

Article

# *Pars pro toto*—Remote Sensing Data for the Reconstruction of a Rounded Chalcolithic Site from NE Romania: The Case of Ripiceni–Holm Settlement (Cucuteni Culture)

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**Abstract:** Prehistoric sites in NE Romania are facing major threats more than ever, both from natural and human-induced hazards. One of the main reasons are the climate change determined natural disasters, but human-induced activities should also not be neglected. The situation is critical for Chalcolithic sites, with a very high density in the region and minimal traces at the surface, that are greatly affected by one or more natural hazards and/or anthropic interventions. The case study, Ripiceni–Holm, belonging to Cucuteni culture, is one of the most important Chalcolithic discoveries in the region. It is also the first evidence from Romania of a concentric arrangement of buildings in the proto-urban mega-sites tradition in Cucuteni-Trypillia cultural complex, and a solid piece of evidence in terms of irreversible natural and anthropic destruction. Using archival cartographic material, alongside non-destructive and high-resolution airborne sensing and ground-based geophysical techniques (LiDAR, total field and vertical gradient magnetometry), we managed to detect diachronic erosion processes for 31 years, to identify a complex internal spatial organization of the actual site and to outline a possible layout of the initial extent of the settlement. The erosion was determined with the help of the DSAS tool and highlighted an average erosion rate of 0.96 m/year. The main results argue a high percent of site destruction (approximately 45%) and the presence of an active shoreline affecting the integrity of the cultural layer.

**Keywords:** underground archaeological heritage; natural and human-induced hazards; Chalcolithic Cucuteni culture; archival maps; LiDAR; magnetic prospection; DSAS; NE Romania

## 1. Introduction

Cultural heritage represents the fundamental recognition of the value of a territory and its assets as a symbol and an emblem of history and society; a memory that preserves and records the changing across time of men and landscapes; a dynamic and evolutionary proof; a sign in space and time of tangible and intangible, material and non-material actions [1]. Archaeological cultural heritage has proven to be an important nexus of social cohesion and identity and a valuable resource of economic income via tourism [2].

Currently, within the interdisciplinary scientific community focusing on archaeology and its sustainable management, it is commonly accepted that archaeological sites are threatened more than ever by the effects of increasingly occurring natural disasters like gullying [3,4], landslides [5,6], rock fall [7], floods [8,9], sea-level rise [10], coastal erosion [11,12], and human activities (high-intensity

agriculture, infrastructure works, and urban sprawl) [13]. Natural disasters, increasingly more intense and frequent with the backdrop of climate change, pose a tremendous threat for cultural heritage [14,15]. While archaeological sites from the shores of seas and oceans are intensively studied [12,16], sites located on shore areas of large inland artificial reservoirs are seldom considered [17,18].

This is often the case of Chalcolithic sites from NE Romania [19,20], largely affected by at least one or more natural hazards or anthropic interventions. We are especially referring to Cucutenian sites, the remains of which are mostly underground and located on various landforms [21] on which grazing [4], or intensive agricultural work, occur.

One such site, Ripiceni–Holm, constitutes one of the most important Chalcolithic discoveries of the region, being the first evidence from Romania of a concentric dwelling arrangement similar to the eastern proto-urban mega-sites [22] of the Cucuteni-Trypillia cultural complex, and solid evidence for irreversible natural and anthropic destruction. This paper addresses problematic aspects regarding the boundaries and internal spatial organization of the settlement, on the one hand, and, on the other, the identification of the main destructive factors and erosion rate, in order to advance a hypothesis regarding the initial size of the site and actual extent of destruction. In our case, we refer to internal erosion resulting from the erection of the dam. To follow the internal erosion of the site, the DSAS extension of ArcGIS was used. DSAS represents a common tool to assess the erosion of the shoreline [23–25].

Many European country strategies involve dedicated efforts to provide archaeologists and cultural heritage institutions with new tools to protect, manage and promote archaeological resources in a cost-effective manner [26–28]. This endeavour is reflected in the specialised literature, which focuses on the main categories of natural hazards and their immediate effects [29,30] and the key non-invasive archaeo-geophysical [31–35] and remote sensing methods [36–38], and addresses documentation, rescue, and diminishment of risks [39]. In Romania, initiatives in this direction, although limited in number, nevertheless exist [5,40–42]. They advance good practices in assessing the state of degradation [43] and destruction factors for prehistoric sites in the area [44]. There is still a lack of accuracy in terms of the Cucutenian sites' real state of destruction, and even less data of archaeological interest regarding their limits, layout or stratigraphy. Considering the amplitude and dynamic character of the risks manifested in the area, it will soon no longer be feasible to document these archaeological characteristics.

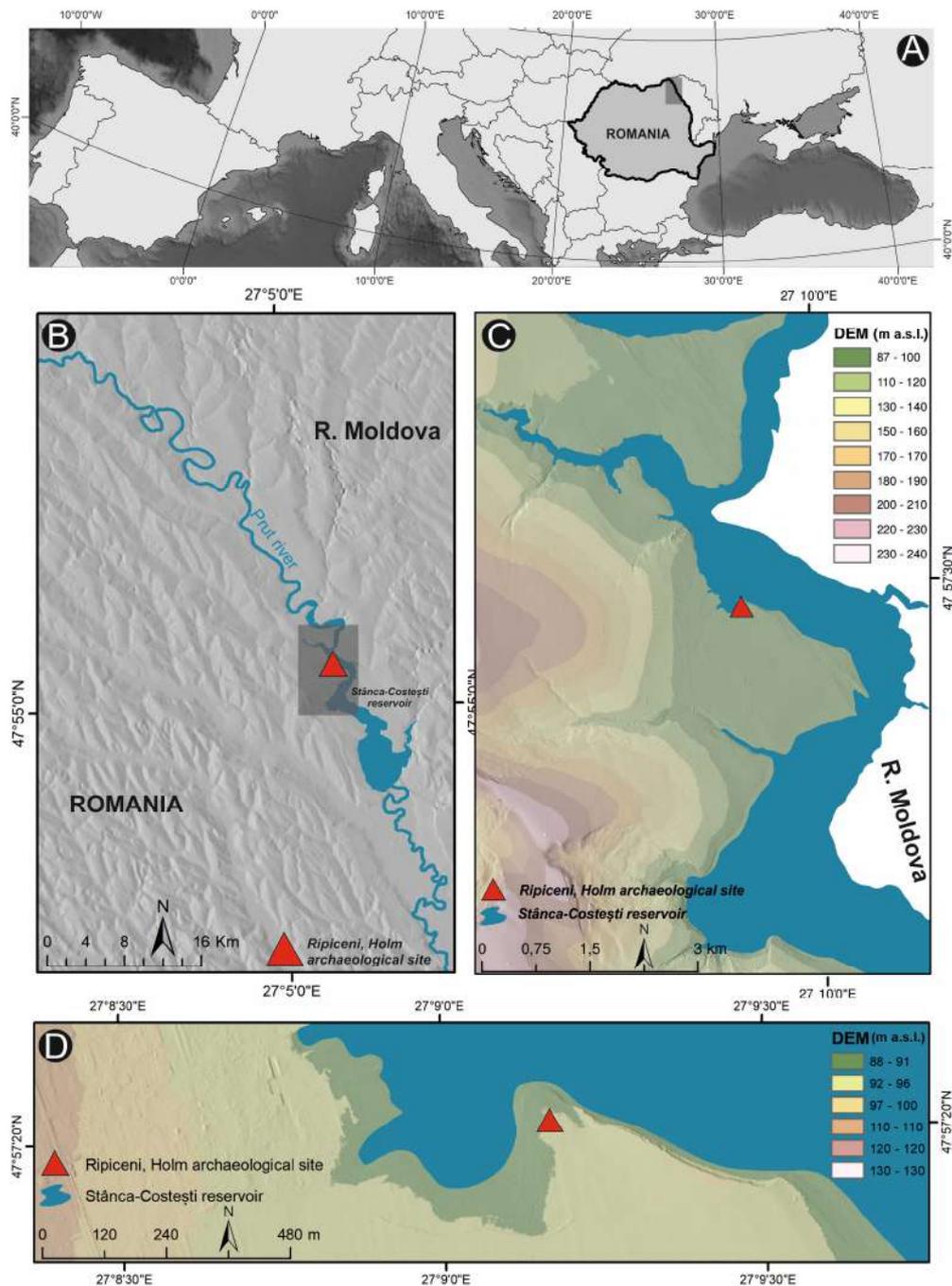
The objectives of this endeavour were to ascertain the state of conservation of the site, to monitor it in order to establish the rate of degradation, and foremost to obtain planimetric data relevant from the archaeological point of view. Assessing the risks for the present case study and the evolution of site integrity in a diachronic manner emphasizes the direct necessity of such an interdisciplinary effort for preserving what has survived so far. In direct connection, we had the possibility of envisioning a plausible reconstruction of the original extent and internal spatial organization of the site.

### 1.1. Regional Settings

Geographically, the settlement is located in NE Romania (Figure 1A) on the eastern part of the Ripiceni Noi village (Botoşani county), on the right bank of the Prut River (nowadays the Stâncă-Costeşti reservoir) (Figure 1B). The site is located on a back slope, with an elevation of ~90 m a.s.l. (Figure 1C). From a geomorphological point of view, the prehistoric settlement (Cucuteni, A-B phase) rests on the second terrace from the stream bed (20–30 m relative elevation, ante 1968, when the reservoir was built, approximately 80–100 m absolute elevation), on a Sarmatian bedrock that is 8–10 m thick with an alluvial cover of 3–15 m. The back slope, detached from this terrace, descends in an SSE direction (Figure 1D). The present-day geomorphological conditions have been extensively shaped by the building of the Ripiceni Sugar Factory in the 19th century, later several brickworks, the Stâncă-Costeşti dam and reservoir, gravel pits, and intensive agricultural works [45].

Being located on the Prut river bank makes it very vulnerable to the action of water (lateral river erosion, water level oscillations). The area is well known in the hydrological literature for its historical floods of 2008 and 2010 [42,46], and the significant changes in sedimentation rate of 7.3% over 33

years due to a high level of water erosion (from rainfall) and deforestation in Romania and Ukraine. Stâncă-Costești reservoir opened officially in 1978, has an area of 5900 ha at normal retention level, and its maximum volume is almost 1400 million cubic meters. The main purposes of the reservoir are river-flow regulation, water supply, irrigation, flood control, and electricity generation. In order for the dam to be built, a significant number of villages were moved, including seven in Romania and eleven in the Republic of Moldova [47].



**Figure 1.** (A) The location of the study area in Europe, (B) NE Romania, and (C,D) Stâncă-Costești reservoir micro-region; (spatial data source: (A) ESRI European boundaries, (B) 0,5 m/pixel LiDAR hillshade, and (C,D) digital elevation model provided by Romanian Water Administration).

## 1.2. Archaeological Background

The site belongs to the Cucuteni culture [48–51], part of the well-known Cucuteni-Trypillia Cultural Complex which stretches from southeastern Transylvania to northeastern Romania, the Republic of Moldova, and to the forest-steppe of Ukraine. From a chronological point of view, the culture's evolution spans from 4600 to 3600/3500 cal. BC in the Romanian area [52]. Our case study is Ripiceni–Holm (formerly known as Ripiceni–La Telescu), henceforth Ripiceni–Holm. The richest occupation layer from Ripiceni–Holm is from the Chalcolithic Cucuteni A-B1 phase (4074–3936 cal. BC according to carbon dating), but there is also evidence of later occupation, from the end of the Bronze Age (ca. 1400–1200 BC), the beginning of the Iron Age (Early Hallstatt–c.a. 1200–1000 BC), the Sântana de Mureș–Černjachov Culture (3rd–4th centuries AD), and modern times [53].

Several field investigations carried out in the proximate area of the Holm site have ascertained the spread of archaeological remains, showing that the settlement covered a much larger area than the one preserved today in situ. Discovered in the late 1960s [54], the site has witnessed several field surveys, test trenches (2006) [55] and archaeological excavations (starting with 2010), all of a limited scale. Only recently has a strategy relying on geophysical investigations been employed. In the more than 500 sqm investigated so far, several dwellings (D. 1–4) and pits have been fully investigated [53]. Since 2016, a 1000 sqm megastructure, probably composed of four conjoined buildings, has also been under investigation [56].

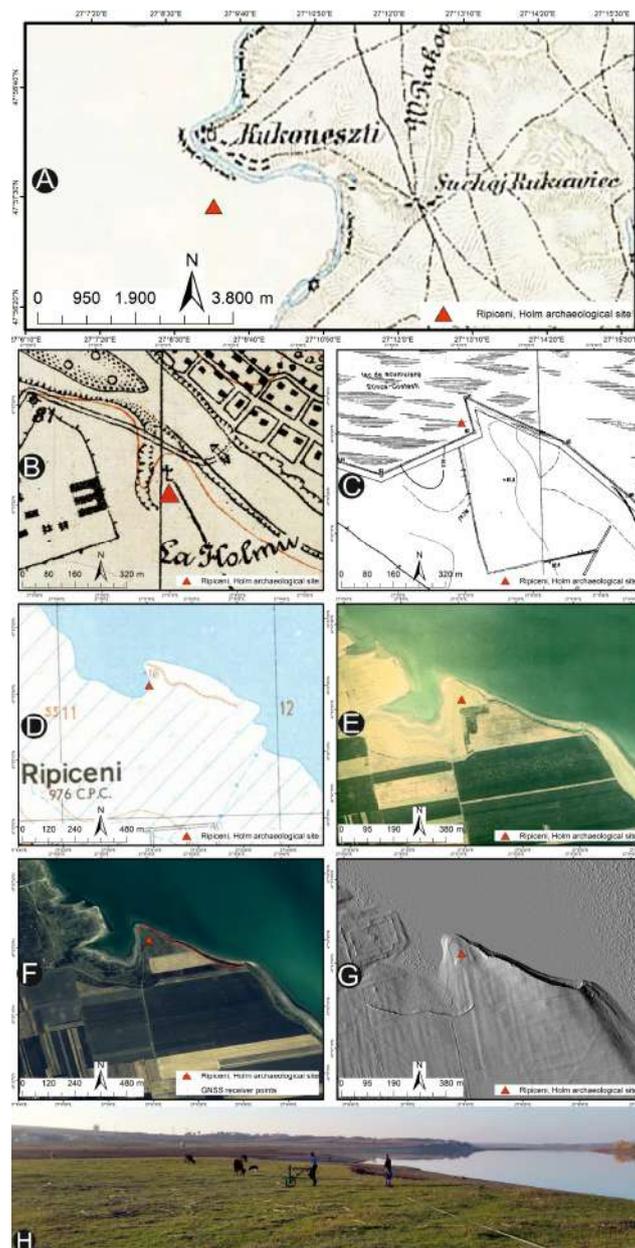
## 2. Materials and Methods

To follow the degradation in time of the settlement, rich cartographic material has been employed: the 3rd Military Mapping Survey of Austria (measurements from 1895 in the area, scale 1:200000) (Figure 2A); Romanian Military Maps (scale 1:20,000, edition 1939) (Figure 2B); topographic plans (scale 1:5000, edition 1976) (Figure 2C); topographic maps (scale 1:25,000, edition 1984) (Figure 2D); orthophotos (scale 1:5000, 0,5 m/pixel, edition 2005 and 2012) (Figure 2E,F); field surveys with differential GNSS Leica receiver (model 1200) from 2012 and 2015, and LiDAR data (0.5 m/pixel) from 2013 (belonging to the Romanian Water Administration (Figure 2G), but only recently opened for cultural heritage assessment or archaeological purposes). There are also satellite images available for the area, but not with a very good resolution, especially for detailed analysis. Problems also arise when projecting the datasets from WGS84 into Stereographic 1970 (Romanian national projection system).

We concentrated on the active NE part of the site where the shoreline was extracted through manual digitisation from the mentioned cartographic material, while the lines from 2012 and 2015 were made by merging together the points measured by GNSS Leica receiver. The errors of the maps as a result of the scale factor were also considered in estimating the rate of the site destruction. To accomplish this task, DSAS (Digital Shoreline Analysis System) software v.5 extension for ArcGIS was used [57]. Different parameters were calculated: Shoreline Change Envelope (SCE, expressed in m), Net Shoreline Movement (NSM, in m) and End Point Rate (EPR, m/yr). SCE is a measure of the total change in shoreline movement considering all available shoreline positions and reporting their distances, without reference to their specific dates; NSM reports the distance between the oldest (1984) and the youngest (2015) shorelines; EPR is derived by dividing the distance of shoreline movement by the time elapsed (31 years) between the oldest and the youngest shoreline positions [58]. For the NNE side of the site a total of 46 transects at 10 m alongshore intervals were analysed using the EPR parameter of DSAS to obtain annual mean rates of shoreline change. The confidence interval in DSAS was at 99.7% and Shoreline Positional Uncertainty was 6 m (according to the maps accuracy). DSAS v5.0 has an option to calculate a shoreline forecast (10 or 20 years into the future) based on historical shoreline position data. This calculation is done by using the Kalman filter [59] to combine observed shoreline positions with model-derived positions to forecast a future shoreline position. The areas of the site at the most risk for future destruction were also identified using this tool.

Two main periods considered for the final analysis were: before the building of the dam in 1978, and after the building of the dam. This is due to the differences in water level and the position of

the shoreline before and after the erection of the dam. Old maps are a rich source of important data regarding historical features of the landscape [60] and the human-induced activities [61]. Recently, more attention has been paid to the historical maps, and likewise to modern aerial and ground-based remote sensing techniques for cultural heritage vulnerability assessment, management, monitoring and risk mitigation [62–65]. The map from Figure 2A was not used in evaluation of erosion rate of the site; it was used only for visual purposes and to depict an older course of the Prut River. We chose not to include it in our study because the scale is not relevant for our analysis.



**Figure 2.** Cartographic material used in the study: (A) 3rd Military Mapping Survey of Austria, measurements from 1895 in the area, scale 1:200,000; (B) Romanian Military Maps, scale 1:20,000, edition 1939; (C) Topographic plans, scale 1:5000, edition 1976; (D) Topographic maps, scale 1:25,000, edition 1984; orthophotos, scale 1:5000, edition (E) 2005 and (F) 2012; Field surveys with differential GNSS system from (F) 2012 and (F) 2015; (g) LiDAR hillshade derived from 2013 DEM, belonging to the Romanian Water Administration; (H) Archaeological site view from the south.

The geological constitution, terrain, and recent developments were all important for planning the research project in the area. With respect to the geophysical surveying, from the methodological point of view, on the basis of the information resulting from the planning stage for the non-invasive surveys, we opted to employ magnetic prospecting (total field and vertical gradient magnetometry) [66–69], one of the most efficient methods of non-invasive investigation, both in terms of time and area covered. The surface of the settlement was divided into  $40 \times 40$  m grids, and data acquisition was made on a N–S direction. The prospecting, initially employing a caesium magnetometer from Geometrics (G-858 MagMapper), with two sensors placed horizontally, spaced at a distance of 0.5 m from each other and 0.2 m above ground level, were carried out in a small area of the site that was accessible and full of archaeological remains. Later on, the rest of the site's surface was covered using a Sensys gradiometer (MAGNETO® MXPDA). The five sensors of the gradiometer were installed on the cart spaced at a distance of 0.5 m between them and approximately 0.2 m above ground level. The squares were georeferenced with a Leica differential GNSS system. The software provided by the manufacturer of the equipment (DLM-GPS, Magneto-ARCH) was used for the preliminary processing of the data and transfer to Geoplot for other specific adjustments (edge match, despiking, destriping, etc.). The resulting geophysical data were integrated and interpreted alongside the cartographic and topographic data using GIS software (ArcGIS 10.4). The maps resulting from the magnetic survey were graphically rendered according to the established standards [70], with white representing the negative values of the magnetic signal, and black the positive ones. The magnetic features identified were classified according to the intensity of the signal, shape, dipole orientation and size, as well as with consideration to any relationship between them or inside a compact group individualized within the site.

### 3. Results

#### 3.1. Cartographic and Geospatial Analysis

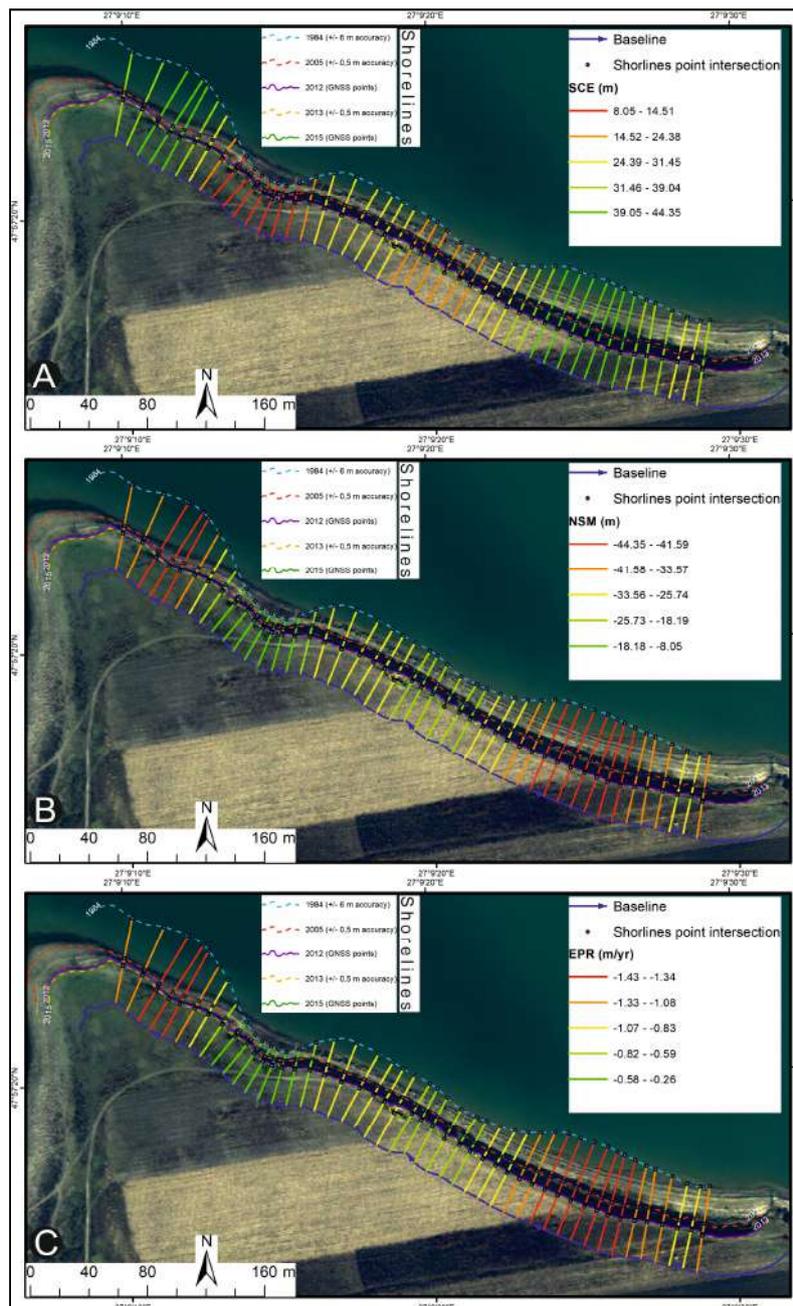
An analysis of the Romanian Military Maps from 1939 reveals that there was a river crossing right where the site is found; a pontoon bridge connected the village of Ripiceni on the right bank to Cuconești Vechi village on the left bank. After the dam was built, approximately 90% of Cuconești Vechi was submerged by the Stâncă-Costești reservoir and consequently, the crossing between the two villages was destroyed. The small gulf visible in the north-western part of the site still exists today.

The shoreline extension in 1939 shows the old course of the Prut before the Stâncă-Costești dam was built, with the average width of the river in this sector being approximately 150 m. Since the reservoir was built, the average width of the river in this sector is 950 m. Several conclusions can be drawn from analysing the reservoir cross-sections nos. 5 and 6 [47]. Cross-section 5, located downstream from the site, shows a steeper slope for the left bank, a gentle slope for the right bank, and low dynamics in regard to sediment transportation or deposition, on account of its location in a meandered area, where water has a slower velocity. Cross-section 6, located approximately 1 km upstream from the site, reveals an area with very high sediment attrition rates and the right bank (Romanian side) is more dynamic than the left bank (Republic of Moldova side), with slow erosion rates from 1976 to 1984, and higher rates from 1984 until 2012. In this section, the thalweg deepened by ca. 8–9 m between 1976 and 2010, which indicates higher water velocity contributing to lateral erosion. Profiles located downstream from cross-sections 6, 5, and 4, respectively, indicate a lower sedimentation rate [47].

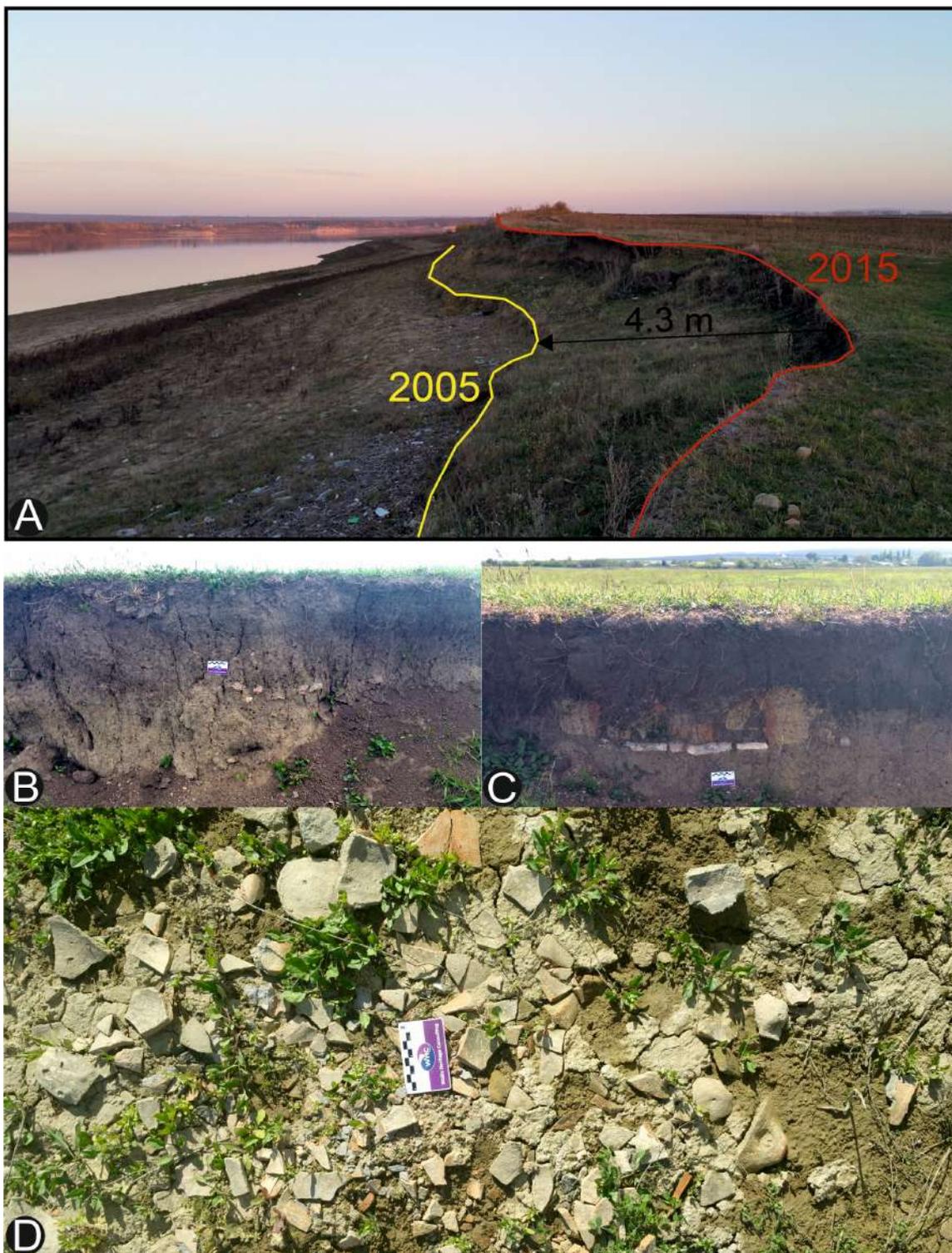
Details of the 1976 topographic plans suggest that several hydrological works had been undertaken on the river bank until that moment (Figure 2C), which are also visible in our magnetic map of the site (highlighted by us, as some recent modern perturbations). In 1976, the north-western part of the site was under water. The small gulf's shoreline also seems to be under water during this period. Before the commissioning of the reservoir, significant works were carried out for protecting the surrounding area from floods. After this period, the water level inside the reservoir reached equilibrium and this is why the small gulf is again visible on the topographic maps from 1984, but the north-western part

of the site was sunken. According to these maps, the line of bank erosion and the water level can be established with a beach measuring ~80–85 m between the two lines. From 1976 until 1984, the highest shoreline retreat was approximately  $-47$  m ( $\pm 6.25$  m, the accuracy estimated for topographic maps, scale 1:25,000, edition 1984). For 1984–2015 we also identified in some sectors high values of shoreline retreat ( $-44.35$  m the highest) (Figure 3A,B). The average erosion rate from this interval (31 years) is  $-0.96$  m/year (Figure 3C).

In the north-western part of the settlement, the gulf expanded, resulting in an area where archaeological remains are spread which was also the case for the north-eastern part of the settlement, and especially on the beach (Figure 4A–D).



**Figure 3.** (A) Shoreline Change Envelope, (B) Net Shoreline Movement and (C) End Point Rate calculated parameters showing shoreline dynamics between 1984 and 2015; (Note that the SCE and NSM are similar due to the only negative values of the transects; no accretion is attested).



**Figure 4.** Details with shoreline limits from (A) 2005 and 2015; (B,C) In situ cultural layer and (D) archaeological remains scattered on the beach from the north-eastern part of the settlement.

### 3.2. Magnetic Prospection Results

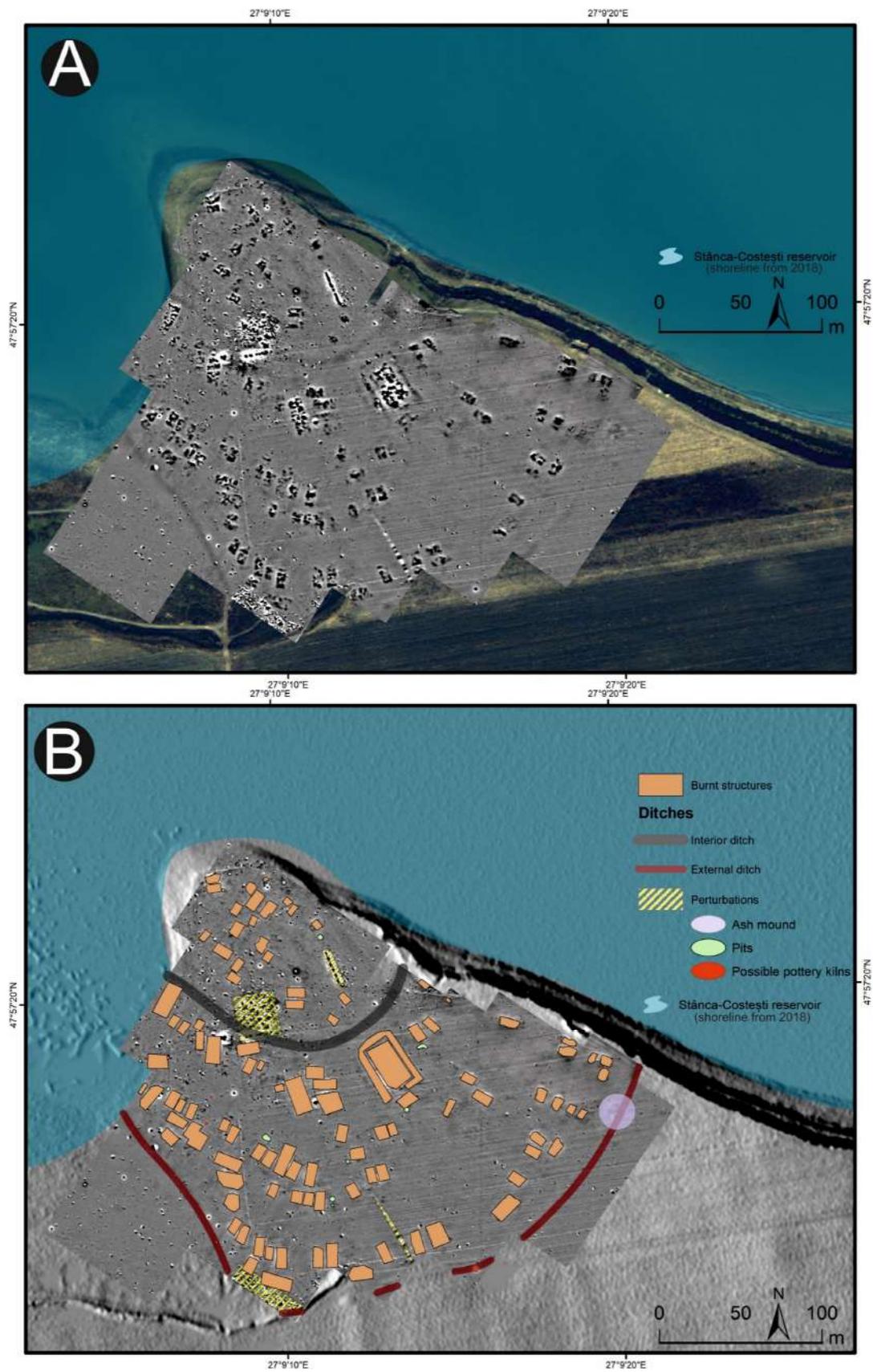
For the areas of the site unperturbed by erosional processes, there were 104 magnetic anomalies identified, generated by structures that witnessed intense heat [22]. Most of these characteristics with intense thermoremanent magnetism originate from the burned dwellings and dependencies

(Figure 5A). Those with weaker magnetic signals and rectangular in shape are dwellings that were not entirely burned, or were poorly preserved. The strongly burned structures ascribed to Cucutenian dwellings do not seem to have had a predefined layout in the NNW part of the site, but do point to a semi-circular arrangement, along axes and rows, in the area outside of the first ditch that delimits the aforementioned group (Figure 5B). Within the general organization of the site, groups of dwellings can be distinguished in some areas, alongside the radial rows. A first interpretation suggests multiple evolutionary stages of the settlement, if we consider the first delineation or fortification (the NNW part) as the initial core of the settlement. In this area, the identified structures are small (areas of ~42 sqm on average) compared to those from outside of the first ditch, and the intensity of the magnetic signal is overall slightly lower (a maximum of 30 nT). The intensity of the signal can be related to the architectural features of the buildings consumed by the fire. Thus, higher intensities point to stronger fires from the larger quantities of building materials used, or on account of the inner layout of the structures. The dwellings outside the NNW core are generally larger (~81.3 sqm on average) [22].

A mega-structure can be identified immediately near the inner ditch. It is rectangular in shape and surrounded by a ditch containing burned materials in some places. This building assemblage covers an area of ~1000 sqm, of which 350 sqm represents the inner delineated area. It seems to be a cluster composed of at least four abutting archaeological complexes. The southeastern side does not close the aforementioned rectangle, which suggests that this area provided access to the inside of the mega-structure. Also, on the southeastern side, close to the entrance, there is another rectangular anomaly, which is much smaller. The area in front of the entrance into the mega-structure is devoid of any buildings, suggesting that the area was a possible meeting point. The entrance into the settlement was likewise from the SE, along the same direction as the entrance to the mega-structure and through the clear area in front of it. The corresponding sector of the settlement's boundary ditch has low magnetic susceptibility, explainable by its deliberate filling by occupants, to facilitate access into and out of the settlement (Figure 5B) [22].

Near a possible main entrance of the settlement, there is another structure that stands apart from the rest, on account of its orientation. It runs on a NE–SW axis, measures approximately 155 sqm, is only partially burned, and it partially blocks the access into the settlement. With respect to its position, the same role of bastion for the entrance into the settlement can be attributed to it, having in mind the finds from Războieni–Dealul Mare [40]. This would again provide support for hypotheses regarding complex fortification works in Cucuteni sites. Close to the exterior of the first ditch, towards the S and SW sector of the settlement, there are three other structures that are much smaller (~150 sqm, ~205 sqm and ~230 sqm, respectively) and orientated differently from the rest, and the role of these structures is difficult to establish (Figure 5B) [22].

Pits represent another category of archaeological complexes identified by the surveys. Several of the more clearly identifiable ones are found near dwellings. Some are characterized by rather weak signals, suggesting that they were borrow pits. Another category comprises pits with higher intensities of the magnetic signal, nevertheless weaker than that of the dwellings and these were probably refuse pits, filled with domestic trash or fired waste. The category of small anomalies also includes those generated by the presence of possible pottery kilns, characterized by strong thermoremanent magnetism and circular shape. The orientation of the magnetic dipole with the negative values towards the N eases their identification. Two are located near the group of dwellings found in the western part of the surveyed tract, and one is positioned in the SE, very close to the external ditch. The group of dwellings from the NNW of the settlement is delineated by a ditch ~5 m wide. The ditch benefits itself of a terrain alveolation so that the resulting landform resembles an acropolis. The external ditch is slightly narrower, of ca. 4 m. The magnetic map also displays some anomalies that are not of Chalcolithic age, viz. Bronze-Age ash-mounds, one of which is conspicuous in the eastern extremity, overlapping the external ditch. Numerous other magnetic characteristics with extremely strong signals are due to recent perturbations (most of them from the hydrological works from 1976) by human activity and due to metallic fragments scattered across the surface of the site (Figure 5B) [22].



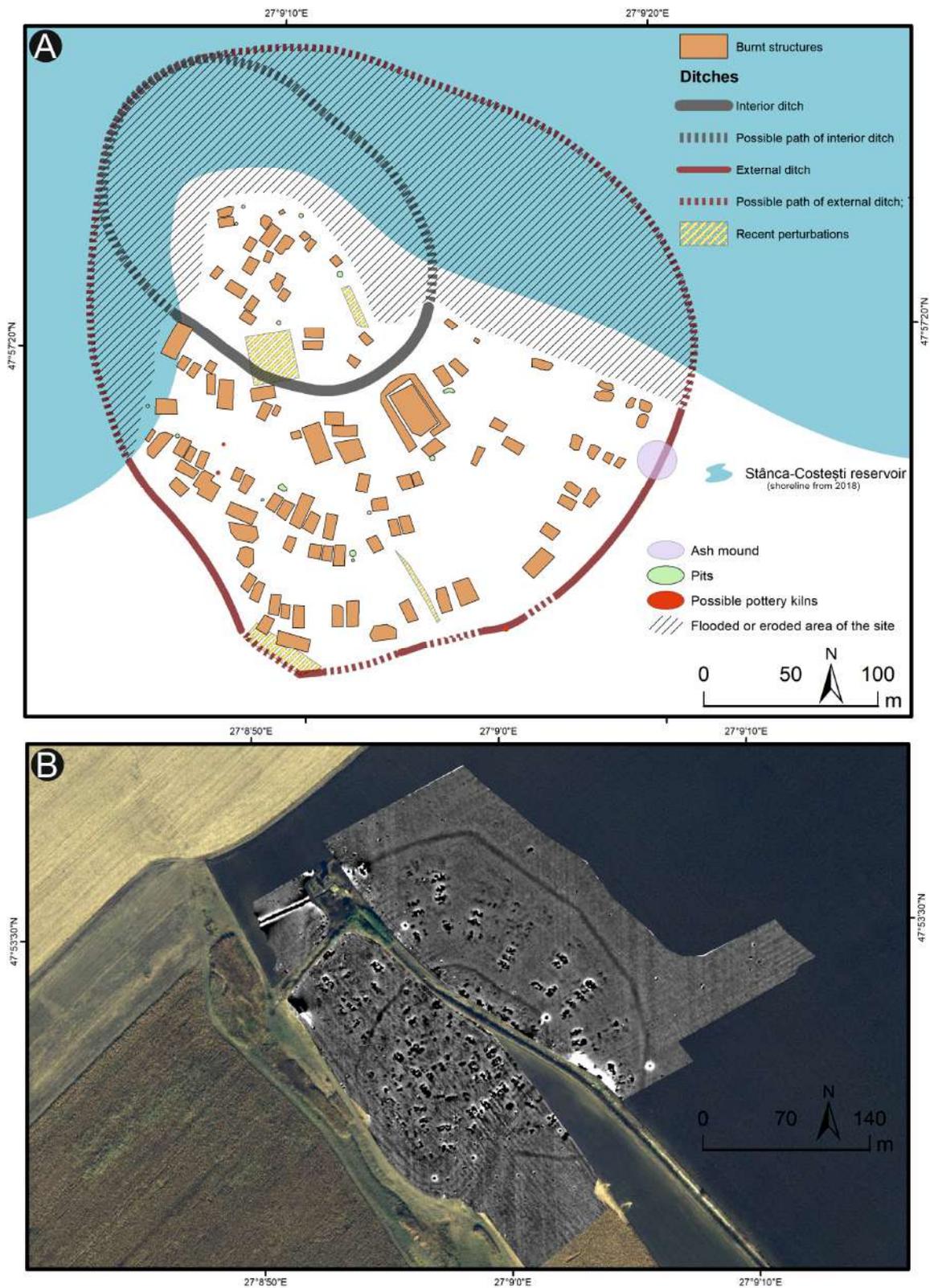
**Figure 5.** (A) Magnetic map (−15/+15 nT, white/black) for the site in question; (B) Interpretation of the magnetogram.

#### 4. Discussion

Climate change and local conditions have a special role in influencing the erosion rates and therefore implicitly the sedimentation rate of man-made reservoirs, especially through winds [71] and land use [72]. Inland shoreline areas have a slower dynamic when compared with coastal ones from seas and oceans. When it comes to comparing the erosion rates from our study with other inland reservoir shoreline areas, it can be stated that they are low:  $-0.96$  m/year on average. Previous studies from Kuibyshev reservoir in Russia [17,18] have reported an average erosion rate varying from  $-1.25$  to  $-6.5$  m/year. A set of reservoirs from the northern part of United States [31] reported average erosion rates of  $-0.6$  m/year (Big Sandy Lake),  $-1.2$  m/year (Allegheny Lake) and  $-11.9$  m/year (Oahe Lake). Other studies have shown the potential of wind and wave energy in determining shoreline erosion that exposes archaeological sites (tribal burial grounds) [73] in the US (Chippewa Flowage in Wisconsin, US). When compared to the coasts of open seas and oceans, which report erosion rates as high as  $-85$  m/year in Jiangsu Province (China),  $-40$  m/year in Hangzhou Bay (China) and  $-50$  m/year in Vietnam [74,75], the rates can be considered as being very low.

From the archaeological point of view, the Chalcolithic settlement from Ripiceni–Holm has a novel and original character in the historiographical landscape from SE Europe, concerning the Chalcolithic, and especially the Cucuteni-Trypillia culture. With a preserved area of 5.2 hectares, and a complex internal spatial organization, the settlement constitutes the first evidence for the origin and the emergence of circular proto-urban mega-sites. This phenomenon subsequently developed in the Republic of Moldova and, notably, in the Ukrainian steppe. This is why we identify multiple similarities between *Holm* and the giant settlements investigated east of the Prut [76–79]. Though on a much smaller scale, the internal organization of the site has the same characteristics: a circular arrangement of the dwellings; their radial layout within the site; clustering of multiple dwellings in some sectors of the site; the presence of large buildings with a different orientation, in some cases near the access roads into the settlement; variation in terms of dwelling size; and the presence of boundary or fortification ditches [80–82]. The differences between the initial core of the settlement and the external area, with respect to the dwellings' size and arrangement, reflect the settlement's evolutionary stages. Likewise, the variation in size of the dwellings from the extended area of the site; the presence of a mega-structure that features right in front of its entrance a sort of esplanade; the grouping of some of the buildings with the assumed kilns; as well as the location of the bastion-like structures, all argue for an organization of the Cucutenian society along hierarchical lines and according to functional criteria [83–85].

The reconstruction of the site landform morphology (Figure 6A) on the basis of cartographic material confirms the existence in the area of quite a large open space (relatively flat terrace) where the community had the chance to expand in a radial mode. In terms of archaeological heritage preservation, the diachronically identified erosion limits and shoreline dynamics described above, emphasize a huge destruction (approximately 4,2 ha; 44,7%) of the site to the west, north and in north-eastern parts (Figure 6A). Earlier we mentioned numerous similarities, in terms of feature types and organization, between our case study and other eastern sites with a concentric arrangement. Another Cucutenian site from Romania was used as a reference point for the reconstruction of a possible initial planimetry. The site from Ripiceni–Popoiaia [86], located just 7 km south of Ripiceni–Holm and recently prospected by our team, has approximately the same internal organisation, but with the core at the South (Figure 6B).



**Figure 6.** (A) Spatial organization of the magnetic features and possible layout of the initial site; (B) Magnetic map (−15/+15 nT, white/black) of Ripiceni–Popoaia archaeological site (Cucuteni culture) representing a similar planimetry with the case study.

## 5. Conclusions

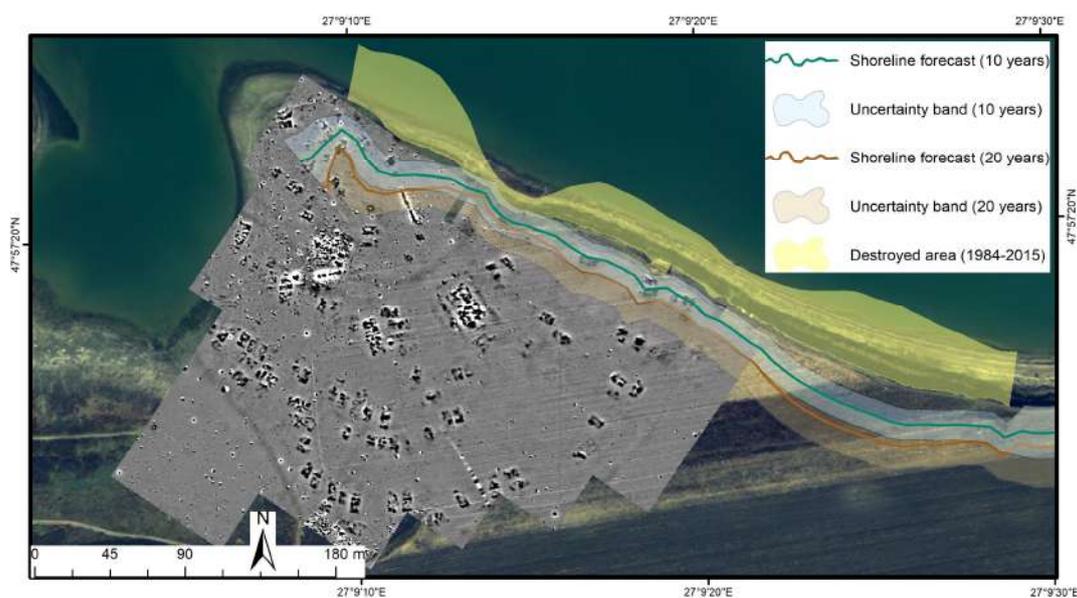
Three categories of conclusions can be drawn from this work: (i) of a methodological nature, (ii) concerning the integrity and evolution of the micro-morphology on the site area, and (iii) of purely archaeological interest.

From the methodological point of view, the diachronic analysis of a substantial body of cartographic records alongside the use of non-invasive surveying methods, and the subsequent integrated interpretation of the results in a GIS environment have been efficient in delivering a clear image of the space occupied by the chalcolithic communities from *Holm*.

Using old editions of topographic maps (1939, 1976, 1984), successive versions of orthophoto maps (2005, 2012), detailed LiDAR data, and differential GNSS readings, we determined the extent of destruction of the site, as well as the timespans during which the site was partially submerged. The estimated average rate of destruction for the interval 1984–2015 (31 years) is of  $-0.96$  m/year. Changes in the course of the Prut River, either natural (meandering) or anthropic (hydrological works), also occurred before 1976 when the dam was commissioned, but the river banks' limits are uncertain, on account of their low resolution in maps. It is nevertheless clear that the terrace on which the site rested was once much more extensive, and that it underwent major changes following the erection of the Stâncă-Costești reservoir.

These results support our proposed reconstruction of the Cucutenian site as a circular settlement with possible extensions towards the North and North-East. To support this, reconstructed planimetry also argues for the arrangement of the site's structures as seen in the magnetic maps. The types of structures identified, and their similarity to those identified in circular sites from the Republic of Moldova and Ukraine, and foremost the analogies with another Cucutenian site from nearby (Ripiceni–*Popoia*), confirms the circular plan of the site. This is the first and earliest such example west of the Prut, and pin-points the emergence of the Cucuteni–Trypillia mega-sites in this region.

Our results, and the analogies available for analysing the site from Ripiceni–*Holm* in a specific context, suggest a degree of destruction of at least 45% (approximately 4.2 ha) of the total area of the site. Furthermore, the shoreline forecasting tool (although in a beta version at this point) from DSAS software estimates an endangered area of approximately 1 ha (to be destroyed in the next 20 years), including most of the N and NE parts of the settlement's core, but also at least five very well preserved houses along the NE boundary of the actual site (Figure 7).



**Figure 7.** Shoreline forecast for the next 10 and 20 years showing endangered areas of the Ripiceni–*Holm* archaeological site.

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