Archaeological research of Castle-Palace in Rivne: 3D-models of archaeological excavations

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Introduction

In this article, the experience of using 3D modelling in archaeological research is considered through the examples of building models using photogrammetric processing of photos. The new possibilities of the use of photogrammetry in archaeological research have been demonstrated and recommendations on the most effective use of photogrammetric processing of photos have been given as well.

Prince Alexander Ostrozkyi's castle in Rivne

The City of Rivne is a regional centre in Ukraine, located in the north-western part of the country (Fig. 1). The territory of the city of Rivne and the surrounding area has a long history. At various times it was part of the Galicia-Volyn principality, the Lithuanian principality, the Polish state, and the Russian Empire.

Fig. 1. Location of Rivne city

According to historical sources (Teodorovych, 1889) the castle in Rivne was built in the 15th–17th centuries on elevated terrain, surrounded by marshy floodplain river mouths (the old name of the river is Ostvytsya). After some time, the dam was built, turning the floodplain river mouths into a large pond and the hill into an island. The construction of a wooden castle on the island was associated with the activities of Princess Mary Nesvytsky, who later became known as Mary Rivnenska. Since the beginning of the 17th century the city belonged to the Ostrozki family.

A fairly detailed inventory of the heritage of Prince Alexander Ostrozkyi's castle in 1620 (Voronchuk, 2006; *Inventar…* 1620) has been preserved. Herein the basic elements of a defensive castle and various buildings present on its territory were named. The form of the elevated castle grounds can also be recreated on the old plan from the end of the 18th century—first half of the twentieth century (Rychkov, 2008). One can have a notion of the shape of the wooden castle thanks to the graphic reconstruction (Fig. 2), which was completed by B.A. Prischepa (2016).

During this work, invaluable experience was obtained for building 3D models by photogrammetry

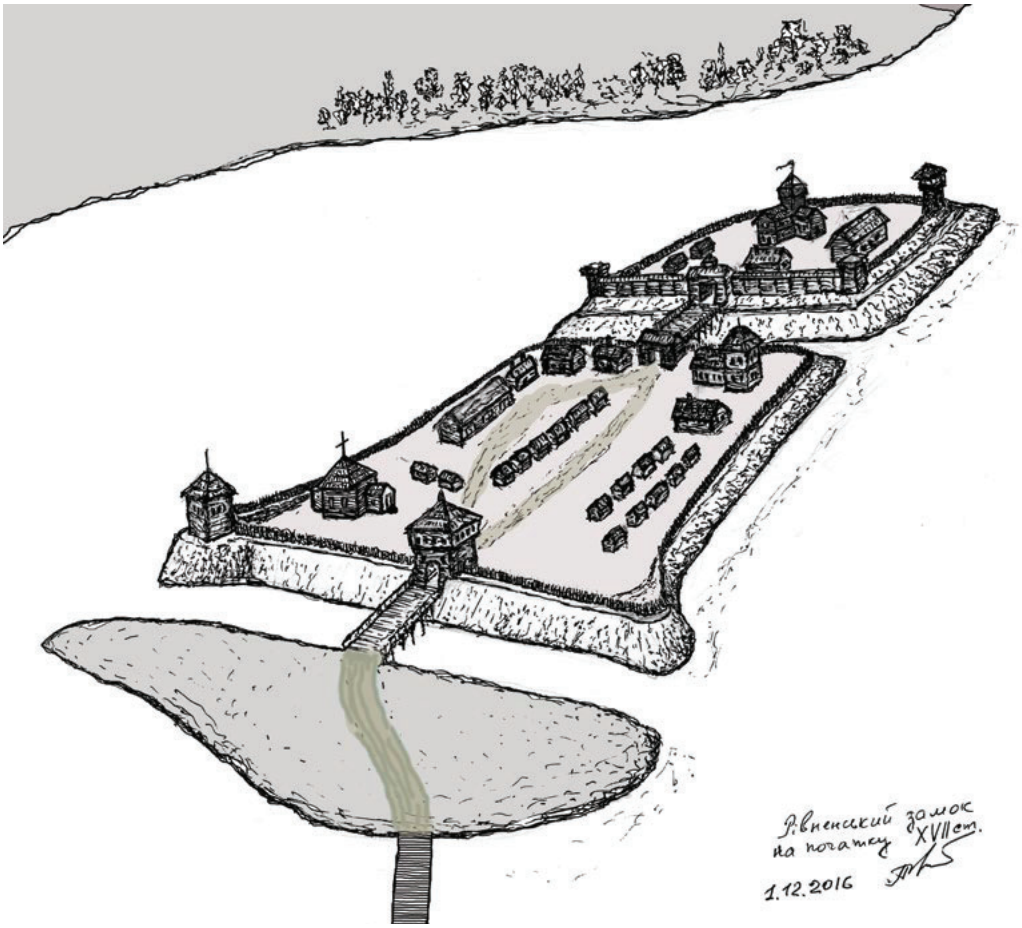


Fig. 2. Reconstruction of the Rivne castle in the 15th–17th centuries (Bohdan Pryshchepa)

In the 18th century the castle lost its defensive purpose. In 1753 the city acquired new owners—the Lubomirsky family (Teodorovych, 1889). The Lubomirsky Princes built a stone palace (Fig. 3) instead of the former castle at the same location. After the Second World War, in the 1950s, the remains of the building were demolished and removed, and the site was levelled (Pryshchepa, Chekurkov, Tkach, 2010).

Archaeological problems

Since Princess Nesvitskiy (Rivnenska)'s castle and Prince Lubomirsky's palace were on the same location at two different times, the site came to be called the Castle / Palace.

Since the very beginning of the works on the site under study, archaeologists were faced with a lack of information about the specific location of the Castle / Palace.

First—the present plans and maps give only a rough indication of its location, because the surrounding area was greatly changed and many old buildings were demolished. The Castle / Palace stands together with auxiliary buildings located on the island in the middle of an expanse of water (Fig.4). Now it is an artificial park in the city centre, which has a dense network of asphalt paths.

Fig. 3. Palace of princes Liubomirsky (post-card, early 20th century)

Fig. 4. Aerial photo of the Liubomirsky's palace (early 20th century)

The area not occupied with asphalt paths has been planted with deciduous trees.

Second—there were no outward signs on the ground which might help an initial search of the Castle / Palace, as the area has been remodelled several times.

Third—the territory was being studied for the first time since the destruction of the Castle / Palace.

Taking into consideration the limited financial and time resources, all this required the use of innovative approaches and techniques in the study. This is where the author joined the archaeological expe-

dition as a consultant with the task of fixing the course of archaeological research and the interpretation of the discovered objects.

Supporting archaeological excavation with photography

Photographing was conducted with a Nikon D3100 camera. The result of photo-fixing was stored in JPG file format with a maximum (for this camera) resolution of 4608 × 3072 pixels, with average file size of 6–7 MB. However, information of the images at close distances (less than 2 m) has been inadequate for problems of interpretation of large objects (Fig. 5). Moreover, the presence of dense foliage crowns and small distance between trees in the location of excavation No. 1 did not allow the use of aerial photography.

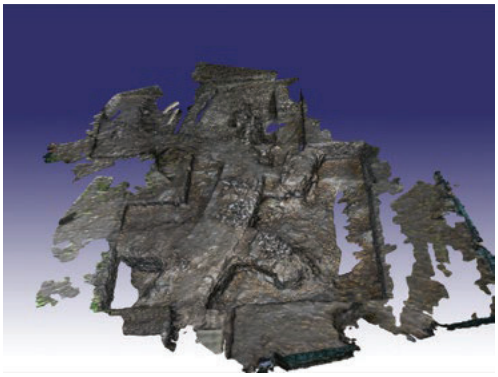
Fig. 5. Photo of the fragment of the discovered stone construction

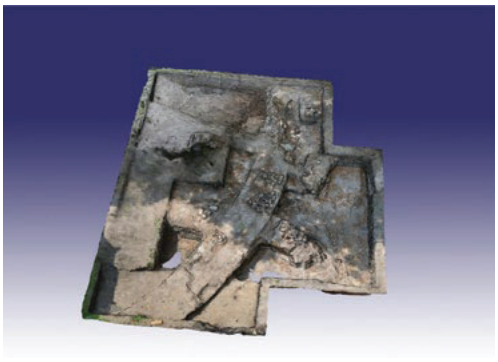
Taking into consideration these factors, the author decided to conduct photogrammetric processing of the images. Photogrammetric processing was carried out with the software Agisoft PhotoScan Professional Version 1.2.5. Any needed editing of the models thus obtained was done with the programs MeshLab (V2016.12) and CloudCompare 2.8. Test photofixation and photogrammetric processing of the images taken on 21 Jule 2016 was not entirely successful (Fig. 6). Analysis of the 3D model of the excavation No. 1 revealed the errors in photofixation. The absence of some sites of the excavation in the pictures led to the creation of „holes" in the surface of the model. The previous errors were rectified, and the fixation of 27 July (https://skfb.ly/YEZ9) was more successful, but in some places „holes" still occurred. The obtained 3D model of the excavation No. 1 was of higher quality (Fig. 7). When fixing on 07 August (https://skfb.ly/YEZX), 220 shots were made and all 220 shots were treated. The 3D model surface of the excavation No. 1 was without „holes". The quality has made it possible to analyse the stratigraphy of the walls of the excavation (Fig. 8).

At that time, to obtain a more complete picture, it was decided to begin work in

excavation No. 2, and this made it possible to fix the southern border of the ditch which separated the yard of the castle from locality. Later on, due to the fact that the excavation areas No. 1 and No. 2 did not increase, and no work was carried out over the entire excavations at the same time, it was decided to hold fixations only in certain areas.

The next fixations of of August 30 (https://skfb.ly/YEX6), September 7 (https://skfb.ly/YFnW), and October 3 (https://skfb.ly/YEU6), recorded the most interesting parts such as the structure of pales which had stabilized the breast-wall; the southern border of the ditch which separated the yard of the castle from the location; and the laminated wooden lattice of pine trunks interspersed with land. The surface of the fosse had been lined with well-preserved wooden logs.





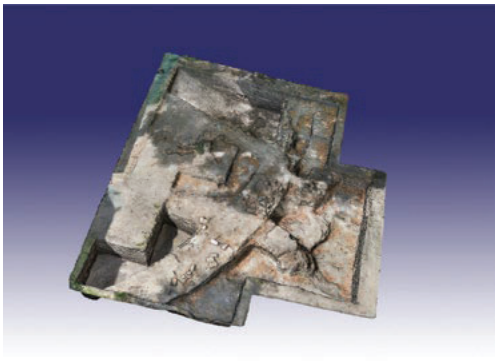


Fig. 6, 7, 8. 3D models of the excavation No. 1 (21 July, 27 July, 7 August 2016)

Conclusions

Photogrammetric processing made it possible to:

- analyse 3D models of excavation during work carried out in the laboratory;

- put excavation ditches of satisfactory quality over the overall plan without the use of expensive equipment;
- prepare graphics for the report even after preservation of the excavations;
- prepare efficiently for the field studies continuing in 2017 at the site of the former Palace / Castle.

During this work, invaluable experience was obtained for building 3D models by photogrammetry. This experience made it possible to formulate the following rules:

- photos should be of high resolution (5Mpixel and more);
- it is better to use a wide-angle lens than a telephoto lens;
- carry out shooting in cloudy weather when possible;
- avoid moving objects and fluctuating shadows of the trees on a sunny and windy day;
- take pictures that overlap by at least 50%;
- the most important details should be photographed from three or more angles;
- when measuring on the model, do not forget to place measuring rulers and arrange markers.

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