7 presents a direct ‘raw data dump’ of the AutoCAD plan view as it is documented on the total station. For a final plan it is only necessary to modify the line widths, types and colours to reflect differences in the recorded features. In addition, data recorded as lines are very useful in faster production of 3D surface

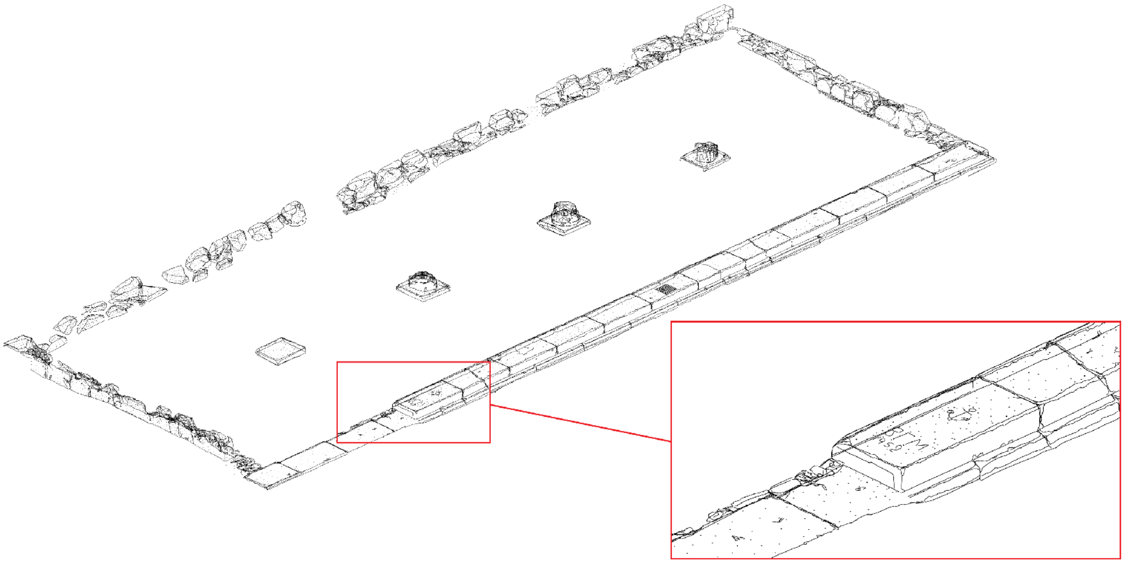

Fig. 6 – Isometric view of Building A as recorded with total station (J. Pakkanen).

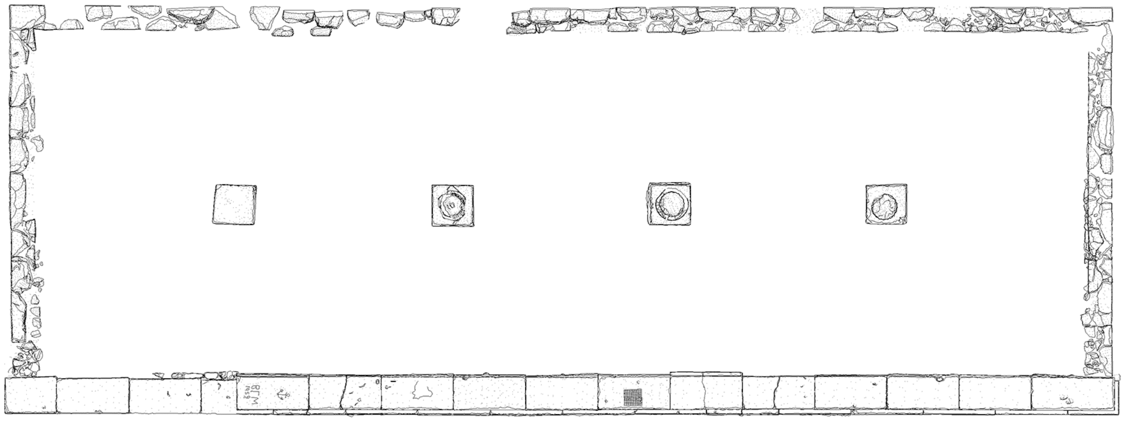

Fig. 7 – Plan view of the raw data on Building A as recorded with a total station (J. Pakkanen).

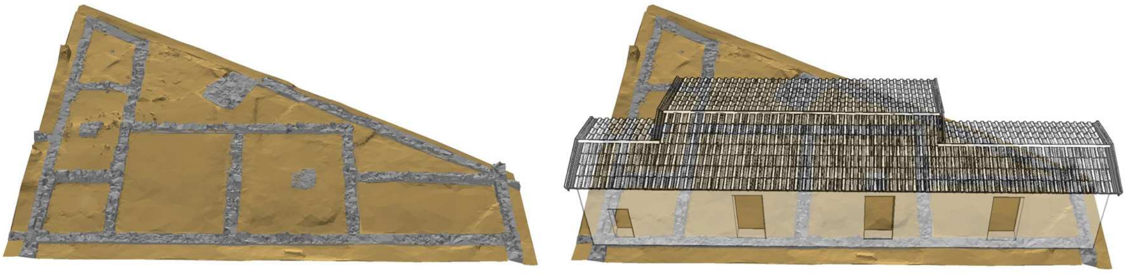

Fig. 8 – On the left an automatically generated 3D model of the architectural and current terrain features of Building D and on the right the same model with an AutoCAD reconstruction superimposed on the remains (J. Pakkanen).

models of the preserved features and also of 3D reconstructions in AutoCAD. The wireframe model of Building A presented in Figs. 6 and 7 comprises some 50,000 points and it was surveyed in ten working days with two total stations (Leica TCR407 and TCR805).

Modelling strategies

Two strategies are employed in making 3D surface models of architectural features from the total station data:

1. *In situ* architecture is principally modelled by creating digital elevation models (DEMs), or triangulated irregular networks (TINs), in ArcGIS 9 (Fig. 8): the largest benefit is that the generation of surface models of both architectural and current terrain features is automatic, and the algorithm uses both line and point data in building up the models. The DEMs can directly be used to give the AutoCAD building reconstructions their archaeological and current surface context.
2. The smaller architectural fragments are modelled in 3D using AutoCAD (Fig. 9). The surfaces are constructed as polygon meshes based on the lines recorded with a total station, and the meshes are created with AutoCAD's *edgesurf* command: in the central section of Fig. 9 one irregular polygon mesh with the size of 12 × 24 rectangles is highlighted in darker colour than the rest. The rendered solid fragments are used in the architectural models to display what is the relationship between the preserved small fragments and the extrapolated reconstructions. The models are also used to produce the publication plans and elevations of the fragments.

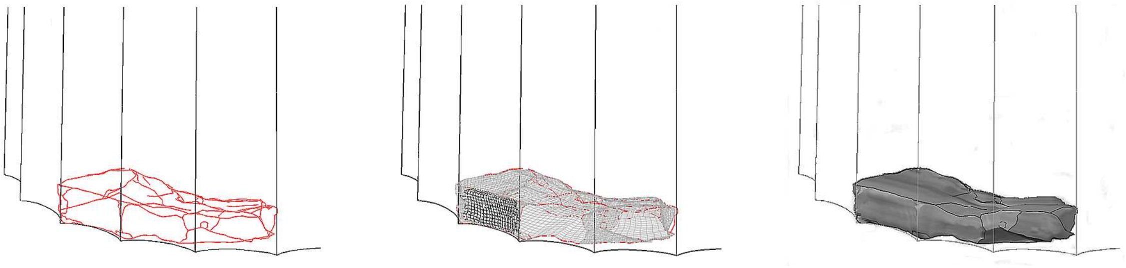

Fig. 9 – On the left wireframe of a column drum fragment as recorded, in the middle with surfaces as polygon meshes and on the right the fragment with rendered surfaces (J. Pakkanen).

In the new excavation areas several architectural features have been discovered: detailed recording of the walls and their archaeological contexts makes it possible to present DEMs of the various stages of excavations. Fig. 10 illustrates the situation of one large trench at the end of the 2007 season (for a report on the excavations, see PENTTINEN *et al.* forthcoming). The points and lines in the model show where the nearly 20,000 total station measurements of this particular area were taken.
Vertical photography is used in the documentation of various phases of the excavations. A number of reference points visible in the photos are marked on the ground and their positions are measured with a total station. The images are processed using GIS where they are rectified and then placed in the correct position in the employed coordinate system. The use of vertical photographs can greatly reduce the loss of excavation data. It is also possibly to add further details to the 3D models by draping actual photographs over the DEMs, as is illustrated by the model of the second large new area opened during the excavation season of 2007 (Fig. 11).

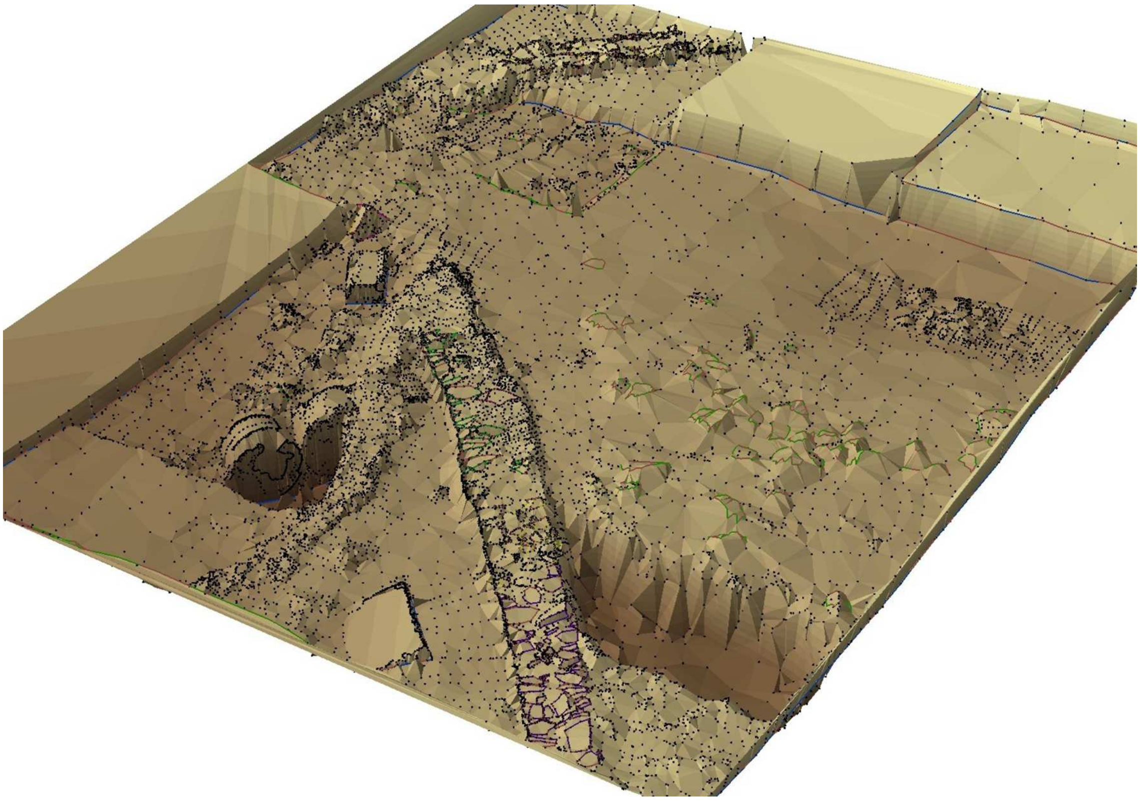

Fig. 10 – DEM of an excavation trench with architectural features: walls, column drums and recycled blocks (J. Pakkanen).

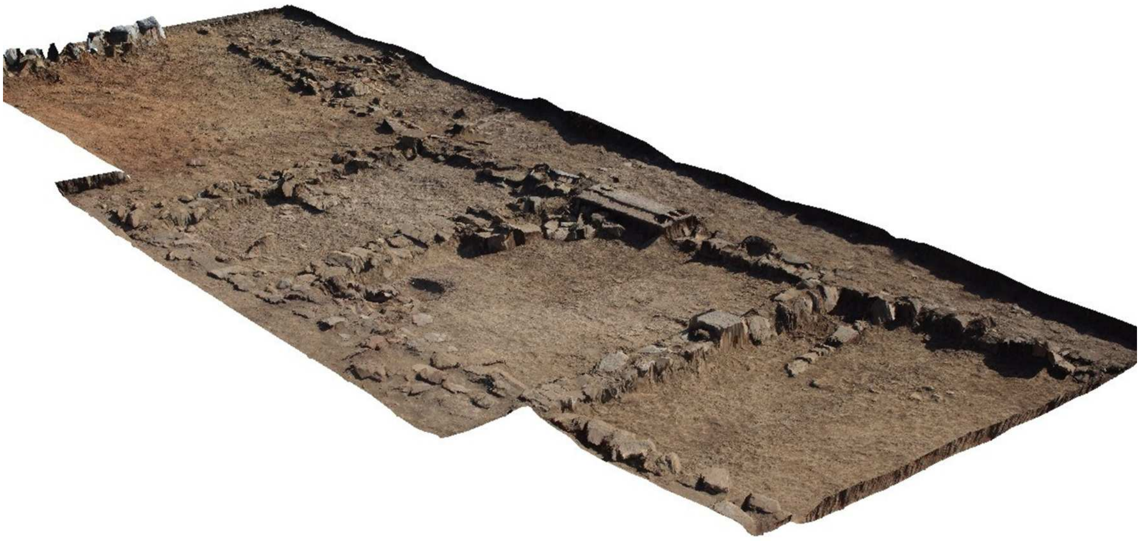

Fig. 11 – Three-dimensional computer model with a rectified photo draped over the archaeological features (E. Savini).

Fig. 12 – Reconstruction of Building D superimposed on the actual remains (J. Pakkanen).

One further advantage of the architectural documentation and modelling strategies employed in the research of the sanctuary of Poseidon at Kalaureia is in making the site more accessible to the wider public: with no standing structures it is very difficult to understand the relationship between the archaeological remains and how the built environment once looked like. The results of the new research are being disseminated on the project website (www.kalaureia.org) and in brochures, publications intended for the general public and new information panels at the site itself. These types of media can make good use of the material produced for the research publications, and some new material specifically generated for these purposes: Fig. 12 presents an integrated site photograph with the architectural interpretation of Building D from south close to the entrance to the archaeological site.

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