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ARCHAEOLOGICAL PROSPECTION AND NATURAL RISK MANAGEMENT IN PREHISTORIC SITES FROM EASTERN ROMANIA. A CASE STUDY: SETTLEMENT FROM COSTEȘTI, CIER (IAȘI COUNTY, ROMANIA)

1. Introduction

The work is based on an elaborated study, started in 2009 and still under way, conducted by the Arheoinvest Platform from the Interdiscplinary Research Department – Field of Sciences within the Alexandru Ioan Cuza University of Iași. The main objective of this endeavour – in the initial stage and to which all subsequent activities were inherently subsumed – is to produce by means of non-intrusive investigation techniques an ample characterization of the archaeological site from Costești (Iași County) known in the dedicated literature as *Cier* or *La școală* (RAJI II 1985, p. 418). Specifically, the investigations sought to produce a detailed assessment of the current state of the site and the adjoining areas, and a comprehensive report suitable for elaborating an adequate research strategy and for inclusion in a long-term management plan. The methodology consisted primarily of archaeological topographic surveying, terrestrial laser scanning, air photography, and geophysical prospections. The present paper contains the most important results achieved so far, some preliminary, obtained through a multi-faceted interpretation of data with state-of-the-art research tools.

2. Characterization of the study area

The site studied in this paper is well known to the archaeological community from Romania. Earlier studies, some of which carried out in the interwar period, attested a rich material belonging to the chalcolithic Cucuteni culture (A3, A-B2/B1), two from the transition to the Bronze Age period (Horodiștea-Erbiceni II) and early medieval (8th – 9th/10th centuries) habitation levels, as well as two necropolises, one Horodiștea-Erbiceni II and the other medieval. The site is located in the northeastern part of Romania, in the Iași County, on the right side of the upper course of the Bahluieț River (ca. 10 km from the source), in a meander within the fossil valley of the creek (figs. 1, 3), on the back side with western exposure of the cornice, successively detached toward the east–north–east, from the Pietrișul hill, and which evolved in various stages (fig. 2). Initially, the site was pentagonal, with rounded corners, being delimited to the west and south-west by a fossil riverbed of the Bahluieț (Ciurea 1938; Boghian et al. 2013, p. 199).

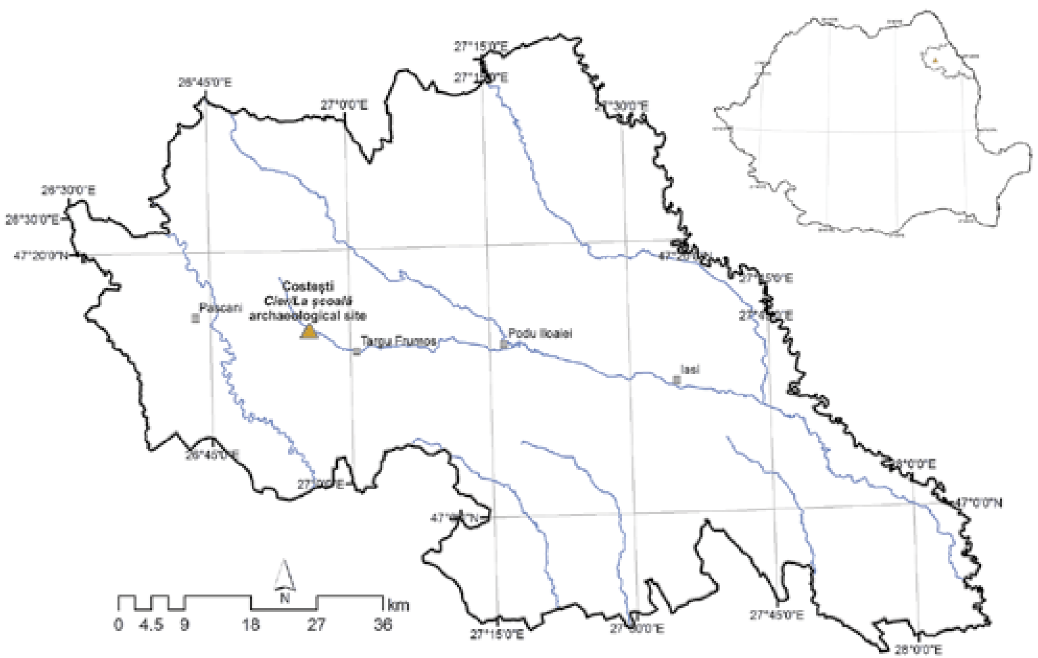

Fig. 1.
Location of the site within Romania and Iași County

3. Methodological aspects

As mentioned in the introduction of this contribution, our study is based on the application of one of the most important methods of non-destructive archaeological prospection; we also interpreted the results obtained independently for each method used, in a GIS (Geographic Information System) environment. When it comes to this type of research, a corresponding methodology requires – when all conditions are met – the appeal to complementary non-invasive methods; it is well known that each of these investigation possibilities has both advantages and limits.

3. 1. Cartographic analysis

After identifying the site from Costești in the field and charting its GPS coordinates, we began our investigation, naturally, by analyzing the available cartographic support. At the beginning, all map portions were geo-referenced on various scales, corresponding to the area of study, and they were overlapped in the GIS. Military topographic maps (scale 1:25000), topographic plans (scale 1:5000), map sheets (scale 1:20000), and orthorectified aerial images (scale 1:5000) were used. We also used a draft from the year 1937, comprising the plan of archaeological excavations conducted here by Professor Vasile Ciurea; the results of the research campaign were published, one year later, in the journal of the Fălticeni museum (Ciurea 1938). Unfortunately, this draft is very general; its geo-referencing by correspondence is approximate, because we failed to identify clear common points between it and the rest of the digital cartographic support.

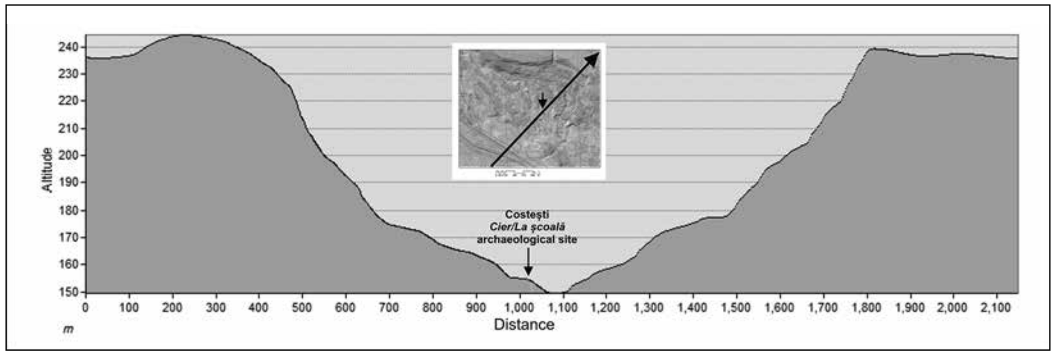

Fig. 2.
Aerial photography from the northwestern part of the site
Fig. 3.
SV-NE cross section through the valley of the Bahluieț River

3. 2. Terrain microtopography analysis

The detailed registration and the field microtopography analysis have represented a priority for our activities for two reasons. On the one side, based on several other successful research projects of our team (Asăndulesei et al. 2013; Bem et al. 2013), we aimed at obtaining a clear image of the degree of the site destruction. On the other, in numerous cases, a minute interpretation of the analysis can provide significant clues to the buried archaeological structures.

Therefore, by using a Leica GPS system (base station and mobile device), we registered a dense network of geodesic points – for both the site surface and the surrounding areas – within the national system of coordinates. In addition, for the inaccessible sector, highly affected by river erosion, we used a three-dimensional laser scanning equipment, which enabled us to obtain a 5-cm resolution of the section in question (fig. 6a). Our team had used successfully this registration method – which has the maximum accuracy of field topography, through the three-dimensional model obtained – before it was used for other case studies (Asăndulesei 2011; Romanescu et al. 2012a; Romanescu et al. 2012b). This method proved to be very useful, especially when it came to monitoring erosion rate. After processing the GPS data, we obtained a detailed numerical field model, with 0.5 m/pixel resolution (fig. 7), to the end of representing accurately the exterior shape of the site and of pinpointing potential characteristics of archaeological nature.

3. 3. Oblique aerial photography

It is well known that aerial photography is a branch of remote sensing, a non-destructive method used for identifying, photographing, mapping, and interpreting traces that indicate the presence of ancient anthropic characteristics (Oberländer-Târnoveanu, Bem 2009). Though the history of aerial photographs with archaeological purposes has a 100-year old international tradition, in Romania, the initiatives in this field can only be characterized as isolated.

Archaeological characteristics of aerial images can be identified due to shadows, differences in soil pigment, moisture, or marks detectable in snow or in agricultural cultures (Scollar et al. 1990). It is unusual for a single photograph to provide all the information about a site or an entire area, irrespective of the type of archaeological research. The visibility of marks depends on the change in the direction and height of the sun, even for sites visible above the ground, because deep shadows often mask the information. The season when people take the photographs is equally important, because archaeologists elaborate maps based on aerial images, at various moments during the day and the year, in order to get as much information as possible on the researched objective (Palmer 2009).

For the Costești site, we took aerial photographs from a small airplane, by using a Nikon camera (model D300), between 3 and 5 PM, on April 28, 2012. The mean altitude from which we took the photos is 500 m, and the photo angle was approximately 45°; we took over 30 photos from all directions.

3. 4. GPR (Ground-Penetrating Radar) measurements

GPR technology has been highly appreciated by the archaeological community because of its capacity to identify and represent accurately the characteristics buried in the ground. It has a reputation as one of the most complex geophysical methods applied in archaeology because it involves collecting large amounts of data and generating an impressive 3D database. The capacity of producing images at different depths, the sometimes delicate interpretation of the data, and the difficulty in correlating them in many profiles within a grid are just some of the aspects that make GPR a difficult venture (Conyers, Goodman 1997). In addition, field conditions (perturbing factors) represent another criterion for obtaining viable results. The ability of providing more precise information than other prospecting methods, related to the depth of archaeological remains, is of great interest to archaeologists, who can really use data on various planes and depths. Despite the data collecting process on sections in depth, the main advantage of the GPR is its ability of providing a three-dimensional image of the prospected archaeological site when several sections are registered (Leckebusch 2003).

The success of GPR measurements in archaeology depends, to a certain extent, on the buried characteristics, on soil topography, and on vegetation. Despite the multitude of factors susceptible to influencing measurements, GPR is still very useful especially where an electrical resistance contrast is identified. This is not a method to apply immediately in all geographic or archaeological contexts but, with slight modifications in data acquiring methodology, it can adapt to a variety of working conditions (Gaffney, Gater 2003).

For the archaeological site of Costești, we used a Mala, Ramac X3M GPR system. Initially, we conducted multiple tests with various antennas; finally, for our measurements, we

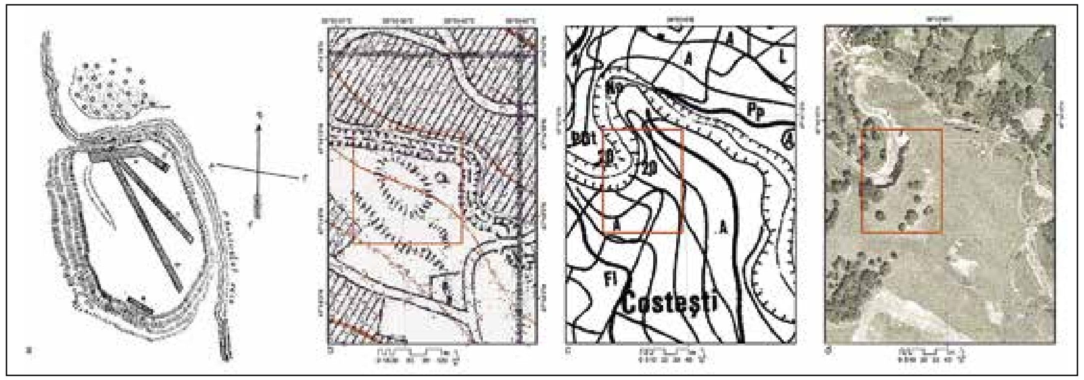

Fig. 4.
Costești archaeological site evolution (cartographic analysis):
a) excavations plan from year 1937;
b) topographic map from the year 1957 (scale 1:20000);
c) topographic map from the year 1975 (scale 1:5000);
d) orthorectified image from the year 2005 (www.ancpi.ro)

chose the antenna with 500 MHz frequency. Depending on the area accessible from the site surface, we made two grids with different sizes (grid A=20 × 47 m and grid B=20×20 m). We took the measurements through parallel lines, in one direction, with a 0.5-m distance between them. GPR scans for grid B were made transversally on grid A, in its north section, to obtain more information for this area (fig. 9a).

4. Results and discussion

4.1. Cartographic support analysis

The field research conducted near the site by the members of our interdisciplinary team (geomorphologists, hydrologists and, of course, archaeologists from the Alexandru Ioan Cuza University of Iași) comprised several phases. In the first phase, we studied carefully the current state of the site, focusing on its degree of degradation. From that moment on, we began taking successive measurements for monitoring the site erosion rate. We also tried to assess as accurately as possible the initial surface of the site. Therefore, a simple cartographic analysis revealed that the current site is the third part of the initial site; the strong erosion provoked by the Bahluieț River destroyed the rest (Figures 4, 5). It is obvious that the river began eroding the site even before 1937, as posited by Professor Ciurea in the aforementioned work. At the same time, though the resolution is not very high, the map fragment extracted from the map sheets, scale 1:20000, shows that the site surface is not considerably altered compared to the year 1937: the shape of the mound is almost pentagonal. In 1975 – a year for which we have a topographic plan under a much larger scale (1:5000) – the situation was very different. Based on comparative analyses, we can state that nowadays the site is approximately 50% destroyed.

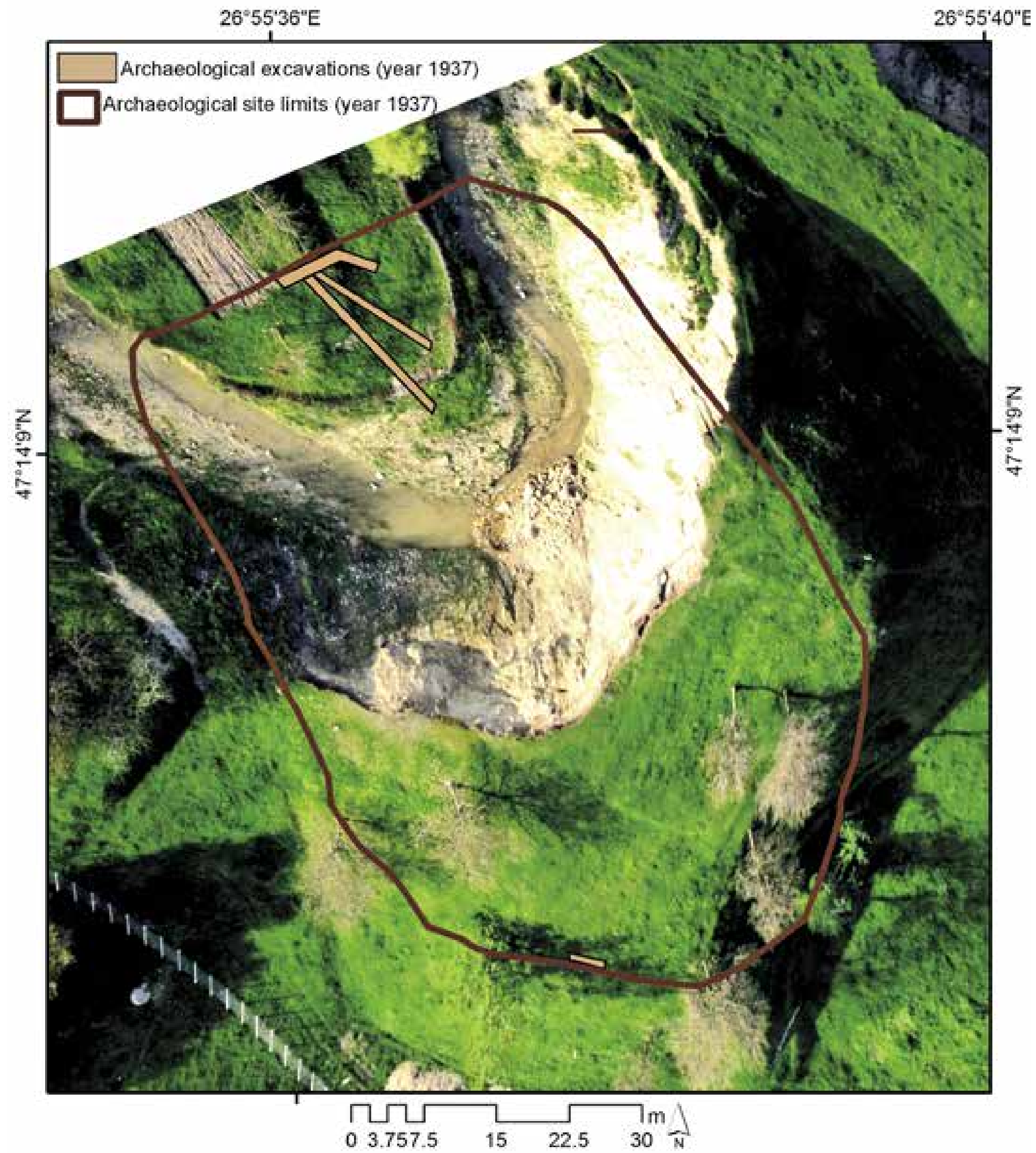

Fig. 5.
Old archaeological excavations (after S. Ignătescu) and site boundary (year 1937)

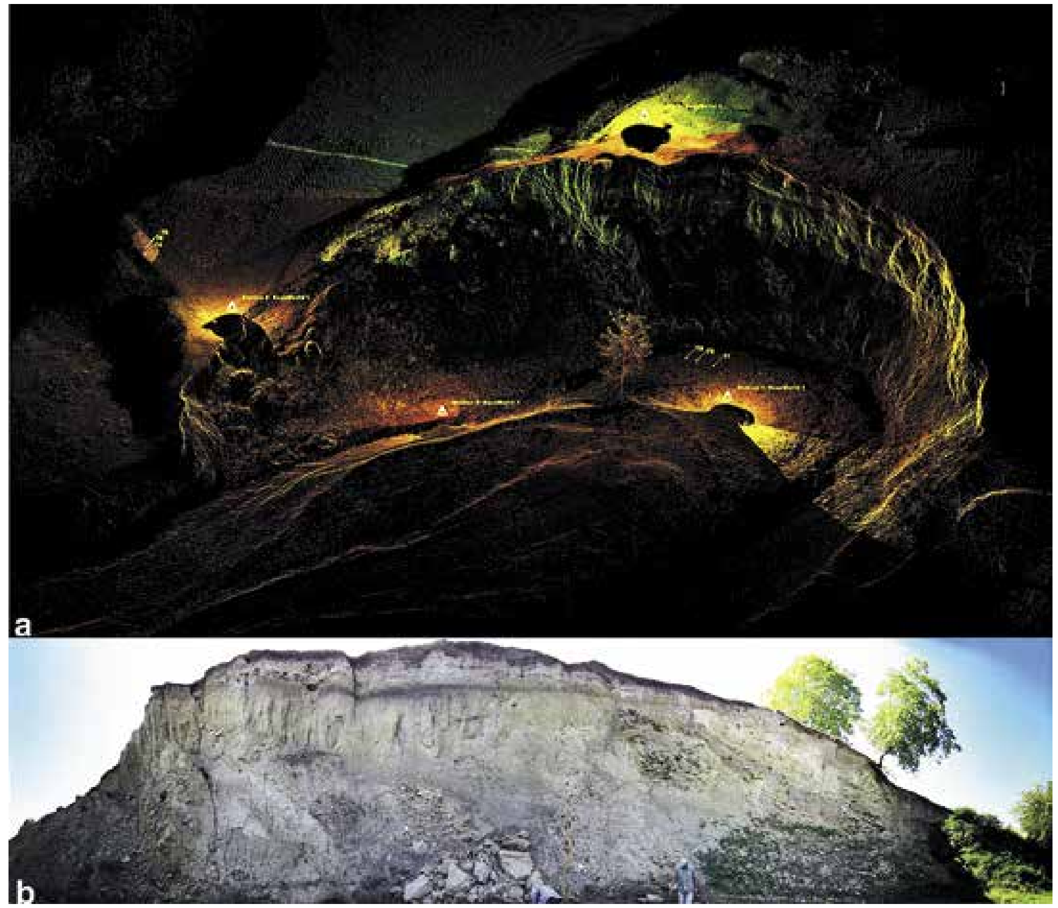

Fig. 6.
a) 3D terrestrial laser scanning of eroded sector of site;
b) panoramic picture of the same sector

4. 2. Background – geo-referenced aerial image.

The strong deterioration of the site – which occurred within the aforementioned timeframe – and the subsequent alterations could be related to an increased hydrological regime during this period for the microregion to which our study case pertains. Furthermore, the archaeological digs conducted on this site over time have contributed to its degradation (figs 6a, b).

4. 3. Terrain microtopography analysis

It was mandatory and very necessary to obtain a digital terrain model by conducting a minute topographic survey, in the context of non-destructive measurements proposed for this study case. The survey was actually the foundation of our study; this is the baseline for all the other products resulted from the analysis and interpretation of the main investigation methods.

Persuaded by the utility of this working phase, we initiated a detailed analysis of the digital model, which provided us with valuable data on the old, abandoned river courses near the site, on the fortification system of the site, or with clues on the landform configuration

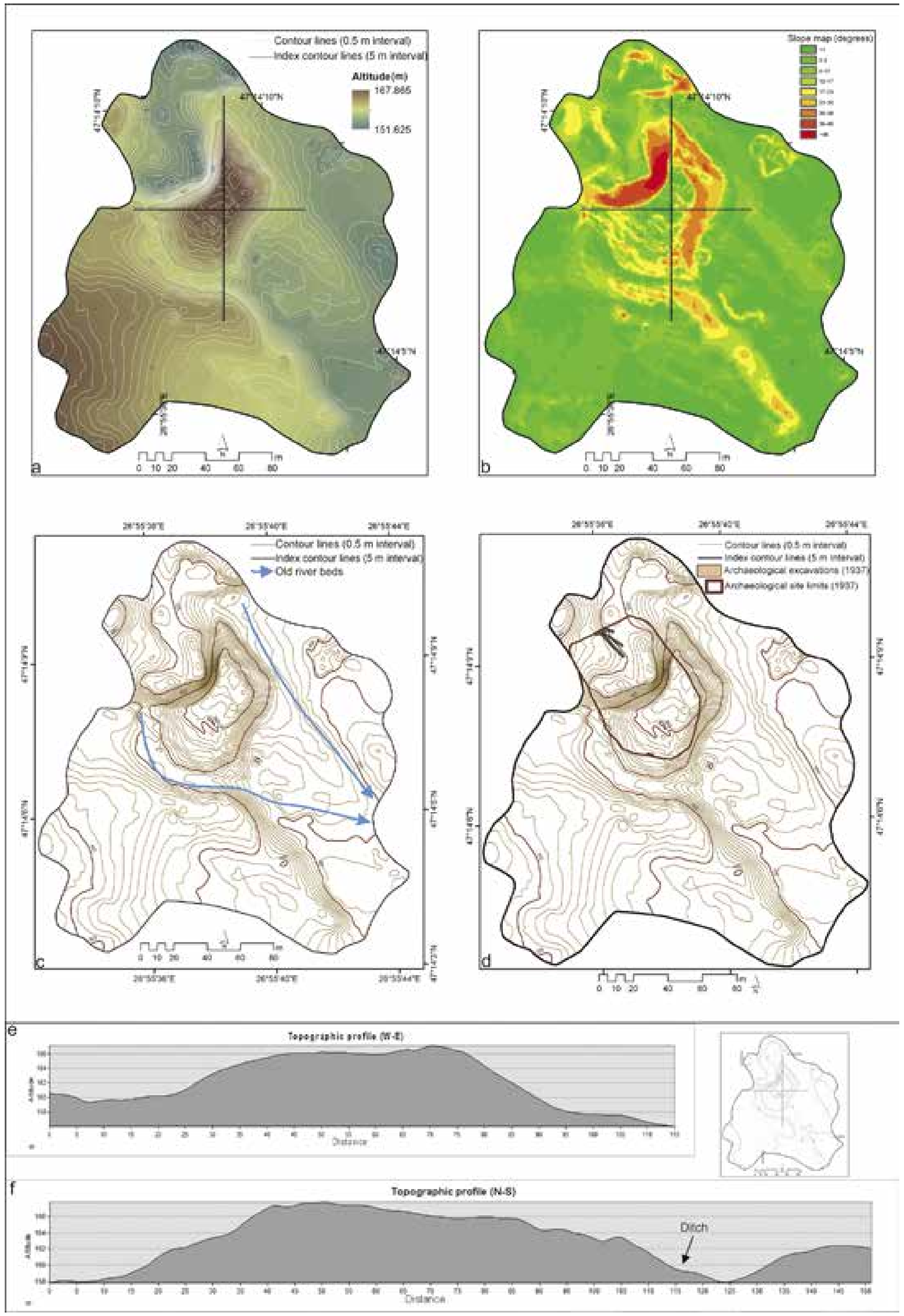

Fig. 7.
a) Hipsometric map; b) slope map; c) topographic map and the old river beds;
d) old excavation tranches and site limit from the year 1937, overlaid on topographic map;
e, f) west–east and north–south cross sections of the site

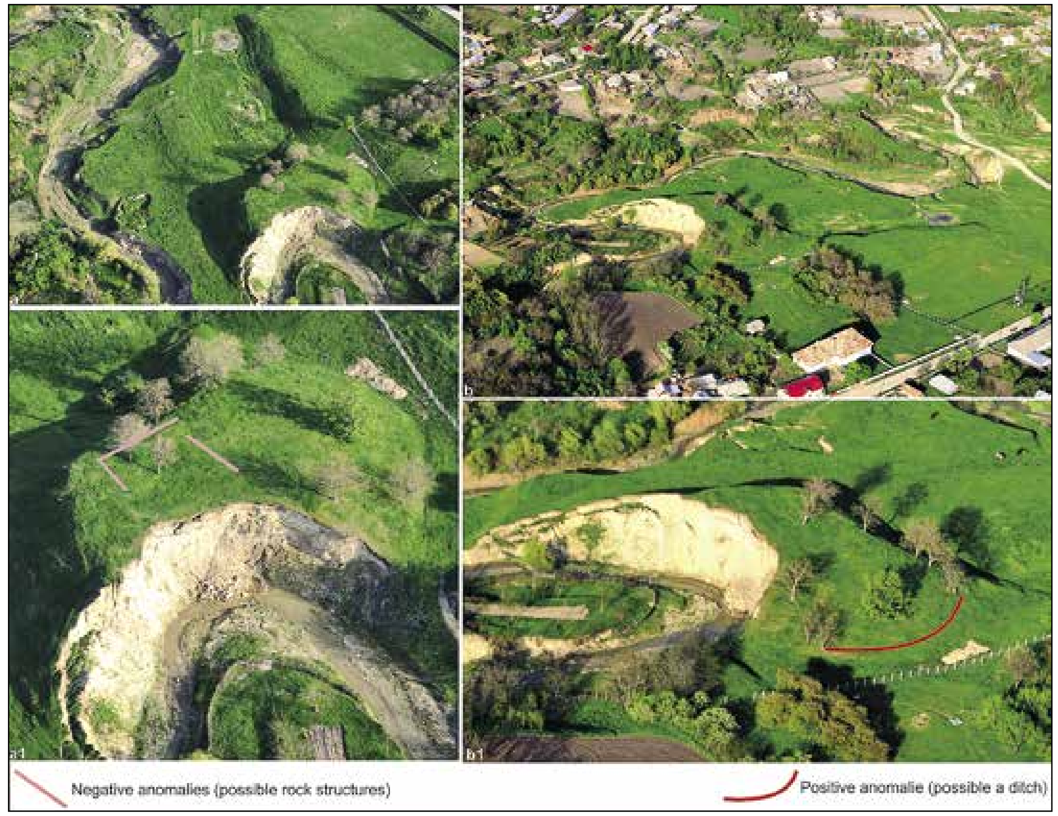

Fig. 8.
Interpretation of aerial photography

(which gave the inhabitants a strategic advantage, beyond any doubt). Therefore, by analyzing the images below and by permanently consulting the other results, we were able to trace easily an approximate trajectory for the old courses of the Bahluieț in this area (fig. 7c).

It appears that, at a certain point, one of these streams bordered the site on the south and the southwest; in another period, the stream would have followed the northern side of the site, on a northwest–southeast direction. Obviously, the inhabitants made the most of this positioning, by building a fortification system based on the advantage provided by the abandoned fossil riverbed with the southwest origin. Moreover, they made a semicircular defence ditch to consolidate the entire southern part of the site; we observed this ditch in both the topographic survey and the aerial photographs and GPR measurements (Figures 7, 11). The advantage of the position for the site inhabitants is also shown by the steep slopes of this mound, distributed on all its sides, with values up to 36° (fig. 7b). The holes on the site surface – visible in the model – were most probably caused by poachers or by the inhabitants of the current village, who used to extract clay from this area. Besides the aforementioned aspects, the detailed topographic survey and the three-dimensional scanning represented the cartographic support for aerial photographs and GPR measurements, thus contributing directly to an accurate interpretation of the detected structures and to a better understanding of the situation as a whole.

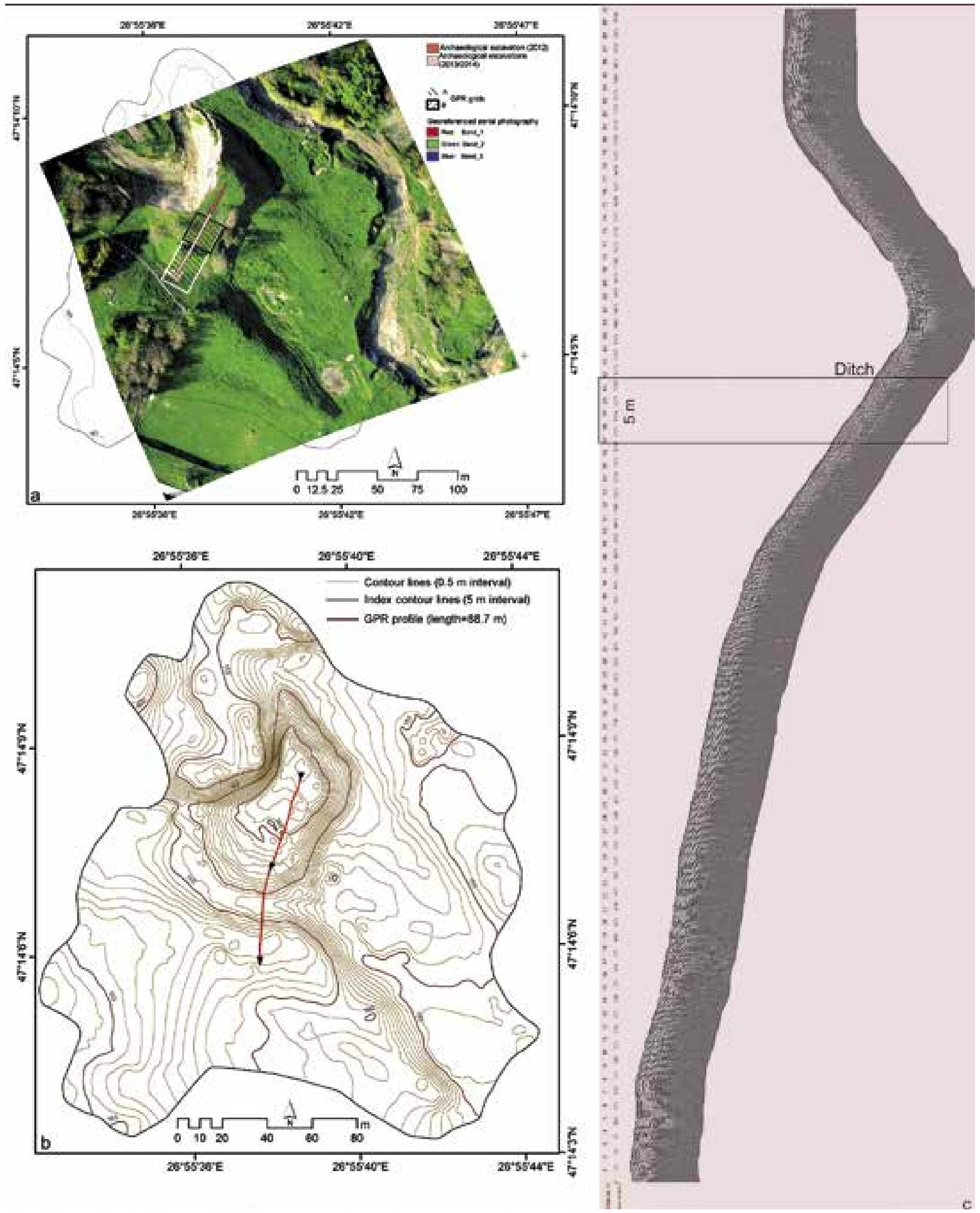

Fig. 9.
a) GPR survey areas and archaeological excavations (years 2012–2014);
b) topographic map and longitudinal GPR profile path (red line);
c) GPR profile (red line from 9b) with topographic corrections

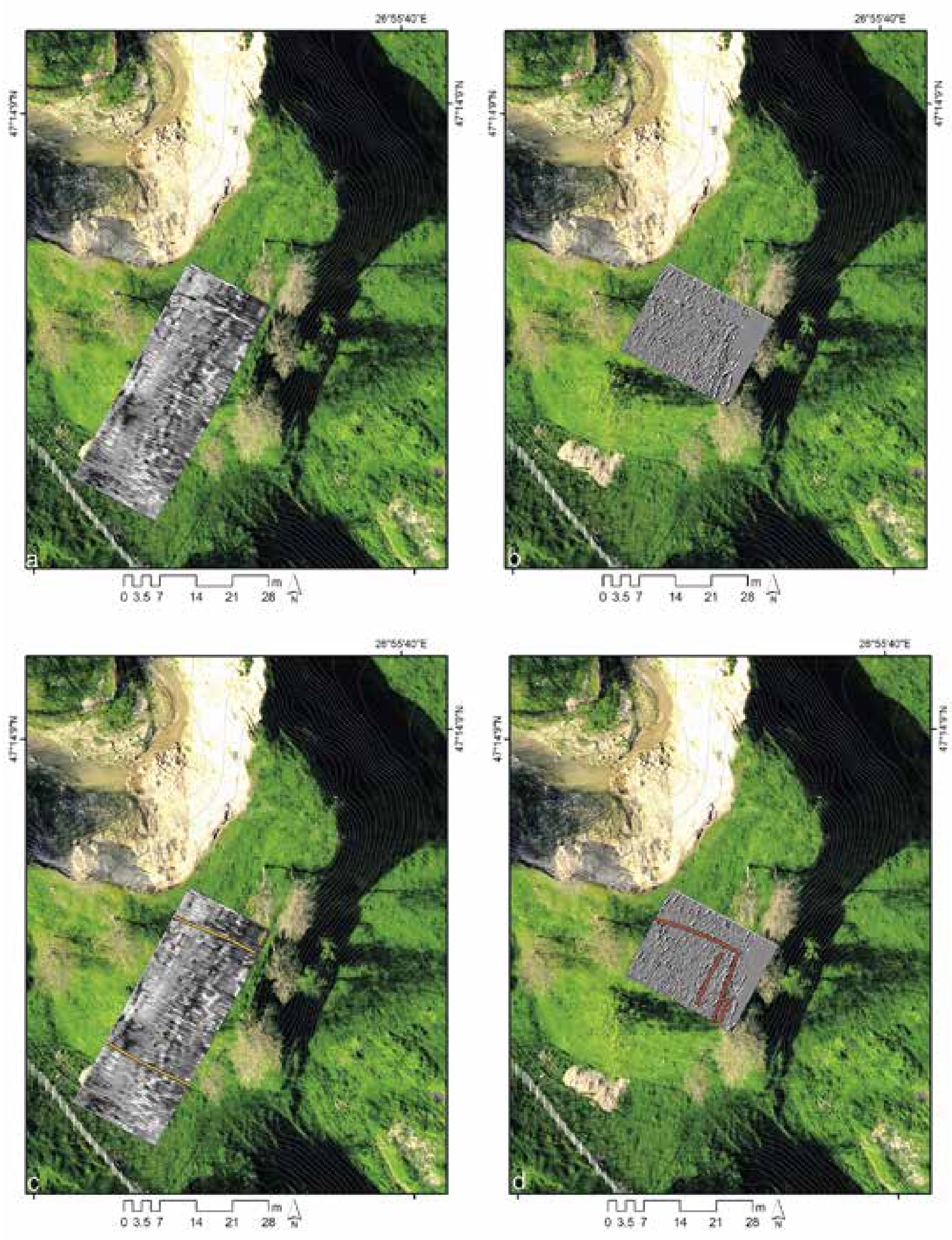

Fig. 10.
GPR interpretation

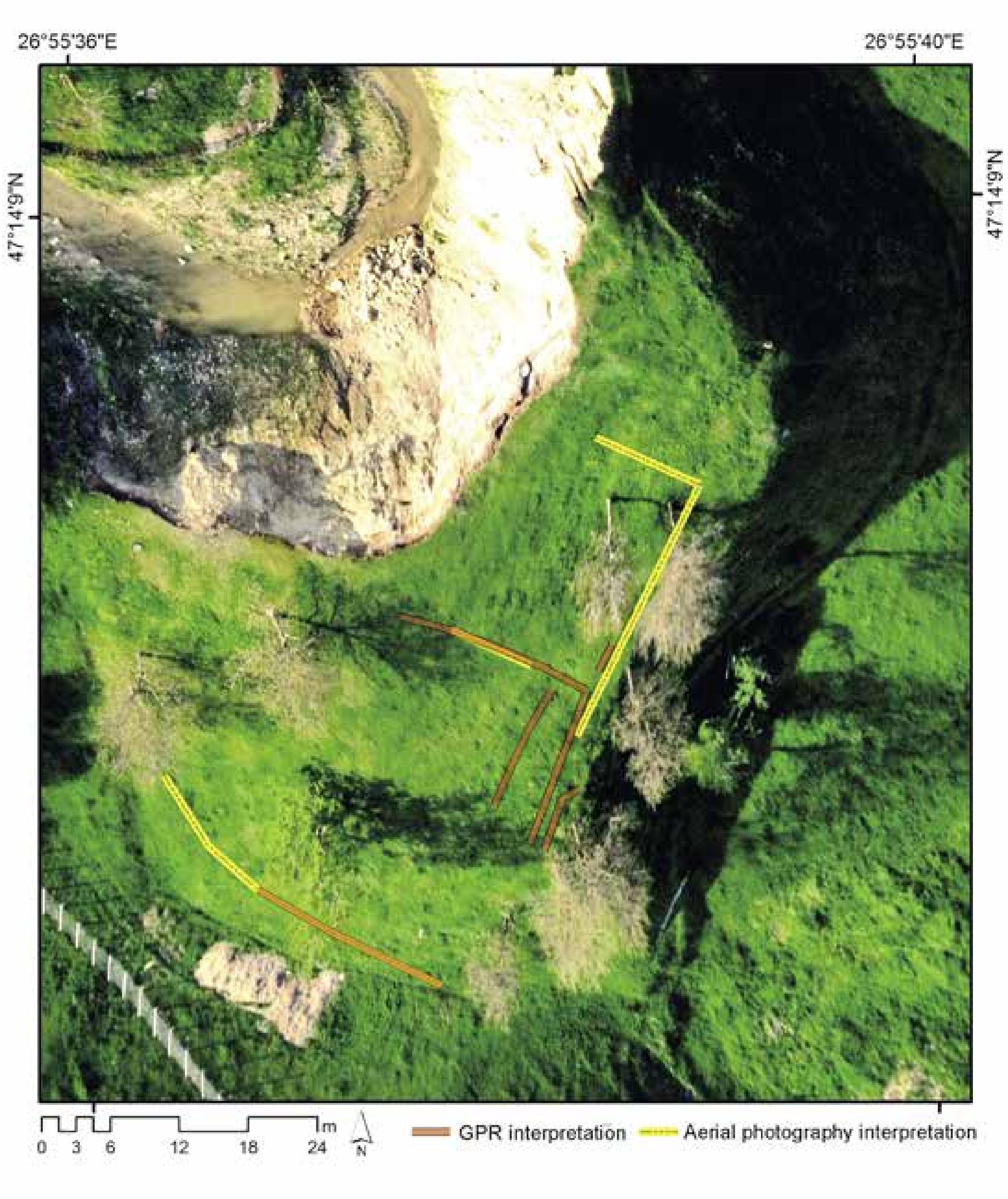

Figure11.
Combined GPR and aerial photography interpretation.
Conclusions and future research directions

4. 4. Interpretation of aerial photographs

The analysis of over 30 aerial photographs for the area in question revealed several aspects that can support, beyond doubt, our initiative of elaborating an ampler characterization of the archaeological site of Costești.

Therefore, based on the overall images of the Bahluieț valley, captured downstream and upstream the site, we clearly distinguished the cornice of detachment and the (currently stabilized) landslide, which evolved during several phases; actually, the settlement is placed on its mound (fig. 2). It is also worth mentioning the windy path of the river, with numerous meanders, as well as its old streams which have altered considerably the configuration of the area. By analyzing the punctual, detailed images of the site, we noticed the presence of large positive or negative anomalies, possibly of archaeological nature. Among them, it is worth highlighting the semicircular defence ditch at the foot of the mound, on the southwestern side of the site (fig. 8). Furthermore, in the upper part of the site, we identified three linear anomalies, two of which make up a right angle. They may be caused by the presence of rock structures, probably vestiges of the old church attested here (after Boghian et al. 2013). This area also comprises several holes, which probably emerged – as previously stated – because of poachers or the inhabitants of the current village, who used to extract clay from this area. At the same time, these images are relevant enough for a solid argumentation on the extremely advanced state of degradation of the site.

4. 5. GPR (Ground-Penetrating Radar) measurements

Following the initial methodology for this study case, we continued with the complementary, integrated analysis of all the results, in our GIS project. The last non-destructive research method applied in this investigation was the geo-radar. Though the conditions of the site location are not ideal for this type of measurements, we believe that we obtained satisfactory results.

After analyzing both the vertical GPR profiles and the time slices, we pinpointed several types of anomalies, of various sizes. Among them, we distinguished several linear or arched anomalies, which we may consider as being of archaeological nature, by interpreting them alongside the other results. We have to mention that the area has been submitted to strong perturbations caused by tree roots or by rolled sandstones due to landslide, visible in the eroded part of the site.

However, we did manage to identify several linear structures, probably rock walls that may be connected to the ones noticed in the aerial photos and to the defence ditch which follows the same path as that of the aerophotograms (figs. 10, 11). We also made a GPR profile, 87 m long (the red line within Figure 9b), on an approximate north–south direction. For this profile, we made topographic corrections, which revealed several small-sized anomalies (unfortunately, they are very difficult to interpret), the geological structure with rolled sandstone, but also the aforementioned defence ditch.

5. Conclusions and future research directions

The non-invasive research of the Costești site and of the vicinity has not been finished. Though we obtained important and relevant information for the archaeological research concerning the fortification system of the site, its layout or the degree of degradation, as well as the landform configuration in this area, we can still study and treat many other aspects in an interdisciplinary manner. We refer here to the site erosion rate monitoring, which will continue, as well as to the need to apply the method of electrical resistivity of soil, which could provide more data, necessary to our investigation. We also mention that we must complete our working methodology; it has proven efficient, but there is always room for improvement. Furthermore, by focusing on GIS spatial analyses applied on chronological levels, on an extended area around this point, as well as by correlating the intra-, extra-, and inter-site research, we will acquire the necessary data for an elaborated *landscape archaeology* study.

6. Acknowledgements

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