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OBLIQUE AIR PHOTOGRAPHY FOR CHALCOLITHIC SITES FROM EASTERN ROMANIA. ANALYSIS AND INTERPRETATION. SOME EXAMPLES[*]

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Keywords: oblique aerial photography, prehistoric sites, GIS, Eastern Romania.

Abstract. *To intervene efficiently in protecting the archaeological heritage it requires precise information, as well as the exact location, the limits of the site or the geomorphological features of the area. As such, an interdisciplinary research based on non-destructive, complementary methods of investigation, which can provide precious information on the underground archaeological remains, is required. The most convenient (affordable) prospection methods employed by archaeologists are, on the one hand, surface research (fieldwalking), which provides the data necessary for a chronological setting, and, on the other, air photography, which offers the possibility to identify the buried structures. The present paper focuses on the use of oblique air photography in the study of prehistoric sites and a case for generalising such practices in archaeological research, with reference to preliminary results obtained for a number of sites from north-eastern Romania.*

Rezumat. *Pentru a putea interveni eficient în protejarea patrimoniului arheologic sunt necesare informații precise, precum poziția exactă, limitele sitului sau caracteristicile geomorfologice ale zonei. Astfel, se impune apelul la cercetarea interdisciplinară bazată pe metode de investigare non-distructive, complementare, ce pot oferi informații prețioase cu privire la caracteristicile arheologice îngropate. Cele mai la îndemână (ieftine) metode de prospectare aplicate de către arheologi sunt, pe de o parte, cercetarea de suprafață (periegheza) ce oferă datele necesare unei încadrări cronologice, iar pe de altă parte fotografia aeriană, ce oferă posibilitatea identificării structurilor îngropate. Lucrarea de față se concentrează pe utilizarea fotografiei aeriene oblice în studiul stațiunilor preistorice limitându-ne la prezentarea unor rezultate preliminarii menite să argumenteze necesitatea și generalizarea unor asemenea demersuri în cercetare arheologică.*

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Introduction

The information from archaeological registries available for the eastern part of Romania reveals an extremely high density of (not only) prehistoric sites in this area[2]. The field investigations carried out by research teams from the Arheoinvest Platform within the "Alexandru Ioan Cuza" University of Iași of several micro-zones from the aforementioned area, have been focused in particular on identifying and accurately charting the archaeological sites[3] listed in older or newer archaeological registries, but which are often accompanied only by brief and lacunary descriptions, no longer corresponding to current realities. Another aim has been to closely monitor the state of these monuments[4], alongside a collecting of as much information as possible on the threatened areas, using non-destructive techniques[5]. It became clear that the majority of sites identified on the field, particularly prehistoric ones, already known or newly identified, are strongly threatened by various destruction factors, of natural or anthropic origin.

To intervene efficiently in the protection of the archaeological heritage, precise information is needed, such as the precise location, the limits of the site, or the geomorphological characteristics of the area. As such, an interdisciplinary approach based on complementary non-destructive research methods that can provide precious information regarding the subterranean archaeological elements is required. The most convenient (financially affordable) methods of prospecting used by archaeologists are, one the one hand, surface research (fieldwalking), which provides the necessary data for a chronological setting, and, on the other hand, air photography, which offers the possibility to identified the buried structures. Definitely, the completion of this methodology with other possibilities for prospecting (e.g. geophysical measurements) can enlarge the body of information, crystallising into a detailed picture of the vestiges in question. The present paper focuses on the use of oblique air

[2] *AȘEZĂRI...*; *RAJI,* I, II; MONAH, CUCOȘ 1985; VALEANU 2003; BOGHIAN 2004.
[3] BRIGAND *et al.* 2012; 2014; 2014.
[4] ROMANESCU *et al.* 2012.
[5] ASĂNDULESEI *et al.* 2012; 2013; ASĂNDULESEI 2014.

photography for the investigation of prehistoric sites, and makes a case for generalising such practices in archaeological research, with reference to preliminary results obtained for a number of sites from north-eastern Romania.

Brief historical foray

Even though the use air photography in archaeological research is more than a century old, in Romania such initiatives started to take place, in a more consistent manner, only relatively recently[6]. Air photography is a branch of remote sensing, a term that designates a wide range of methods and techniques for detecting archaeological sites by means of measurements taken from afar[7]. It can be defined as a non-destructive methods used in identifying, photographic, charting, and interpreting traces that indicate the presence of old anthropic characteristics[8].

The emergence and evolution of this method, considered the oldest and, at the same time, the most efficient of the archaeological prospection techniques is treated at large in countless works[9]. With specific use in archaeological research, the first initiatives date from the beginning of the last century, in England. During the early period, the photographs were taken from a balloon, and only after WW2 did the advancement in photographical and aviation technology allowed the thriving of this method[10].

One of the first archaeological areas photographed was the Roman Forum, in 1897, from a balloon. A few years later, in 1908, the same area is photographed again, followed by the capture of the ancient port of Ostia[11]. Arguably one of the most famous applications was P. H. Sharpe's photographing of Stonehenge (Fig. 1) from an army balloon in 1906[12].

[6] PALMER *et al*. 2009.
[7] PALMER 2009, 9.
[8] OBERLÄNDER-TÂRNOVEANU, BEM 2009, 62.
[9] WILSON 1982; BEWLEY 2000, 2003; CERAUDO 2013; MUSSON *et al*. 2013; GIARDINO, HALEY 2006.
[10] WILSON 1982, 10; BEWLEY 2000, 3; GIARDINO, HALEY 2006, 48.
[11] PETRE 1966, 199.
[12] WILSON 1982, 11.

A substantial contribution is brought starting with 1921 by Osbert G. S. Crawford, who, alongside Alexander Keiller, publishes in 1928 the study entitled *Wessex from the Air*, a seminal work for air photography, in which he illustrates and interprets images from across Southern England[13]. Around the same time (1929), across the Atlantic, American aviator Charles Lindbergh photographs several ancient Maya settlements, including Tikal, Tulum and Chichén Itzá[14]. The interwar period was a particularly prolific one for air photography, applied in the most diverse places, such as the Middle East and northern Africa. Later, 1949, the Cambridge University Committee for Aerial Photography (CUCAP) commenced the program of air-surveying England and Europe for various purposes, including archaeology[15].

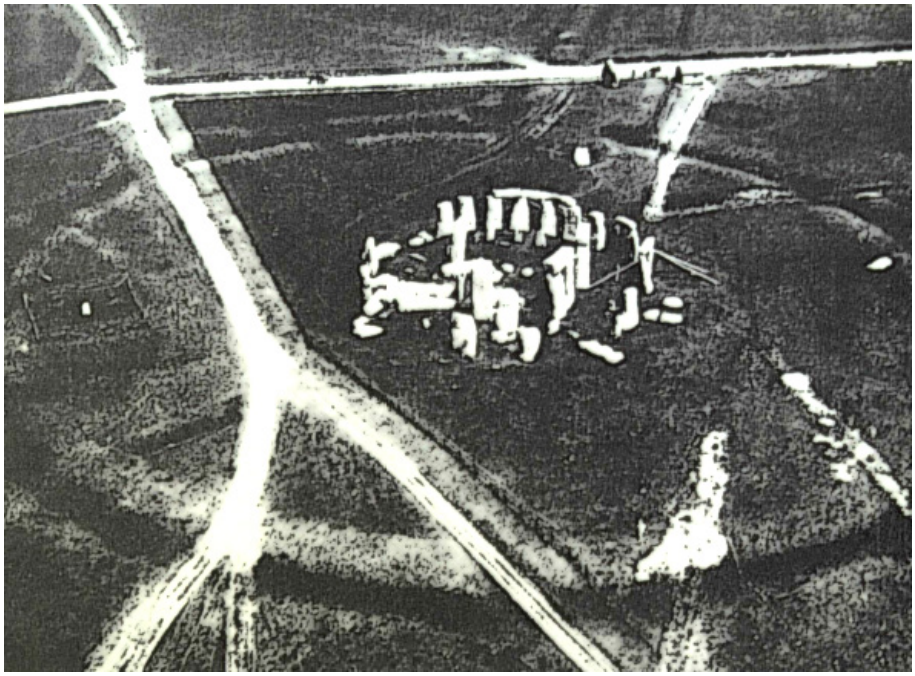

Figure 1. Stonehenge — Aerial photography from a balloon, summer 1906 (Wilson 1982).

[13] BEWLEY 2003, 275.
[14] PARRINGTON 1983, 108; DONOGHUE 2005, 555.
[15] BEWLEY 2000, 4.

As stated above, even if the history of air photography for archaeological purposes is more than a century old, in the case of Romania initiatives of this kind can be best described as isolated for most of the 20th century. Across time, all attempts to establish structures with the goal of training archaeologists and developing programs of complex air investigations, eventually failed. From the interwar period, we have knowledge of an air photograph taken in 1938 of the running archaeological campaign in Histria, overseen by Scarlat Lambrino. It was not by happenstance that this occurred: one of Lambrino's student, Dinu Adamești*e*anu, who in 1939 left for a scholarship in Italy, will play an important role in promoting air photography first in Italy, and then in Romania[16]. Archaeologist, professor and ardent promoter of air archaeology, Adamești*e*anu will years later (1965) be invited to join other prominent figures from Italy and elsewhere, and deliver a lecture at the annual international course organised by the Lerici Foundation entitled *Air photography and archaeological research*[17]. Under the care of Professor Adamești*e*anu, who obtains the authorities' support for establishing an archive of photographs for archaeological use, and, more importantly, the consent to train a young archaeology student in this field, in Italy, air photography begins to entrench itself in Romania, so that the following years witnessed notable progress in this field[18].

Research area

The micro-zone comprising the sites for which air photographs were taken is defined by the hydrographic basin of the Bahluieț River (Fig. 2). This is an integrant part of the lower Jijia and of the Bahlui plain that occupy the southern half of the Moldavian Plain, with some morpho-sculptural particularities that fully argue for its delimiting as a distinct subunit[19]. The micro-zone has a geological foundation in which marls (less clayish than in the northern part) predominate, with sandy intercalations, of Bessarabian age.

[16] OBERLÄNDER-TÂRNOVEANU, BEM 2009, 62.
[17] PETRE 1966, 198.
[18] OBERLÄNDER-TÂRNOVEANU, BEM 2009, 64.
[19] BĂCĂUANU 1968, 199.

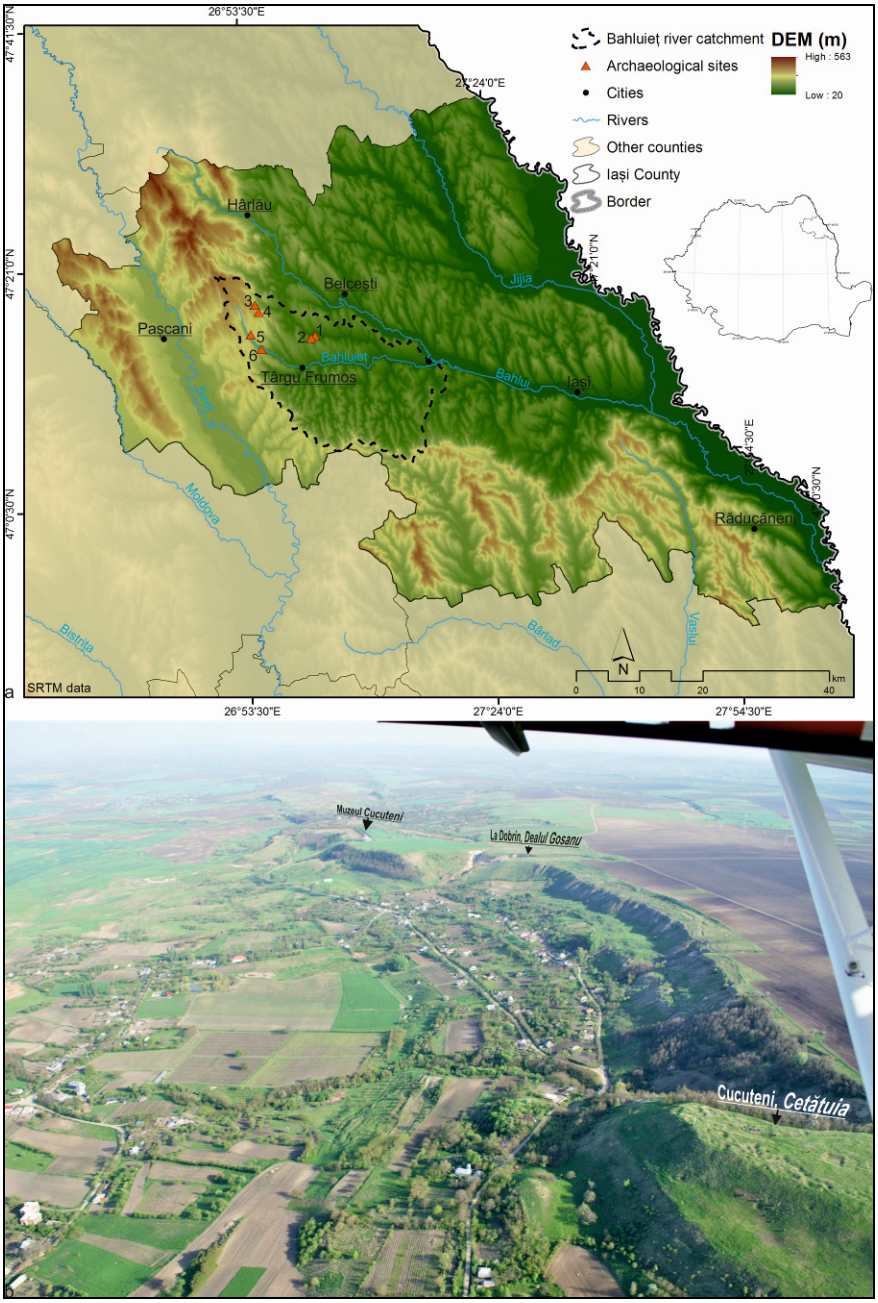

Figure 2. a: Location of the Bahluieț river catchment in Romania and Iași County; b: Aerial image for Valea Oii River valley (view from the North)

The hilly terrain is milder; the average height ranges between 100 m and 150 m, while the maximum ones, of over 200 m, are seldom encountered[20]. Unlike the northern part of the Moldavian Plain, the accumulation landforms (flood meadows, terraces, glacises) are much more extensive[21].

The Bahluieț (S=558 km²; L=50.1 km) originates in the area of Poarta Ruginoasa, on the southern edge of the Mare Hill, from the altitude of 310 m. Up to the city of Târgu Frumos, the bed has rather steep slopes, around 7.8°/km. Along this upper sector, the Bahluieț collects several brooks, such as the Păștănia (Chetrosu), Probota (Valea Bunei) and Cucuteni (Valea Oardei) on the left bank, and the Rediul from the right bank, all originating from the Ruginoasa–Strunga saddle. The Bahluieț is, likewise, the main collector of the affluents coming from the Bârlad High Plateau. These watercourses are generally small, have steep slopes and intermittent or semi-permanent flow. The only notable affluent of the Bahluieț from the left is the Oii (Brăscăria/Recea) brook, originating in the Mare Hill–Hârlău[22].

Methodology

To procedures for taking photographs can be listed for archaeology: vertical (Fig. 3, 4) and oblique (Fig. 5a). The former refers to a series of specialised activities addressed to both archaeologists and to geographers and geologists, which is rather complex and expensive. The oblique photography technique is usually more accessible for archaeological research, requiring only a regular camera and capturing images with it from a small airplane, such as the Cessna 150/152 or 172[23].

Archaeological characteristics can be identified in air photographs from the shadows, the differences in soil colouration and humidity, or the marks visible in snow or in crops[24]. It is seldom the case that a single photograph provides all the information about a site or an area. The

[20] BĂCĂUANU *et al*. 1980, 297.
[21] BĂCĂUANU 1968, 199.
[22] UJVARI 1972, 542–543.
[23] BEWLEY 2000, 6.
[24] SCOLLAR *et al*. 1990, 33–75; RENFREW, BAHN 1991, 70.

visibility of the marks depends on the changes in the direction and height of the sun, and even in the case of sites visible on the surface of the soil the deep shadows mask the information. Similarly important is the season during which the image is captured. In this sense, archaeologists elaborate maps based on air images captured at different moments of the day and year, in order to extract as much information as possible from them[25]. The forming of detectable marks in crops or due to differences in soil colour can be easily explained. For instance, a ditch dug in the parent rock will subsequently fill with sediments that in terms of composition differ from the surrounding deposits by having a greater porosity that favour waterlogging, which translates to more a thriving vegetal cover. In the case of marks ascertainable from differences in soil colour, they are most conspicuous in images captured in winter, fall or spring, often brought about by tilling[26]. It is particularly noteworthy that any of these types of marks can indicate, in some cases, complexes that are not of archaeological relevance, since any chances at the level of the parent rock can be ascertained in air photographs[27].

The methodological approach of this study relied on multiple successive work stages. The first consisted of a necessary documentation stage in which archaeological registries and specialised works treating our study area were consulted, and the sites belonging to the Eneolithic Cucuteni culture were selected[28]. For obvious reasons, only ten of them were selected for air photographing. In total, around 600 photographs were taken for these sites. The present paper presents several preliminary results obtained after the processing of the images for the following case studies: (1) Bălțați, Filiași–*Dealul Mare*; (2) Bălțați, Filiași–*La SV de Dealul Mare*; (3) Cucuteni–***Cetățuia***; (4) Băiceni–*La Dobrin / Dealul Gosanu*; (5) Giurgești–***Dealul Mănăstirii / Sub pădure***; (6) Costești–***Vatra satului / Lângă școală*** (Fig. 1).

[25] DOUGLAS, NICKENS 1991, 87–88; DONEUS *et al*. 2007; PALMER 2009, 28 –29;
[26] BEWLEY 2000, 7.
[27] PALMER 2009, 29.
[28] *AȘEZĂRI...*; *RAJI,* I, II; MONAH, CUCOȘ 1985; VALEANU 2003; BOGHIAN 2004.

Figure 3. View from NNE of the *Dealul Mare* archaeological site.

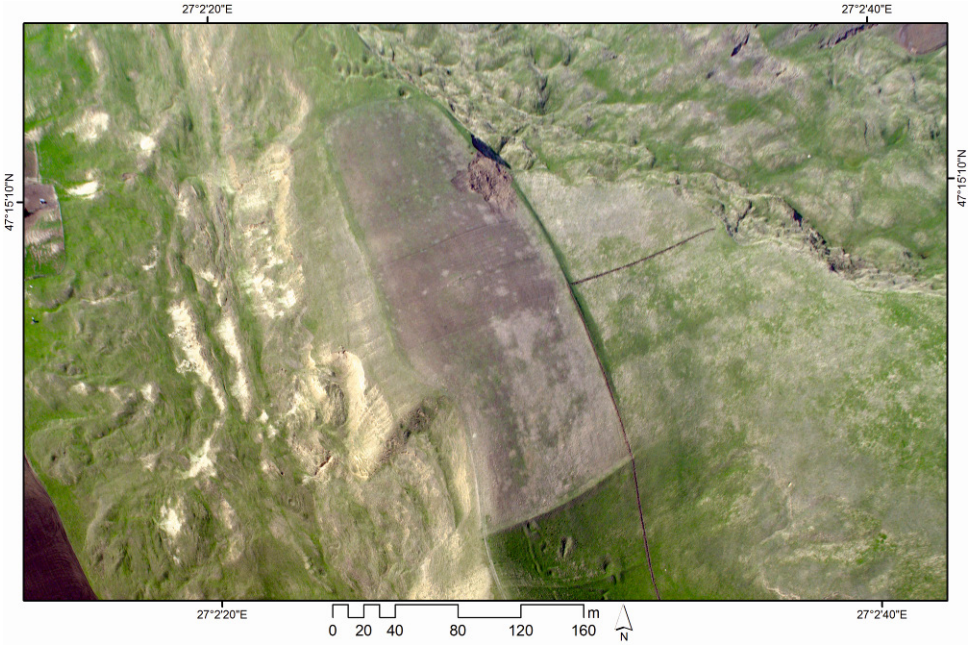

Figure 4. View from SSW of the *Dealul Mare* archaeological site.

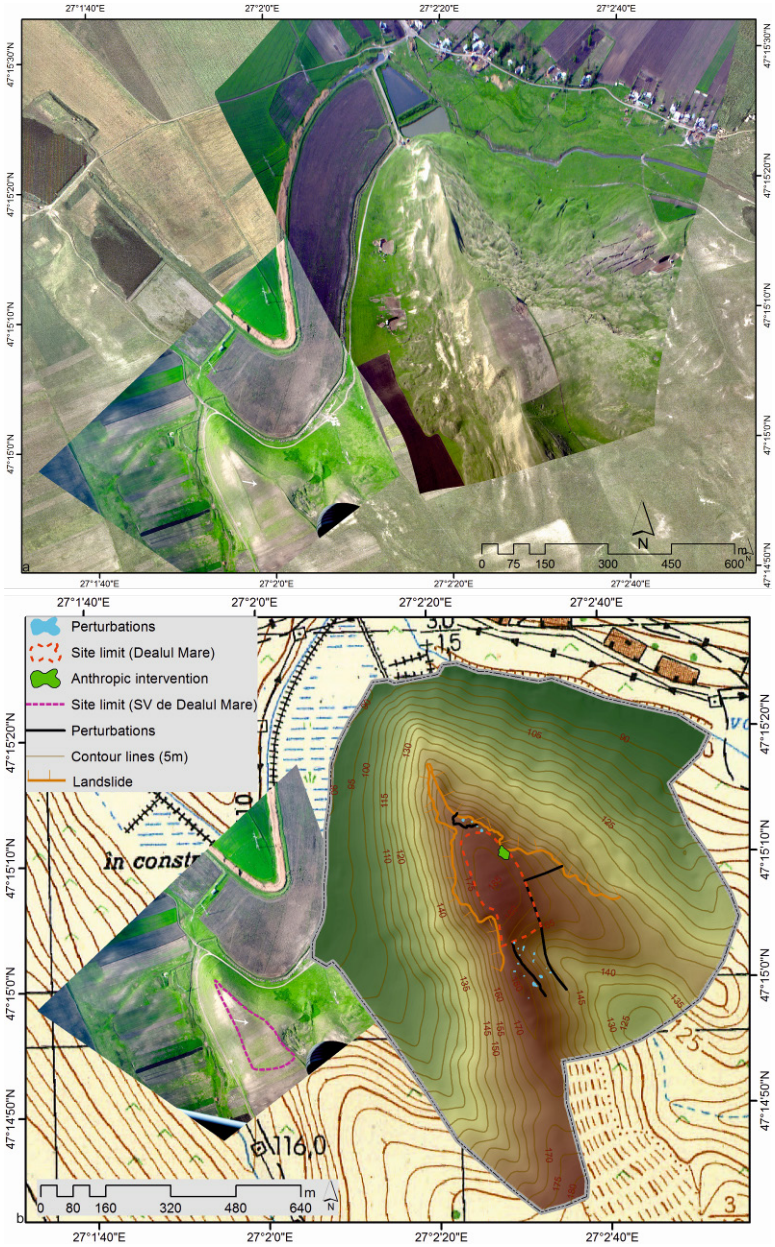

Figure 5. a — Georeferenced aerial pictures for the *Dealul Mare* and *La SV de Dealul Mare* archaeological sites overlaid on a orthorectified image; b — Results of interpretation overlaid on detailed topographic map.

After the identification of the sites on the ground, their GPS positioning and their charting, the flight path was easily set, in agreement with the pilot (Fig. 6). The moment for capturing the images was an afternoon in late May; the approximate height was 500 m, and the photographing angle was 30–45°. A Nikon D300 digital camera was used for this task.

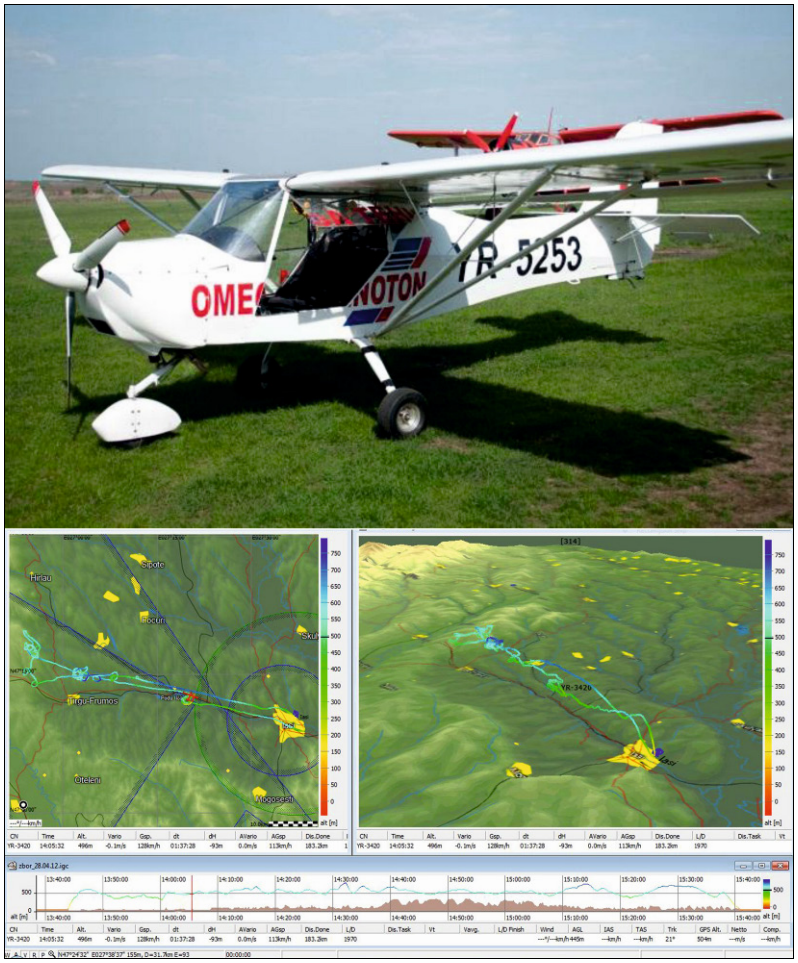

Figure 6. Small aircraft (up) and the flight route (down).

For such a study, of essence is to be able to extract all the information of archaeological nature that can be obtained from oblique photographs or orthorectified images, in order to produce maps with the distribution of

identified structures that are easy to understand by those without specialisation in this narrow field. Thus, the high-quality images in which it was possible to read archaeological clues regarding the state of degradation of the sites or the presence of active hydro-geomorphological processes, were graphically processed, incorporated into a GIS, and geo-referenced (Fig. 5). Referencing to the national coordinates system (STEREO 70) was achieved by introducing correspondence points in the orthorectified images. To obtain the best results, the alignment of these images was combined, where the possibility presented itself, with known points on the ground or with the detailed topographic surveys of the sites (Fig. 5b). All this data was imported, layer by layer, into a GIS project, for interpreting it.

Discussions

Even though the first results of our study appear to be promising, we still have to proceed with caution in interpreting the aerophotograms, having in mind that any prospection method has advantages and disadvantages.

On account of the incipient stage of our research, the present paper analyses by means of oblique aerial photography, besides the elements of archaeological interest, a component of the landscape evolution with regard to the identification, evaluation and impact of natural and anthropic risks affecting the archaeological sites. Unfortunately, it emerged that all six case studies presented in these pages are affected by at least one type of risk.

Thus, the Cucutenian settlement *Dealul Mare* (Fig. 3, 4), for which a positive anomaly can be identified, representing a fortification work[29] (a noteworthy element for this time period), is immediately threatened by landslides in its northern, eastern and western side. While site itself has not yet been affected, an immediate intervention is necessary to stop this erosional process from damaging it. More concerning is a recent anthropic destruction caused by an open clay quarry inside the site's perimeter, in the north-eastern corner (Fig. 5a, b). The presence of trenches, probably from during WW2, fortunately only in the proximity and not crossing the

[29] We mention that this defensive system has not yet been clearly set chronologically.

site, contribute to the advancement and expansion of the erosion. We have to mention at this moment the Cucutenian site discovered by our team (Fig. 5), located at the foot of the versant on which *Dealu Mare* is found, in the south-western side, and similarly affected by landslips.

Hydro-geomorphological processes have also been registered in the case of the archaeological sites from Cucuteni–*Cetățuia* (Fig. 7), Băiceni–*La Dobrin* (Fig. 8, 9) and Giurgești–*Dealul Mănăstirii* (Fig. 10, 11), which are affected by landslides or gullying. At the same time, anthropic interventions can be seen in the form of military trenches or archaeological-looting pits. More than half of the settlement from Costești, on the right bank of the Bahluieț, has been destroyed by the erosion caused by this watercourse[30]. The series of both positive and negative anomalies registered for this site, caused by the presence of a defensive ditch at the base of the site or of possible stone structures (Fig. 12, 13, 14), were subsequently confirmed by archaeological excavations[31].

Figure 7. View from E of the Cucuteni-*Cetățuia* archaeological site.

[30] ASĂNDULESEI 2014.

[31] BOGHIAN *et al.* 2014

Figure 8. View from S of the *La Dobrin / Dealul Gosanu* archaeological site.

Figure 9. View from E of the *La Dobrin / Dealul Gosanu* archaeological site.

Figure 10. View from SE of the Giurgești-*Sub pădure* archaeological site.

Figure 11. View from NW of the *La Dobrin / Dealul Gosanu* archaeological site.

Figure 12. Interpretation of aerial pictures of the Costești– *Lângă școală* archaeological site (Asăndulesei 2014).

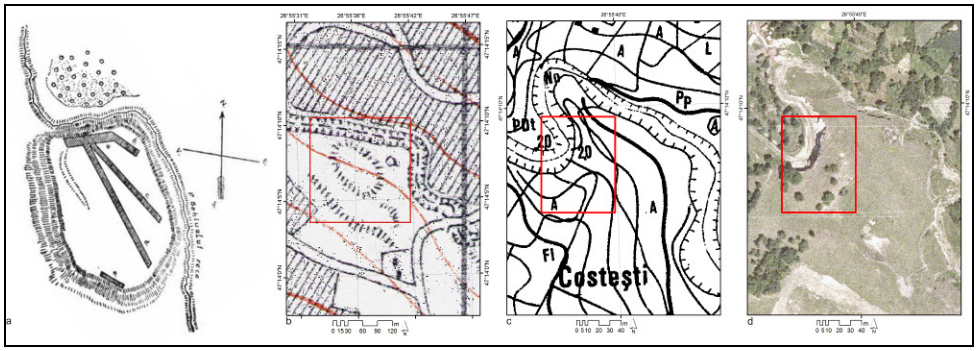

Figure 13. The evolution of the Costești archaeological site (cartographic analysis): a — excavations plan from year 1937; b — topographic map from year 1957 (scale 1:20,000); c — topographic map from year 1975 (scale 1:5000); c — orthorectified image year 2005 (www.ancpi.ro).

Figure 14. View from NW of the Costești–*Lângă școală* archaeological site.

Conclusions

Our efforts to carry out such a study for the north-eastern part of Romania have been quite worthwhile, fully meeting our set goals. Following the methodological course demanded by the two main research facets (the analysis of the archaeological evidence, and the assessment of the level of damage sustained by the sites), we obtained a unitary image of the study area. The identification of archaeological characteristics in many of the case studies, referring, foremost, to fortification or boundaries works (Fig. 3, 4, 5), integrated and correlated with other types of results from non-invasive surveying, can efficiently work to develop a coherent plan for mitigatory or systematic intervention.

At the same time, the wide images, captured from various angles, both for the case studies and for the extended Bahluieț catchment (Fig. 2b, 8, 14), offers the extraordinary possibility to conduct ample research on the landscape from the study area. In the same train of thoughts, the comparison of the aerophotograms with older or newer imagery, accompanied by cartographic analysis, can provide key elements for studies on the evolution of the landscape (Fig. 15).

Figure 15. Bahlui river with a sector of meanders prior to entering in Iași.

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