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NON-INVASIVE METHODS IN THE RESEARCH OF PANNONIAN VILLAS

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Research on the Roman villas of Pannonia is predominantly based on topographic surveys and archaeological excavations,[2] although non-invasive archaeological methods have also made an important contribution to our knowledge. Since its creation in 1994, the collection of aerial photos in the Aerial Archaeological Archives of Pécs University has continuously grown, mostly from aerial archaeological reconnaissance conducted by Otto Braasch. These photos provide important information on Roman buildings and, in exceptionally good cases, on the broader area and layout of the villas and their estates. While the number of photos grew, the aerial reconnaissance was not followed up by other research. In summer 2012, we had the opportunity to investigate the buildings of the villa at Cserdi near Pécs, and to assess the potentials of non-invasive techniques in archaeological research.

Several major villas, which also functioned as the centres of large estates in the Roman Age, were identified during the aerial archaeological reconnaissance of the Roman border defence system[3] conducted by the Aerial Archaeological Archives of Pécs University. The surveyed sites included several villas in the province's interior and the complex of buildings in the Tokod border area,[4] With the help of the personnel of the Pécs–Pogány Airfield who generously provided the necessary technical background, we could gather

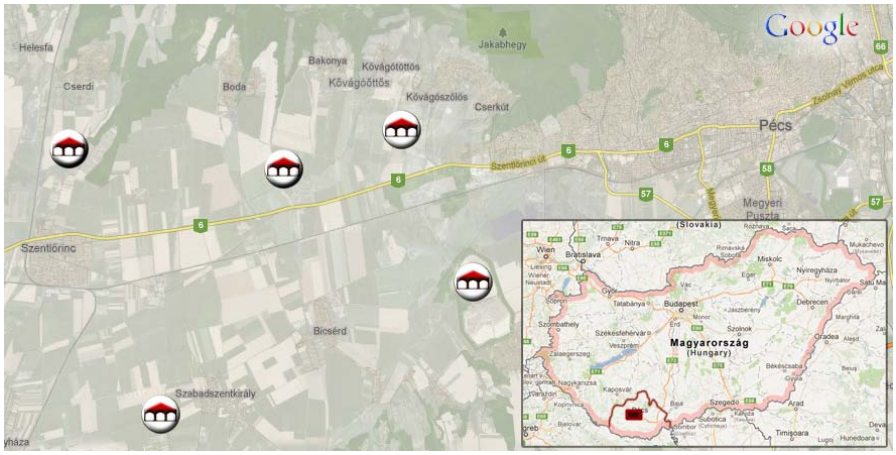

Fig. 1. The Roman villas lying west of Pécs

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[2] Dénes Gabler, Die ländliche Besiedlung Oberpannoniens. In: *Ländliche Besiedlung und Landwirtschaft in den Rhein – Donau – Provinzien des Römischen Reiches*, Band 2, hrsg. Helmut Bender – Hartmut Wolff. Passauer Universitätsschriften zur Archäologie. (Espelkamp: 1994), 377–419; Zsolt Visy, Die ländliche Besiedlung und Landwirtschaft in Niederpannonien. In: *Ländliche Besiedlung und Landwirtschaft in den Rhein – Donau – Provinzien des Römischen Reiches*, Band 2, hrsg. Helmut Bender – Hartmut Wolff. Passauer Universitätsschriften zur Archäologie. (Espelkamp: 1994), 421–449; Mária Bíró, Roman Villas in Pannonia. *Acta Archaeologica Academiae Scientiarum Hungaricae* 26 (1974), 23–57; Edit B. Thomas, *Römische Villen in Pannonien. Beiträge zur römischen Siedlungsgeschichte* (Budapest: Akadémiai Kiadó, 1964).

[3] The "Culture 2000" and the "Central European Danube Limes" World Heritage Sites Projects.

[4] Máté Szabó, Régészeti kutatások a Ripa Pannonica polgári településein (Archaeological research on the civilian settlements of the Ripa Pannonica). In: *A Danube Limes program régészeti kutatásai 2008–2011 között (The Danube Limes project archaeological research between 2008–2011)*, eds Zsolt Visy – Máté Szabó – Annamária Priskin – Róbert Lóki (Pécs: A Pécsi Tudományegyetem Régészet Tanszéke, 2011), 147–162. http://book-let.com/books/danube_limes/#/160/

a wealth of new information on the villas around Sopianae (Pécs), the one-time administrative centre of the Late Roman province of Valeria. Some villas had been investigated earlier and thus we could fit our findings into an already existing framework. The broadening of the investigations will contribute to a better understanding of the region's settlement patterns during the Roman Age and to new advances in the region's landscape archaeology *(Fig. 1)*.

Of the photographed sites, we have conducted extensive investigations at the site of the villa economy near Cserdi, west of Pécs, using non-invasive methods during the past few years. We identified the buildings during aerial archaeological reconnaissance conducted in 2008. The features outlined by the vegetation indicated that we had located a complex of buildings remarkable even by Pannonian standards. Owing to the seasonally changing vegetation cover, we were able to study the smaller details of the site's layout on the photos *(Fig. 2)*.

The photos of the site were first examined using the segmentation and transformation procedures customary in photogrammetry. During this phase, we highlighted or homogenised the archaeological features based on similarities. The multi-step segmentation and transformation yielded false colour images, which – according to our assumption – provided more detailed information on the condition of the buried remains. We could distinguish wall remains and the rubble around them, and we could also draw some conclusions regarding the site's stratigraphy. Yet another result of the assessment of the photos was that the primary interpretation of the archaeological features was based on an "objective" image generated by a computer which could also be automatically vectorised *(Fig. 3)*.[5]

Fig. 2. Aerial view of the villa's buildings (photo: Máté Szabó, Aerial Archaeological Archives, Pécs, inv. no. 39278/2011)

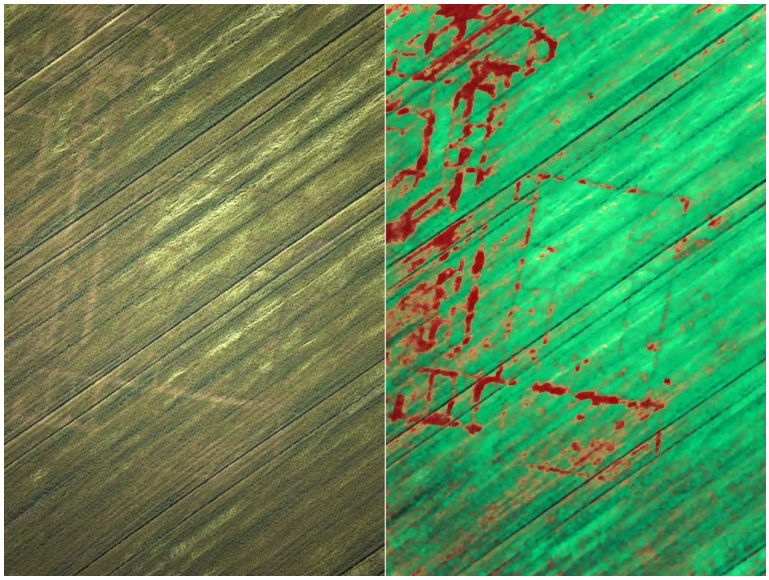

Fig. 3. Image manipulation provided a much more accurate image of the archaeological phenomena recorded on the original photos (left photo: original, right photo: manipulated)

[5] It must be repeatedly emphasized that the goal of segmentation is not to automatise perception, which is a very complex biological, psychological and learning process. See Randolph Sekuler – Robert Blake, *Perception* (New York: Mcgraw-Hill College, 1994, 3rd, revised edition). Perception can hardly be left to computers; at the same time, the procedure enables the extraction and homogenisation of certain details that make the interpretation of aerial photos much easier.

When fitting the images of the building remains identified over a roughly 1.5 hectares large area, we were not satisfied with merely using the usual photogrammetric options. Following the preliminary assessment of the site, we received permission from the landowner to map the features outlined in the field sown with wheat. The geodesic survey enabled the high-precision mapping of the archaeological features outlined by the vegetation and, also, to check the accuracy of earlier surveys. As was to be expected, the angle from which the photographs were taken and the distortions caused by the terrain meant that the archaeological features appeared with a divergence of one to ten meters on the photos compared to their location measured in the field *(Fig. 4)*.

Fig. 4. Groundplan of the villa based on the aerial photos (brown) and the groundplan based on the aerial photos (grey) with the help of survey points (red crosses)

Following the assessment of the aerial archaeological photos with an accuracy of a few decimetres, we also surveyed the site with an FPV aerial device[6] and a robot helicopter.[7] Opinions differ regarding the archaeological usefulness of these instruments – for our part, we believe that their role in documentation is indispensable. In knowledge of the growth phase of the wheat crops covering the site, the flights were made at sundown, the ideal time of day for aerial archaeology. The UAVs were controlled with the aid of a HD quality live-streaming video, and thus the operator and the archaeologist could immediately correct flight paths based on live images. The FPV aerial device enabled the exploration of the archaeological features and their area, while the microcopter provided a highly detailed documentation *(Fig. 5)*. An educational video was made for the broader public (http://vimeo.com/34774675).

Fig 5. The moments before the launch of the microcopter

In addition to aerial reconnaissance, the site was also surveyed in the field from 2011 to enlarge our knowledge. The collection of surface artefacts was accompanied by microterrain measurements that enabled the modelling of the site. We conducted a small excavation in summer 2012, based on the already available data. The location of the features to be explored could be accurately planned using the precise measurements gained earlier. In addition to the excavation, we also conducted additional surveys, collected surface finds and we also performed a systematic metal detector survey.[8] The primary goal of the excavation was to map the villa economy and to assess the potentials of the site's future excavation. We opened trenches in five locations (Trenches A–F; *Fig. 6*).[9] The excavated area totalled 34.65 m^2. The location of the trenches, the excavated levels and the finds were all recorded with geodesic accuracy. The documentation also included a 3D photo survey, a soil radar survey and aerial photography using

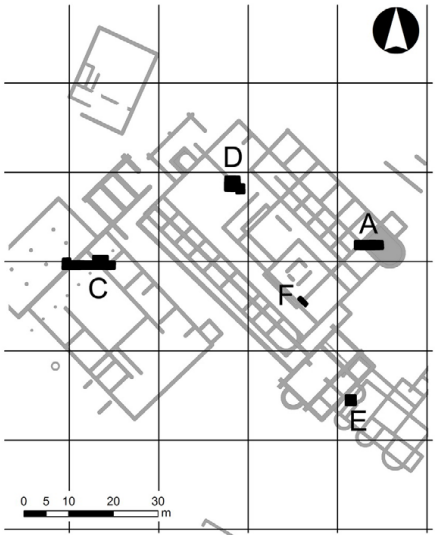

Fig. 6. Groundplan of the villa's buildings based on the aerial photos and the excavated areas

[6] FPV: First Person View unmanned, remote control aerial device operated through a video system.

[7] I would here like to thank András Balogh and Norbert Sandó (Pazirik Kft.) and Péter Szalánczay for their help.

[8] The project was conducted with a team of volunteers through grants from Pécs University and the Hungarian Scientific Research Fund (OTKA).

[9] Originally, we had also planned on opening a trench in another location too (this would have been Trench B), but the area was not investigated and in order to avoid later confusion, we did not use this letter for denoting another trench.

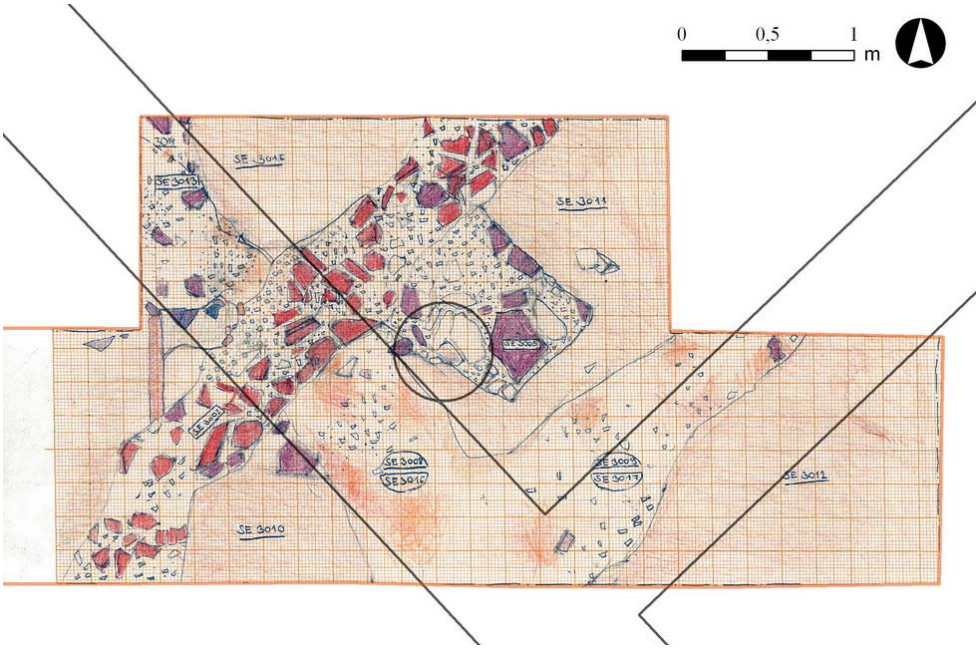

Fig. 7. The black line indicates the remains visible on the geocorrected aerial photos that could be identified with an accuracy of a few decimetres during the excavation

UAV,[10] on which another educational film was made (http://index.hu/video/2012/08/20/legiregeszet).

The excavation confirmed the accuracy of the cropmarks surveyed with geodesic GPS *(Fig. 7)*. The greatest divergence was recorded in Trench C, where there was a difference of roughly 40 cm between the pillar identified on the aerial photos and its actual position. The tentative chronology of the buildings set up during the image segmentation was also confirmed: the foundations of the earlier buildings were only faintly outlined by the cropmarks, while the later ones could be clearly made out.

We assumed the presence of an occupation surface, a hypocaustum system or perhaps a mosaic floor in Trench A, based on the mostly homogenous, negative anomalies across the entire room visible on the aerial photos. To our disappointment, we found that the floor layer was completely destroyed; as it turned out, the phenomena appearing on the aerial photos could be identified with the roughly 30 cm thick mortary foundation of the hypocaustum *(Fig. 8)*. Underneath the mortary foundation, we discovered the rubble of earlier buildings, which in turn overlay Celtic pits. Small fragments of painted wall plasters were all that survived of the room's decoration and we noted that one of the walls had been entirely dismantled.

The greatest surprise awaited us in Trench D, which we had opened in order to clarify the position of the rooms relative to each other, which could not be reconstructed from the aerial photos. Our preliminary assumption was that the building remains had been destroyed, the stones had been taken away to be re-used and that we would only find rubble. In fact, the excavation indicated the exact opposite. The reason for the lack of cropmarks on the photos was that there was an almost intact floor in the area of the trench, which stunted the growth of vegetation *(Fig. 10)*. The walls were covered with plaster

Fig. 8. The foundation of the hypocaustum system in Trench A

Fig. 9. Fragment of a wall painting found during the excavation

[10] UAV: Unmanned Aerial Vehicle.

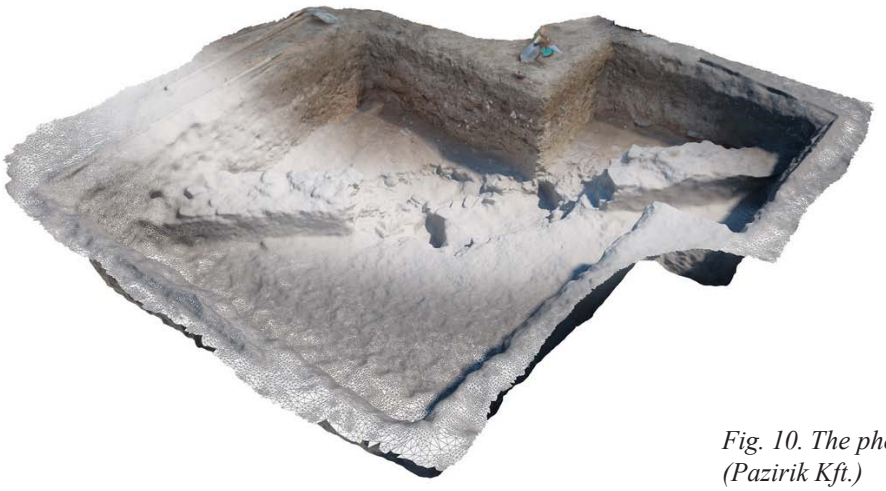

Fig. 10. The photo 3D model of Trench D (Pazirik Kft.)

and the rubble contained countless fragments of the one-time wall paintings. Trench F was a control ditch, while Trench E was opened on a strongly eroded slope in the hope that we could survey the villa's bath. Unfortunately, only the wall foundations had survived.

Parallel to the excavation, we also surveyed the site's environment. Even though the site has been known to amateur collectors and illicit antiquities dealers, the field surveys and the metal detector survey yielded countless finds. We also succeeded in identifying the intensively cultivated fields of the villa's estates, which were aligned along a road still marked on the map of First Ordnance Survey, and the fields appearing on the aerial photos *(Fig. 11)*.

The non-invasive investigation of the villa and its area, as well as the trial excavation yielded a wealth of new data for the better understanding of the site and its environs. The finds suggest that the site was occupied during all four centuries of the province's existence, even if the aerial photos clearly indicate that it attained its greatest importance during the Late Roman period. The pre-Roman occupation and the causes leading to the villa's destruction raise several questions. The promising results of the site's research definitely encourages us to continue the exploration of the region's Roman sites and, also, to study the period's land use with similar methods.

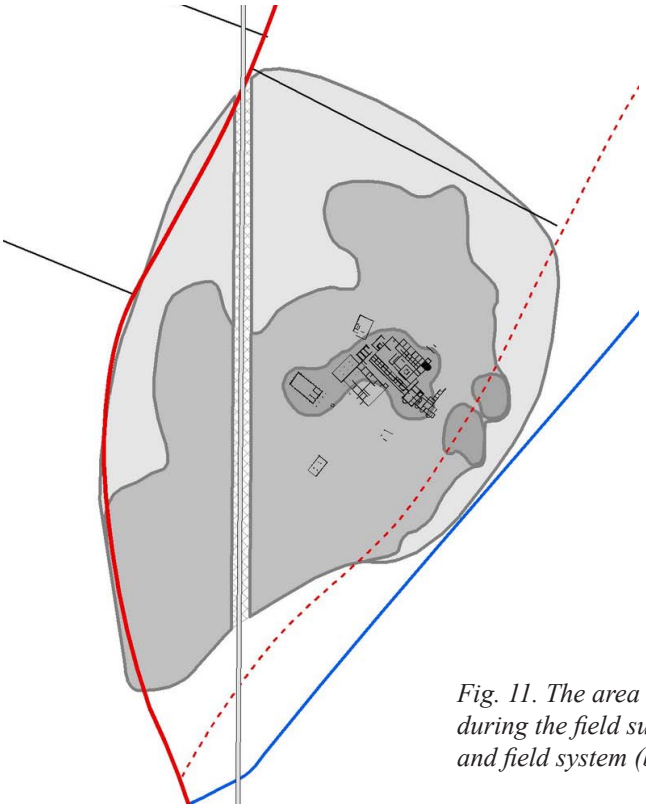

Fig. 11. The area of the villa and its estate identified during the field surveys, aligned to an earlier road (red) and field system (black)

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