ANALYSIS OF LANDSCAPE TRANSFORMATIONS IN THE AREA OF ANCIENT TROESMIS DURING THE 19TH AND 20TH CENTURY

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Abstract: *The latest archaeological research on the ancient site Troesmis, located between Măcin and Turcoaia (Tulcea County), raised questions about the transformations that affected the area, especially the Danube shore platform and bank (Măcin Branch). Cartographic materials and aerial photographs from different periods in the last two centuries have been analysed in order to find an answer. These were assessed and compared to the contemporary situation (documented by orthophotoplans and drone images as well as exploration on the ground). In addition, information from the archives and specialized publications concerning the geology of the area, the exploitation of local natural resources (especially stone) and land developments in the second half of the last century were also used. The conclusion is that a large part of the shore platform below the two fortifications still visible at Troesmis (and under the fortress of legio V Macedonica spotted by way of geomagnetic prospections on the plateau between them) underwent changes at the end of the 19th century and especially in the 20th century after the establishment of small-scale quarries and the building of the narrow-gauge railway serving the big quarries, the anthropogenic intervention being the major cause for landscape transformations.*

Rezumat: *Cercetările arheologice din ultimii ani asupra sitului antic Troesmis, între Măcin și Turcoaia, jud. Tulcea, au permis formularea unor întrebări privind procesele de transformare prin care a trecut zona, mai ales faleza și malul Dunării (Brațul Măcin). Pentru a găsi răspuns, au fost reperate materiale cartografice și fotografii aeriene din diferite perioade din ultimele două secole. Acestea au fost evaluate și comparate cu situația contemporană (documentată prin ortofotoplanuri și imagini din dronă precum și prin explorare pe teren). De asemenea au fost utilizate informațiile de arhivă și din publicații de specialitate referitoare la geologia zonei, la exploatarea resurselor naturale locale (mai ales piatra) și la amenajările funciare din a doua jumătate a secolului trecut. Concluziile sunt acelea că mare parte din faleza de sub cele două fortificații încă vizibile la Troesmis (și de sub lagărul de legiune reperat prin prospecțiuni geomagnetice pe platoul dintre acestea) a fost modificată la finele secolului al XIX-lea și mai ales în secolul al XX-lea de carierele de mică intensitate precum și de amenajarea liniei de vagoneți care deservea carierele de mare anvergură, intervenția antropică fiind așadar cauza cea mai semnificativă a transformărilor peisajului.*

Keywords: *Troesmis, landscape transformation, Danube, Iglița, cartography, aerial photography, stone quarries.*

Cuvinte cheie: *Troesmis, transformări peisaj, Dunăre, Iglița, cartografie, fotografie aeriană, cariere piatră.*

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INTRODUCTION

Ancient Troesmis is situated on one of the old river branches of the Lower Danube (Măcin Branch), between the modern settlements of Măcin and Turcoaia (Tulcea county), being one of the main antique centres in this region.

Attested as a Getic settlement, Roman legionary fortress, Roman municipium, and, later, as a Late Roman and Byzantine fortification, Troesmis was well known as an important strategic point. This had important historical implications near the Danube border of the Roman Empire. The Troesmis archaeological site is located at approximately 15 kilometres south of Măcin town and 4 Kilometres north of Turcoaia village. The site is dominated today by two fortifications (Fig. 1), conventionally called the Eastern fortification, dating back to the 4th-6th century A.D., and the Western fortification, possibly built in the Middle Byzantine period. The latest studies have highlighted the existence of other ancient settlement cores, first of all the fortress of the *legio V Macedonica*. The estimated area of archaeological importance, supposed to be used mainly between the 2nd and the 13th century A.D., has approximately 506 ha[1].

The whole area has been designated as Natura 2000 site, more precisely, according to the Habitats Directive, a SCI (Site of Community Importance), being part of the Măcin Branch (Danube) SCI[2]. Despite the historical and natural/geographical importance of the area, a suitable monitoring, protection and conservation management plan is far from being provided.

The first investigations of the site began around 1861[3], but only after 1877, when the region of Dobruja became part of Romania, the research in Troesmis area intensified with the first excavation campaigns of Gr. G. Tocilescu. Later, in 1971, A. S. Ștefan, using the available aerial photographs, took over the sketches drawn by the topographic engineer Pamfil Polonic for Tocilescu and proposed a stereorestitution of the core of the Troesmis site. The research done by Ștefan has confirmed Polonic's data on the existence of aqueducts as well as of several tumuli near the two visible fortifications, developing the idea of other possible settlement nuclei existing in Troesmis area[4].

Several tumuli that most probably belonged to the necropoleis near the settlements core in Troesmis were observed, but many of them can hardly be recognised today, as they were flattened by agricultural works in the area[5]. The anthropogenic activities in the area of Turcoaia - Măcin have intensified in the last 150 years, but mostly after 1900, when the region of the ancient site has suffered major

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1 Alexandrescu, Gugl 2014, 294-296; Alexandrescu *et alii* 2016, Fig. 177 - see note 55 below.

2 Natura 2000 site Măcin Branch ROSCI0012 has a total area of 10,235 ha (Brînzan 2013, 290).

3 For the updated history of the site's research see now Alexandrescu *et alii* 2016, 29-74.

4 Ștefan 1971; Ștefan1974.

5 Alexandrescu, Gugl 2014, 301-304, Fig. 12-15.

losses and destructions as a result of agricultural and pastoral activities, limestone exploitation, granite quarrying and processing as well as archaeological poaching.

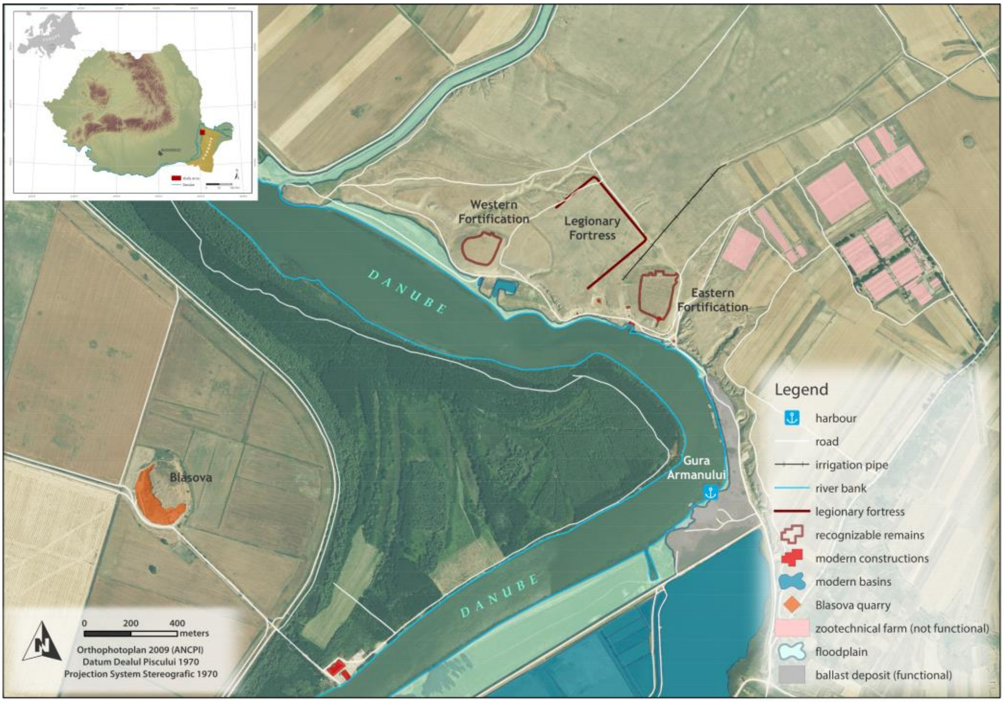

Fig. 1. The ancient Troesmis study area – general map and site localization.

Our study proposes an analysis of the landscape transformations in the area of the ancient Troesmis, focusing on the shore of the Danube. Due to the limited cartographic and historical data available for the region, more precisely for the Măcin Branch, the study focuses on the changes occurred in the last two centuries, a period that witnessed the highest rate of landscape transformation.

From an archaeological point of view, it would have been of interest to clarify certain questions raised during the ongoing Troesmis research project regarding the location of the harbour during the Roman and Byzantine periods[6]. The existing cartographic and photographic materials as well as the changes in the landscape in the last 200 years do not bring additional data for such analyses. One further question of interest is the end of the legionary fortress towards the river[7].

6 Alexandrescu *et alii* 2016, 17, 27.

7 Alexandrescu *et alii* 2016, 188-192, Fig. 137.

METHODOLOGY

The analysis of the landscape transformations in this area have relied on several cartographic materials from different time periods, as presented in Annex 1. Generally, we tried to use high scale cartographic materials in order to identify detailed landscape changes and the modifications occurred during the last decades in the study area.

The first set of maps used for the study was made shortly after the enforcement of the Organic Statute (Regulamentul Organic), implementing one of its directives[8] regarding the need for accurate and professionally measured border maps between the Principalities (especially the line of Wallachia) and the Ottoman Empire. Several sets of maps were made by Captain Karl Begenau[9], one of them being of particular interest for our study, as it also shows some details of the right (Ottoman) side of the Danube (Annex 1, No. 1): The plan of the Danube line (Planul Linii Dunării - 1844), approximate scale of 1:216,000.

The so-called map of Szathmari (1864), scale 1:57,600 (Annex 1, No. 2) and the General Staff Map (1887) scale 1:200,000 (Annex 1, No. 5) were also used. With similar scales, the Army Geographic Institute topographic maps from 1900, scale 1:50,000 (Annex 1, No. 6) and the Army Geographic Service topographic maps from 1916, scale 1:100,000 (Annex 1, No. 8) - all in Cassini projection - were used. The Austrian Map from 1910 (1869-1910), scale 1:200,000 (Annex 1, No. 7), was also consulted. At a finer scale, the study included the topographic plans (1880-1884) made by the Romanian General Staff at a scale of 1:10,000 (Annex 1, No. 3) and the Romanian maps under 'Lambert-Cholesky' projection system (Planurile Directoare de Tragere)[10] from 1940/1953, scale 1:20,000 (Annex 1, No. 10).

For the modern period of cartography, the military topographic maps drawn by the Military Topographic Directorate (D.T.M.) in 1960 (first edition - Annex 1, No. 11) and 1981 respectively (second edition - Annex 1, No. 14), were preferred for their high level of detail at a scale of 1:25,000, Datum Pulkovo 1942 and Gauss-Krüger 5N projection. We have also used the topographic plans 1:5,000 edited by the same institution (D.T.M.) in 1974 (Annex 1, No. 13).

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8 Pârjolescu 1908, 11; Băcilă 1927; Lăzărescu, Lăzărescu 2012, 181.

9 Popescu-Spineni 1978, 263; Lăzărescu, Lăzărescu 2012, 181.

10 It refers to the first Romanian topographic plans in the 1916-1959 period, scale 1:20,000, in Lambert-Cholesky projection, supervised by the French Officer Andre Louis Cholesky as a Commander of the Geographical Service of the Romanian Army during the period from September 1916 to February 1918, following the Franco-Romanian military convention (Brezinsky 2006). The calculations for transforming from the various projections (as previously mentioned) into the Lambert-Cholesky projection were made by the Romanian officers (Osaci-Costache 2000, 138).

We also considered thematic maps, such as the geological map (1988), scale 1:50,000 (Annex 1, No. 15), issued by the Romania's Geological and Geophysical Institute, in order to extract the lithology for the Troesmis area.

Apart from the cartographic materials, we also included aerial images in the study. Thus, for the historical view, aerial photographs processed by the Military Topographic Directorate (1960-1970), scale 1:5,000 (Annex 1, No. 12) for Troesmis area were used. For the actual period, we analysed the orthophotoplans with scales of 1:5,000, from 2005 and 2009 (Annex 1, No. 16-17), processed by the National Agency for Cadastre and Land Registration (ANCPI).

All the cartographic materials (excepting the map of Captain Begenau - Annex 1, No. 1, which was used solely for informative purposes) were georeferenced and in some cases reprojected to the Stereographic 1970 projection (EPSG: 31700), Datum Dealul Piscului 1970. The same holds true for the aerial photographs or orthophotoplans.

The georeferencing process was conducted using two methods. The first method consisted in georeferencing the maps using the coordinates drawn on the maps, as is the case with the topographic maps with scales of 1:25,000 from the 1960-1970 period. In the first stage, the maps were georeferenced in the original projection - Pulkovo 1942, Gauss-Krüger Zone 5N (EPSG: 28465), and then re-projected in Stereographic 1970 (EPSG: 31700). The second method consisted in choosing a series of common points between the map/aerial image and the reference map (in this case we used the topographical map with a scale of 1:25,000 from 1981 - Annex 1, No. 14). The maps were georeferenced directly using Stereographic 1970 projection, Datum Dealul Piscului 1970 (EPSG: 31700).

The high difference between the scales of most maps available for this area (more than 1:10,000 scale difference) did not allow a high precision superposition of cartographic materials, otherwise risking an error of more than 10 meters. Thus, the maps were analysed separately, but by comparison, in order to highlight the occurred changes. A superposition with an error of 1 meter (maximum accepted in this case)[11] was possible between the aerial photographs from 1960-1970 and the orthophotoplans from 2005 and 2009.

[11] According to Imbroane (2012, 318-321, with the previous special literature and discussion on the matter), in order to detect the maximum acceptable RMSE (Root-Mean-Square Error), the value of a detectible dimension in field must be identified and transposed on the reference map/image. For the operation, the standard equation must be used based on the so-called natural principle (the minimum visible dimension) which states: **map denominator × 0.2/1000 = the resolution in mm** (where 0.2 mm represents the maximum threshold for a point perception. Thus, according to the equation, for the orthophotoplans with the scale of 1:5,000, objects with dimensions less than a meter cannot be detected in the field (Imbroane 2012, 321).

In order to have high precision in cartographic analysis, it is necessary to maintain scale proportions in comparisons, thus avoiding obtaining misleading data extracted from the maps. A recent study[12] presented an evolution of the Măcin Branch in the last 100 years, based on different maps (the scale of the used maps was not concluded), which revealed a tendency of the river bank towards erosion and, thus, affecting the fortifications[13]. Such errors can lead to false results and risk the opportunity to find the real evidence that would reveal the cause and effect chain.

Apart from the cartographic analysis, in July 2016 several in-field surveys were conducted to evaluate the landscape transformations in the area of the fortifications of Troesmis. Observations were made on the actual state of environment and erosion, photographs, GPS control points (using a Garmin 62s). Additionally, the aerial photographs taken with a drone (Phantom 3 DJI model) in the spring of 2016 and 2017, allowed us to make a series of correlations with the cartographic materials and to extract new information regarding the landscape.

RESULTS

Analysis of historical cartographic materials

The oldest map at a scale less than 1 million for the Northern Dobruja area[14] was identified in the Maps collection of the Library of the Romanian Academy and was made by Captain Karl Begenau[15] (1844 - Annex 1, No. 1) at a scale of 1:216,000[16].

Analysing Begenau's map (Fig. 2), the Danube's river branch Măcin can be easily observed as being very similar to the one seen today. Some differences can be identified for the river islets and secondary river branches, which were more numerous and apparently more active some 200 years ago. This is the case with Dunărea Veche Lake (Old Danube Lake) in present days, which was still connected

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12 Gavrilă *et alii* 2012, 332.

13 Gavrilă *et alii* 2012, 334-335.

14 Popescu-Spineni 1978, 231.

15 On his career, see Băcilă 1927; Gavra 2010, 25 and 28-30; Lăzărescu, Lăzărescu 2012. It is not yet clear how the Prussian officer got to Wallachia, but is to be assumed to have happened through the Russian mission of General Kisselef, which was eventually similar with the case of Baron R. von Borroczyn (Florea 2014, 63-64). Begenau was also a gifted painter and will be known for his aquarelles of the main cities along the Danube (*Album der untern DONAU-Gegenden Nach der Natur gezeichnet*, Berlin 1860) as well as for different illustrations of monuments in the region.

16 The scale was determined using the later map of Begenau from 1854 (see note 18 below) with a 5-hour scale/5 ceasuri = 1: 180,000. 1 hour scale represented approximately 4.5 km in the 19th century (Stoicescu 1971, 96).

with the Măcin river branch back in 1844, according to Begenau's map. Although the map's accuracy is to be appreciated for that time, we must mention the low accuracy in depicting Romania's relief, as extended triangulation works were not completed at that time[17]. Begenau marks the old and new numbering of the border posts[18] on the Danube frontier with the Ottoman Empire. The numbers and their corresponding names in the area of interest for the present paper, according to later maps[19], are the following: 200/223 = Iglița; 199/222 = Mâna Iglița; 198/221 = Turcoaia. Further important is that the map illustrates all the Danube islets, with precise identification of those on the Romanian and Ottoman territories respectively. The islets are also numbered and there is a colour differentiation - rosa/red for Romanian, green for Ottoman. Islet number 76 is identified as the Iglița Islet[20]. On the later map of Begenau (1854) the right bank of the Danube (the Ottoman side) is not as widely illustrated and there is a visible difference/correction for the location of the Iglița Islet. The numbering of the border posts changed, but the map legend identifies the places and enables the correspondence with earlier and later maps.

On the Ottoman side of the border, there is a mention of an Ottoman border post made of wood and hay, built for 16 men (part of a border post line, similar to the Romanian one), near the house of D. More, the so-called Iglița farm[21], where the history of the recovery of the ancient Troesmis began around 1861.

A more precise map is that of the Austrian team led by Marshal August von Fligely, finished in 1857, at the scale 1:57,600. At the express command of the Romanian Ruler A.I. Cuza, the map will be lithographed and translated by the painter Carol Popp de Szathmari, and published in 1864 as *Charta României Meridionale*[22]

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17 In 1845, Romania was still using the measurement done by the Austrians for Transylvania, knowing that, once the first Romanian geodesic and topographic surveys were to be conducted in 1859 and 1870, the first Romanian high precision maps and topographic plans would be drawn - Popescu-Spineni 1978, 231; Timar *et alii* 2006; Zsombor *et alii* 2013. https://www.geomil.ro/Despre/Istoric (03.02.2017).

18 A later and less detailed version of the map (1854 - *Muntenia. Harta grănitzeră spre Dunăre*, sheet 11: Polițești and sheet 12: Brăila), also made by K. Begenau, presents the numbering of the border posts at that time, which had changed according to the reorganisation of the frontier surveillance (1850 - see Neagoe *et alii* 2004, 150-157) and will still be the one valid for the Austrian maps from 1855-1857 and, consequently, for the so-called Szathmari map.

19 See previous note for the set of maps from 1854; the so-called Szathmari map (Annex 1, No. 2); see also Pappasoglu 1865, sheet 30 (measurements from 1863).

20 See note 27 below.

21 Brennecke 1870, 69-70.

22 For further details on the project, the main characteristics of the result as well as the labelling system of the sheets: Zsombor *et alii* 2013; on the history of the maps of different

(Annex 1, No. 2). As Romania did not include the present-day territory of Dobruja at that time, the map does not show the precise details of the right side of the Măcin Branch (Danube). Instead, it presents in great detail the limit of the loess river bank on which the fortifications of Troesmis are situated, providing a glimpse of the river bank configuration at that time.

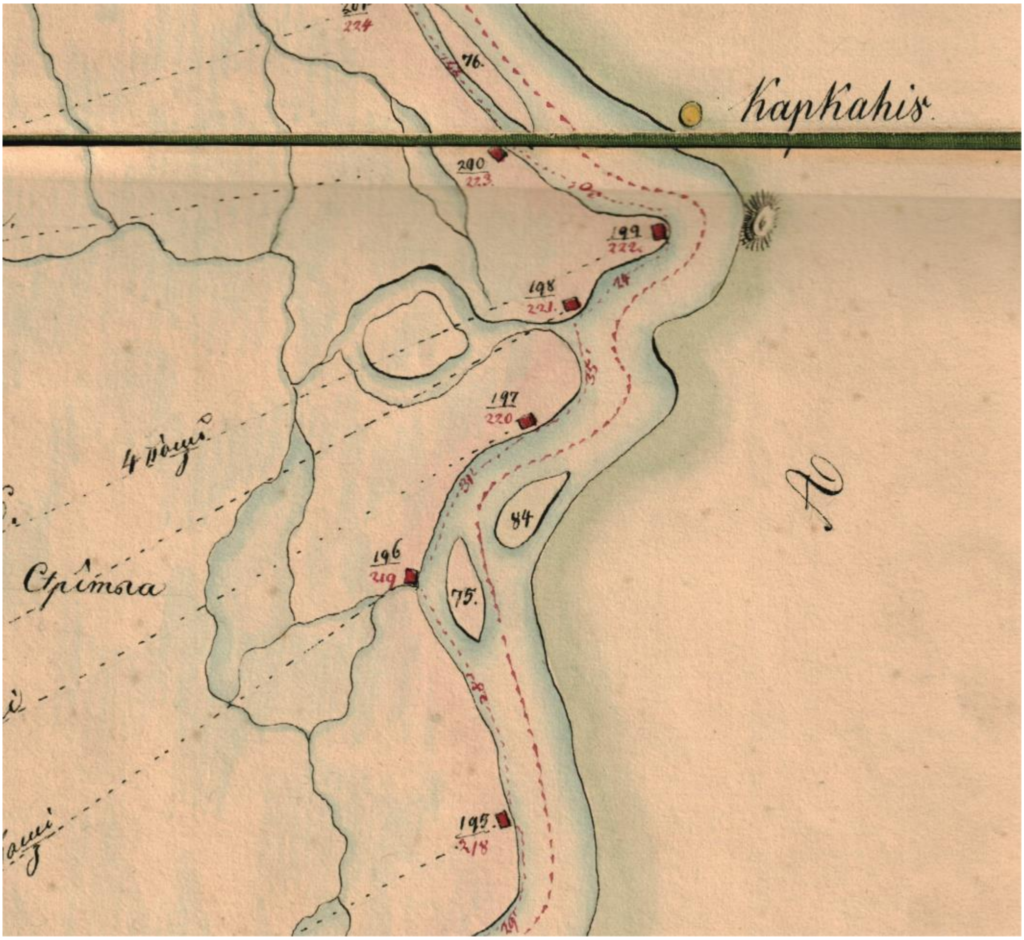

Fig. 2. Captain Begenau's Map, 1844 – detail of the area of the Troesmis site with Carcaliu village in the upper right corner and the location of the place called Strâmba on the Insula Mare a Brăilei (written in Cyrillic script).

historical regions of Romania, see Pârjolescu 1908, 52-53, 34-36, and especially on the Austrian map from 1855-1857, Pârjolescu 1908, 14-18.

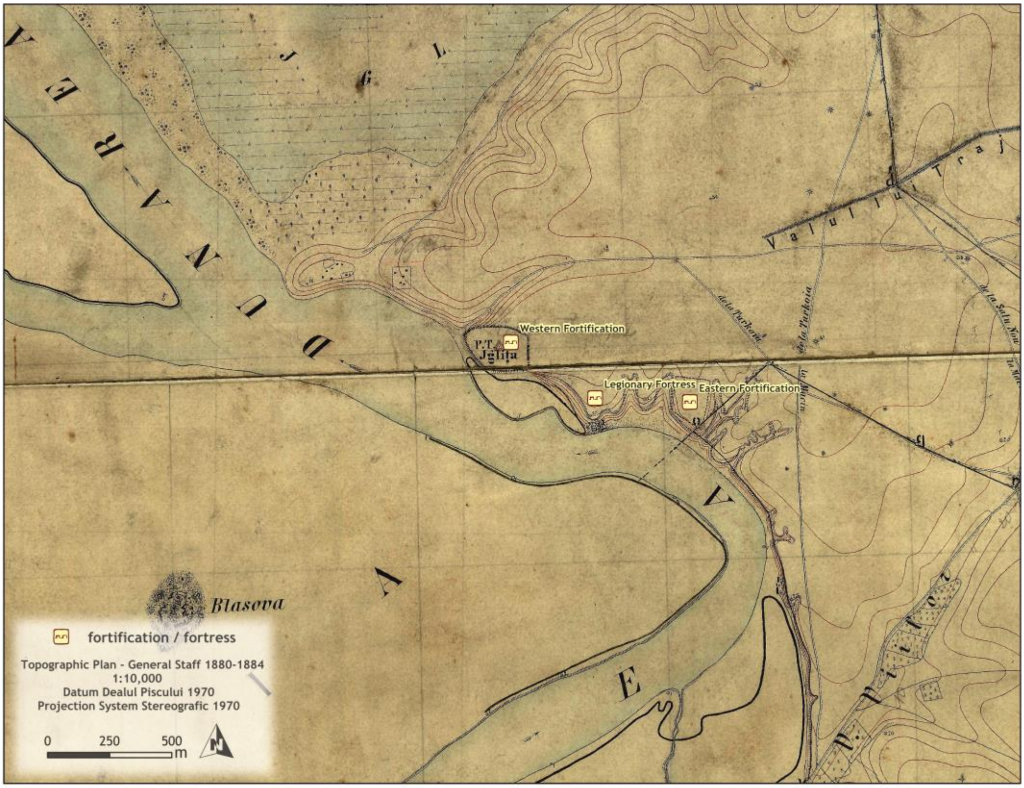

Fig. 3. Troesmis site on topographic plans in 1880-1884.

In the following period, new mathematical determinations were made on the ground in order to make a new higher precision map of Romania. Thus, in 1875, ground survey works started in Moldavia and Dobruja and continued until 1892 for Moldavia and until 1884 for Dobruja. For Moldavia, this resulted in a series of plans at a scale of 1:20,000, while for Dobruja, plans were made at a scale of 1:10,000, in the end having 736 map sheets, with 50 cm side (25 square kilometres in field) and with the Black Sea as level of reference[23] (Fig. 3). For Muntenia, the following were used: the Clarke reference ellipsoid (determined in 1880) in the period from 1892 to 1916 and the equivalent conic projection Bonne[24] for the military maps (1:20,000).

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[23] Pârjolescu 1908, 52-53, 34-36; https://www.geomil.ro/Despre/Istoric (03.02.2017).

[24] Starting with 1850 and up to Romania's unification in 1918, several cartographic projections were used on the country's territory. This was also due to the complicated political situation at that time, with different influences from the neighbouring empires. Thus, the Cassini transverse cylindrical projection was used east from Zimnicea central meridian (230˚ east

The area of the Eastern and Western Fortifications is highlighted on the topographic plans from 1880-1884, scale 1:10,000 (Annex 1, No. 3). The Iglița hamlet can still be seen on these early plans, west of Troesmis[25]. No important transformations were made to the environment at that time, the Iglița Pond being situated north of the homonym settlement. As for the loess deposits and river bank, there are some notable differences compared with the later maps and plans (1940, 1960, 1970, 2009 - Annex 1, Nos 10, 12, 13, 17). The high scale of the plan allows the direct comparison of some of the gullies and erosional processes specific to the area. Thus, the large gullies appear on the map in the same position, whereas the small ones, close to the river bank appear to be less pronounced than they are today. The area close to nowadays temporary storage place of the ballast and south-east of Troesmis is much more fragmented today than it was in 1884. The big quarry on the east side of the Legionary Fortress did not exist in the 19th century, and probably the others were not that developed as well. The plan offers many other details on the road network, tumuli and even the so-called Trajan's Wall (i.e. the Roman aqueduct[26]), being an important evidence of some of the artefacts and archaeological objectives that might have been lost during the last century.

The topographic plans drawn at the end of the 19th century were further used for future upgrades of different map editions in 1900, 1913 and 1916 with scales of 50,000 and 100,000 respectively (Fig. 4).

On the topographic map from 1900 (Annex 1, No. 6) the inflections of Dobruja's river bank of Danube are well represented, the same as the loess terrace scarp and the gullies that used to cross the loessoid deposits from the fortifications area since then. What can easily be seen is the precisely mapping of the Danube river banks on both maps, indicating a high stability in the area. The Iglița toponym is found on both maps, close to the area of the Troesmis site[27].

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from Paris), based on Bessel ellipsoid, whereas the Bonne equivalent conic projection was defined on Clarke, west from the meridian (Năstase, Osaci-Costache, 2005, 21-22).

25 See also Lahovari *et alii*, vol. 4 (1901), 41, *s.v.* Iglița, sat; Velea 2012, 61-64.

26 See Alexandrescu *et alii* 2016, 473-482.

27 The toponym was generously used in the area to designate, beside the hamlet and the pond, an islet on the Danube, on which the Blasova quarry was located, in the administrative unit Chițcani (see Fig. 4 and 5) - see Lahovari *et alii*, vol. 4 (1901), 41 and Lahovari *et alii*, vol. 1 (1898), 469, *s.v.* Blasova, munte and Blasova, sat. - It is probable that the 18th century maps of the Ottoman Empire, mentioning Iglița, refer to the quarry that seem to have been of importance in that time and eventually in the next century, which was the reason for the choice of D. More to establish his farm in Iglița: Laurie & Whittle, London, *A New Map of Turkey in Europe divided into all its provinces, drawn chiefly from the maps published by the*

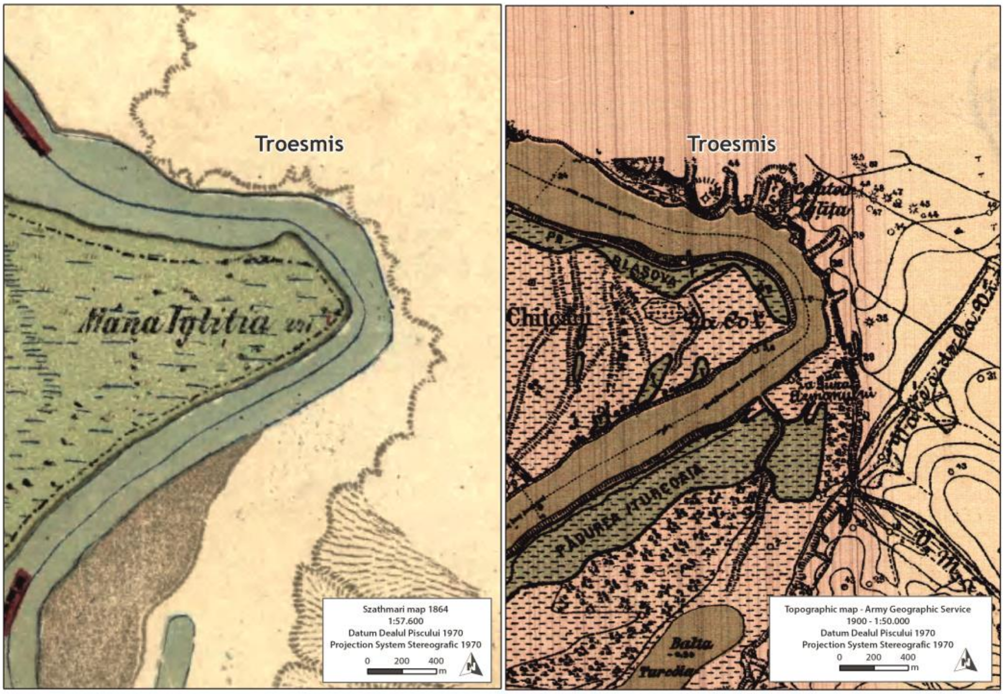

Fig. 4. Troesmis site position on the Szathmari map and on the military topographic map from 1900.

In 1916 the foundation of the aerial photography service was laid; later, the service would provide raw material for high precision maps. At the same time, the Army Geographic Service together with the French Major A. Cholesky decided to unify the cartographic projections used till then and use the Lambert conformal conic projection for drawing the Romanian maps under 'Lambert-Cholesky' (1916-1959) projection, scales of 1:10,000 and 1:20,000[28] (Annex 1, No. 10).

Together with the development of the aerial photogrammetry in Romania, after 1917, the old maps were updated and thus the Romanian maps under 'Lambert-Cholesky' (1916-1959) projection system were developed. The project was set for the entire country at a scale of 1:20,000. The precision of these maps was very high although the Krasovski ellipsoid was not implemented yet; the plans were similar to the first topographic maps made later after the transformation of the Military Geographic Institute into the Military Topographic Directorate. These maps were

Imperial Academy of St. Petersburg (1794), and W. Faden, London, *European Dominions of the Ottomans, or Turkey in Europe* (1795).

28 http://www.geo-spatial.org/download/planurile-directoare-de-tragere?lang=en.

drawn at a scale of 1:25,000, Gauss-Krüger Projection, Datum at Pulkovo 1942, and up to the end of 1960 they covered the entire Romania[29].

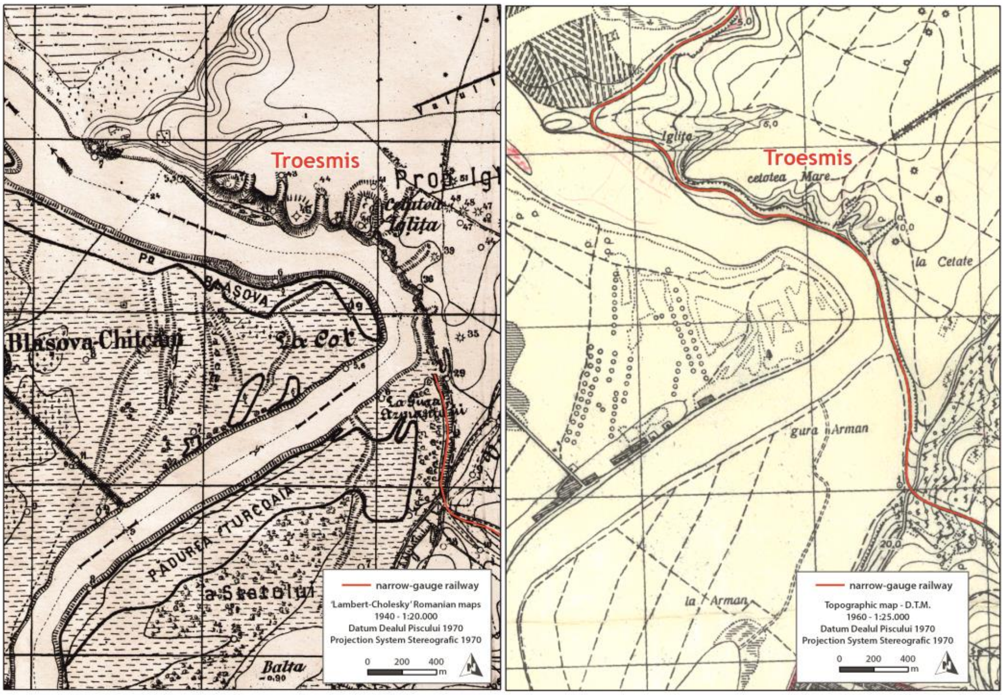

Fig. 5. Narrow-gauge railway marked on the 'Lambert-Cholesky' Romanian Map from 1940 and on the military topographic map from 1960.

The analysis of the two maps (Fig. 5) reveals a series of similarities, such as the general configuration of the river banks of Măcin Branch, Iglița Pond, flood areas, gullies and the configuration of the river bank where the fortifications are situated. Starting with 1940, an important detail on the Lambert-Cholesky Romanian Map is the narrow-gauge railway[30] that used to connect the exploitation quarry at

29 In 1930, the cartographic projection for Romania is changed again and new calculations are made in order to establish a suitable projection for the country and, at the same time, compatible with the projections used in Europe at that time. Thus, the Stereographic 1933 projection is made with a single secant plane, based on the Hayford ellipsoid 1910 (Imbroane 2012, 140-141). This is an important stage that precedes that in 1950-1960, the time of modernisation and strong development of the D.T.M.

30 According to some sources, the line must have been a Decauville railway type, but the scarce information about the line gauge, made us use a more general term in this paper, which would describe the railway built to serve quarrying near Troesmis.

Iacob-Deal, opened around 1880, with the Danube River[31]. Until 1940, this narrow-gauge railway led to the spot used nowadays as a temporary storage place of the ballast, where the granite was loaded on the barge (Fig. 6). After 1940, on the topographic map 1:25,000 (first edition, 1960 - Annex 1, No. 11) featured an extension of the narrow-gauge railway used to bring material from Iacob-Deal (the quarries east of the village of Turcoaia) to the loading places, as well as from the quarries in Piatra Râioasă and from near the village of Greci (Morsu, Carabalu, Ghiunaltu, Baba Rada quarries)[32]. Additional loading places below the Eastern fortification are presumable[33]. The narrow-gauge railway passed beneath the loess cliff and Troesmis site, went around the Western fortification and then on the other side, on the Iglița Pond shore, towards the intersection with the main road and from there directly to the Greci village[34].

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31 Cantuniari 1913, Geological sketch of Turcoaia-Cerna region – Cantuniari already depicted the narrow-gauge railway which led to Gura Armanului. The first quarries on Iacob-Deal date back to 1880 (Velea 2003, 96-101). The railway was built, most probably, a few years after 1896, as Vlase Ștefănescu opened the quarry in Iacob-Deal and started to build and organise the infrastructure for the exploitation and his workers (Netzhammer 1909, 316; Velea 2003, 101 and 103).

32 Quarrying near Greci began around 1900, but the transport to Gura Armanului was quite difficult. The authorisation for the narrow-gauge railway line Carabalu-Iglița, meant to bring stone from the quarry in Carabalu (near Greci) to the loading place on the river, was given in 1922 to entrepreneur D. Capriel from Galați, who started successfully to exploit granite in Dealul Manole in 1908 and in 1911-1912 in Carabalu - Velea 2003, 112; Velea 2012, 79.

33 There seems to have been a certain difference in the infrastructure according to the wares to be loaded: grain (Ionescu 1904, 670, mentions a loading place for river barges at Iglița; it could be the one visible on the illustration by Netzhammer 1909, 315), gravel, stone blocks etc. The boats were docked near barges, on the river side, without a proper piers installation (see Netzhammer 1909, 295). The loading procedure was quite complicated and required certain skills (Velea 2003, 307). In one of the letters of the archaeologist E. Coliu (Trohani 2007-2008, 573-574, No, 25), when making excavations in Troesmis in the summer of 1939, there were mentioned two stops of the passenger ships Lydia and Concordia, making daily trips from Brăila, which could be used to get to the Troesmis site: "Ferma Strass" (the Strass Farm = the former farm of D. More, to be located in the area of the Iglița headland) and "Cetatea Trosmin" (to be located beneath the Eastern Fortification, near the remains of the stone breaker). The loading place in Gura Armanului is not mentioned, probably due to the distance between the site and the port.

34 Illustrations from the quarries in Iacob-Deal and of the loading place in Gura Armanului (Gura Orman): Netzhammer 1909, 295; Cantuniari 1940, 774-775, 780-784; Velea 2003, 300-305.

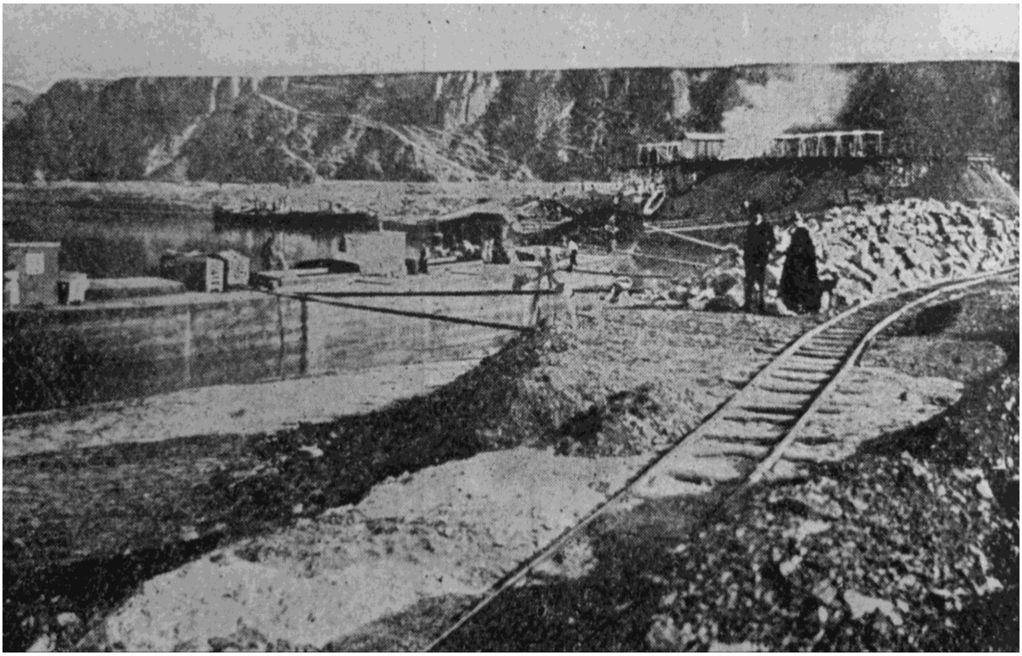

Fig. 6. The narrow-gauge railway at Gura Armanului river-port (after Cantuniari 1940, 784).

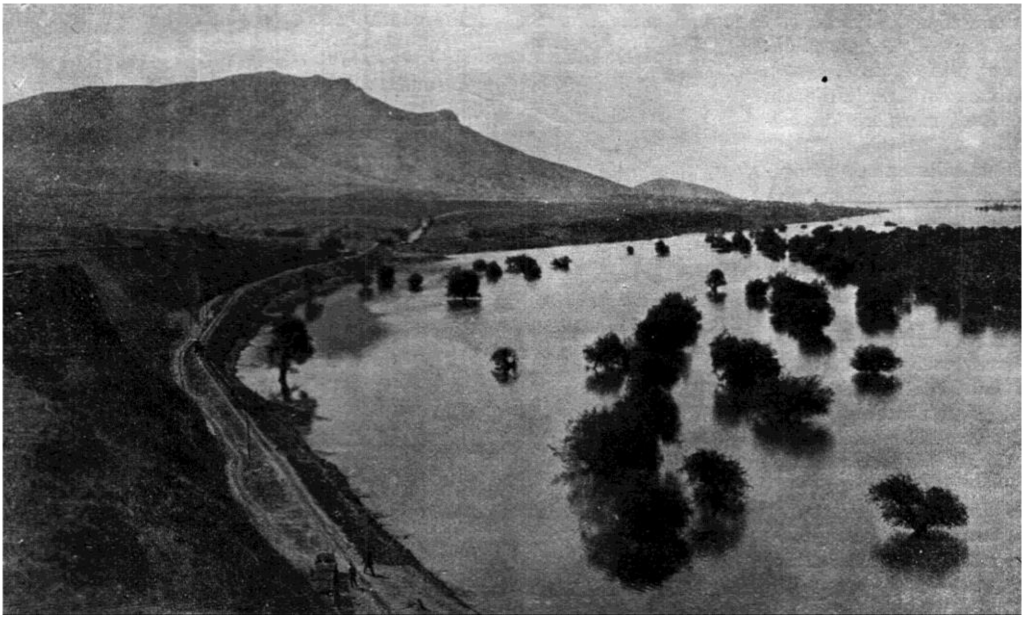

Fig. 7. The Danube river before the transformations of Insula Mare a Brăilei, together with the narrow-gauge railway passing beneath Troesmis' loess cliff (after Cantuniari 1940, 773).

The analysis of historic maps reveals small changes in the natural environment in this region. The stability is very high, with small variations of the Danube river bank and some changes in the areas from the Danube floodplain and ponds. Significant changes in the area are only made by humans, activities such as rock exploitation having the most important impact at this moment.

Analysis of contemporary cartographic materials

In an attempt to continue the cartographic series started in 1960, D.T.M. releases a second edition of the topographic map that gets final in 1981 (Annex 1, No. 14). No other topographic map at such a high level of detail is currently available for the public. Still, year 1981 saw new major transformations that took place in the area of the Troesmis fortifications.

First, in 1972, major transformation works were done to turn Insula Mare a Brăilei[35] from a natural swampy area into agricultural land which was also dedicated to other connected activities linked to the economic needs of the time. Draining the ponds inside Insula Mare a Brăilei and the Iglița Pond west of the Western fortification paved the way to agricultural development and led to an increase in demand for agricultural land. A part of the Danube floodplain was transformed into a series of lakes, with several dams and hydrotechnical works being performed. New connection roads were constructed and a pig farm was built north-east of the Eastern fortification, right on one of the archaeological sites associated with the Troesmis site and necropolises area[36]. Connected to this farm were some basins on the river's waterfront, while other installations seem to have been used for fishing, etc. There is no documentation available and the still recognizable remains are difficult to clarify[37].

In order to ensure water supply for the agricultural lands north of the fortress, a high capacity irrigation pipe was installed in the area[38]. For this a water pump was also installed near the Danube River. The narrow-gauge railway was dismounted in 1974[39] (the line no longer exists on the topographic map 1:25,000 from 1981) and replaced with a 5-km long road for overweight trucks, which was meant to ensure the continuity of granite exploitation and transportation.

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35 Andronache 2008, 20.

36 See Alexandrescu *et alii* 2016, 24.

37 See Alexandrescu *et alii* 2016, 22-27.

38 On the project and its direct archaeological importance see Simion *et alii* 1980; Bogdan-Cătăniciu 1984.

39 Velea 2003, 158.

These changes were major and substantially affected the area, leading to environmental and relief degradation, including the local landscape[40]. Eventually, these changes can be perceived as direct and indirect losses of the archaeological site of Troesmis.

Aerial images analysis

Aerial images offer the advantage of capturing many details that would otherwise go unseen due to the generalization on the maps. For the analysis of the Troesmis area we used aerial photographs of D.T.M. taken between 1960 and 1970 (Annex 1, No.12) and orthophotoplans with relevant information for the area of interest covering two-time intervals (2005 and 2009), taken by ANCPI (Annex 1, No. 16-17). All images have been georeferenced in Stereographic 1970 projection, Datum Dealul Piscului 1970, with an error of 1 meter. Thus, due to the comparable scale and resolution of the datasets, in this case it was possible to compare directly the images on time series and analyse the landscape transformation.

The aerial photographs on Troesmis area seized the moment short before the start of the draining works at Insula Mare a Brăilei. This offered the possibility to track some of the changes that took place in this time interval. First of all, they made clear the existence of several tumuli, also registered by A.S. Ștefan[41], north and north-east of the Eastern fortification, which appears on the orthophotos to be beneath the pig farm built in the area. The draining of the Iglița Pond and the dam construction around the area were visible on the aerial photos from 1960. It is clear on those images that, in the sector of interest, there were no major improvements on the Insula Mare a Brăilei or in the Danube floodplain. Furthermore, the water basins near Turcoaia, the water pump and the high capacity irrigation pipe were not built at that time. The narrow-gauge railway seems to have disappeared, but unfortunately not so many details are visible on the river bank, beneath the loess cliff due to the overexposure of the photo.

A major change in the landscape, compared with the orthophotos from 2009, is the presence of several gullies that appeared over the last decades east of the nowadays temporary storage place of the ballast (Fig. 8). This aspect can be correlated with the activities in the area, offering a glimpse on how the whole Danube bank from Troesmis must have evolved towards the present-day form.

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[40] Rădulescu *et alii* 1969 (*apud* Velea 2012, 43-44).

[41] Ștefan 1971; Ștefan 1974.

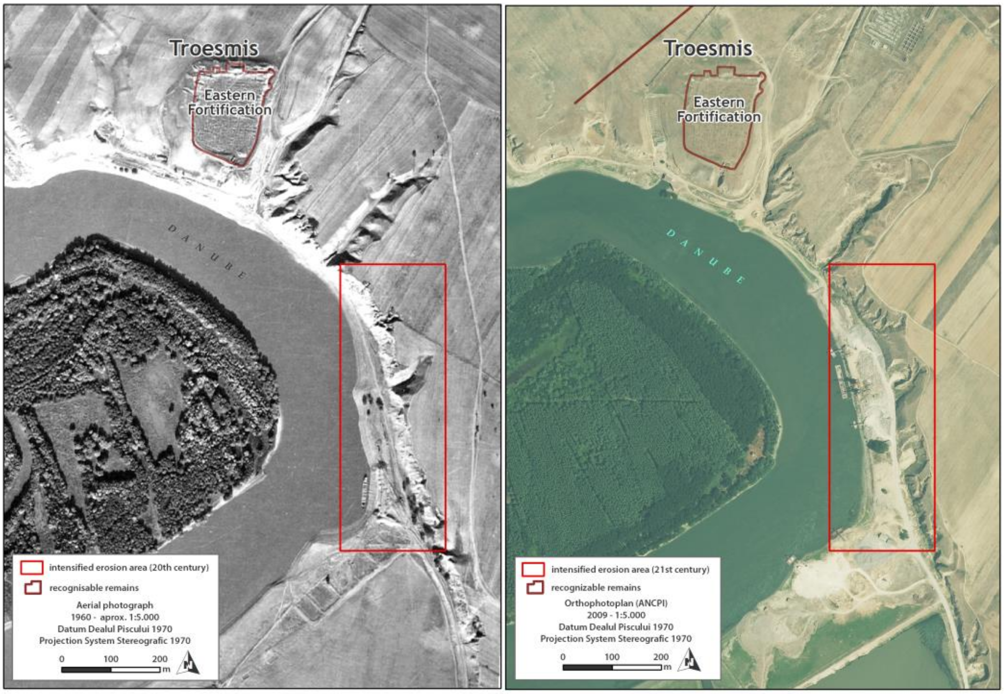

Fig. 8. Details of aerial photography (1960-1970) and orthophotos (2009). The area affected by erosion in the last 50 years is highlighted.

Unlike the orthophotos, the aerial photography confirms the stability of some of the geomorphological processes in the area. For instance, some of the gullies or slopes are clearly stabilised, but there are also some loess cliff sectors that are still dynamic, although without showing the direct cause for these differences in the river bank erosion.

The orthophotos from 2005 (Fig. 9) showed the highest Danube water level for that season. This allowed the mapping of the Danube floodplain. The image showed that the Danube level can cover the access road to the temporary storage place for ballast, close to the loess cliff. The comparison between the two images reveals the level up to which the Danube rises during flood season near the Troesmis site. But most of the floodplain is now dammed and the water can no longer reach too close to the cliff.

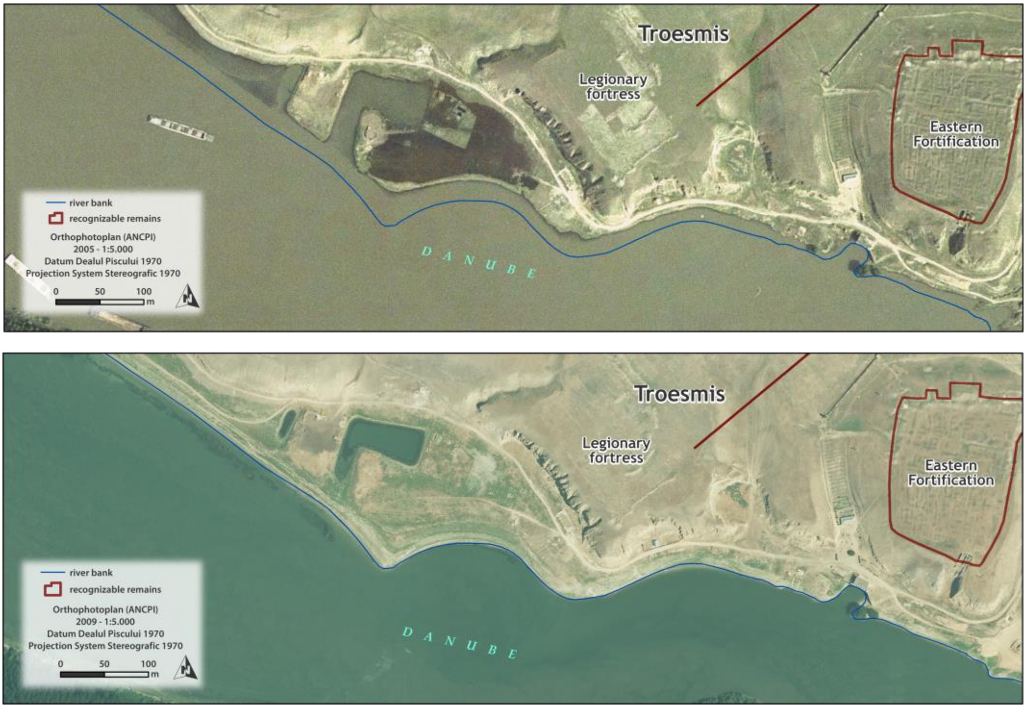

Fig. 9. Detail of the orthophoto from 2005 during the flood season (up) and of the orthophoto from 2009 during the dry season.

Insula Mare a Brăilei (The Great Brăila Island)

Insula Mare a Brăilei has undergone changes ever since ancient times. A recent study[42] shows that deforestation and impact activities started in the Lower Plain of Danube some 3000 years ago, but no sooner than around 1000 A.D. have these actions doubled their rate. Due to the intensification of agricultural activities, the sedimentation rate also increased in the Danube Delta in the last 2000 years, facilitating its extension. But above all, the 1820-1977 period[43] and the year 1850[44] are mentioned as reference years for the exponential growth of the human impact upon the environment. Thus, it is important to see the entire picture of the Danube's regional evolution in order to understand the phenomenon that lies at the basis of the actual evolution of the environment.

42 Giosan *et alii* 2012, 4.

43 Rădulescu *et alii* 1969 (*apud* Velea 2012, 43-44).

44 Giosan *et alii* 2012, 5.

Insula Mare a Brăilei was initially a complex system of lakes, ponds and lake vegetation which worked as a regulator for the Danube in case of high water levels or floods. Once the economic activities started to develop, the same as the request for agricultural land, a large project for land improvement and sanitation was developed between 1960 and 1972[45]. Although some improvements had been made before 1900, those made at the middle of the last century were unprecedented.

The new distribution of the discharge on the Danube as a consequence of dam construction alongside Insula Mare a Brăilei caused a rise of stream flow levels in the upstream compared with the levels registered before the damming. Thus, the multi-annual average discharge rose by 290 m^3/s (from 5,980 m^3/s to 6,280 m^3/s). The maximum average discharge also changed, from 10,170 m^3/s to 11,030 m^3/s[46].

After damming the Danube river course, the flow section diminished. This led to a rise of the water level so that, at the same discharge, the water level is higher nowadays[47]. Downstream, at Brăila, the multiannual average water levels increased by 33 cm as a consequence of damming. As for the flooding risk, after the damming it moved from an insignificant level towards a moderate risk, with a small rising tendency[48].

All these data show the fact that the anthropogenic improvement of Insula Mare a Brăilei, affected the discharge and transportation of sediments along the Danube. This can determine a series of changes on the river bank in some situations. But as we have already mentioned in the beginning, these aspects must be looked at from both a global and historical perspective.

In order to see if the dams and draining had any negative impact on the area of ancient Troesmis site, we present the arguments that refute the hypothesis:

1. The improvements to Insula Mare a Brăilei did not directly affect the area close to the Troesmis site, because in Blasova area no significant improvements were made, as proven by the historical maps and aerial images.
2. The Danube does not have high water level fluctuations. An average of 33 cm could not affect the river bank from Troesmis, which has a difference of up to 8 meters in altitude. The aerial image showing the Danube at high water level (Fig. 9) highlights this fact. The area is dammed with concrete in some areas, so that the loess cliff is not affected by water level fluctuations that vary across the year.

45 Andronache 2008, 20.
46 Andronache 2008, 37.
47 Andronache 2008, 35.
48 Andronache 2008, 54.

3. The road at the base of the loess cliff indicates that works for road-improvement must have been done previously. A much more plausible factor is the direct influence of the erosion than the discharge fluctuations.
4. The continuous activity in the area for a period of more than 100 years, with an intensification in the last 50 years, to the temporary ballast storage place (trunk transportation produces much more damage than the narrow-gauge railway) is another hint at the cause for the destabilisation of the Danube river bank.
5. The evolution of the erosion in the last 100 years[49] was possible to map only in the area of the temporary ballast storage place, where activities were further carried out (a visible fact on historical maps and aerial photographs and orthophotos) and less in other areas (beneath the fortifications or towards west)
6. The only river bank that was not affected by the erosion is that below the Western fortification and the only explanation is that there were no exploitation works at the base of the loess cliff. The rest of the river banks and loess cliffs were affected by different anthropogenic activities and thus destabilised.

These arguments made us draw the conclusion that, although there are some elements to support landscape changes, topoclimatic variation and fluctuation in the hydrologic regime, these are insufficient to prove that they have influenced the erosion of the loessoid cliff from the Troesmis site[50]. If this cliff was affected by erosion, then other factors must have been responsible for this action. Based on the comparison between the topographic plans of the General Staff from 1880-1884, with a scale of 1:10,000 (Annex 1, No. 3), the maps of the Army Geographic Service from 1916, with a scale of 1:100,000 (Annex 1, No. 8) and the orthophotoplans from 2009, although at different scales, it can be noticed the level of changes in the region after draining and damming (Fig. 10). With all these changes, the river banks remained mostly unchanged until present days, not being influenced by these marginal transformations.

[49] See also Rădulescu *et alii* 1969 (*apud* Velea 2012, 43-44).

[50] *cf*. Gavrilă *et alii* 2012, 335. Their hypothesis on flooding of the loessoid cliff can be explained only by the methodological approach. Comparing maps at different scale (large scale maps with small scale maps) often generates errors, especially when high precision measuring is conducted based on the cartographic material.

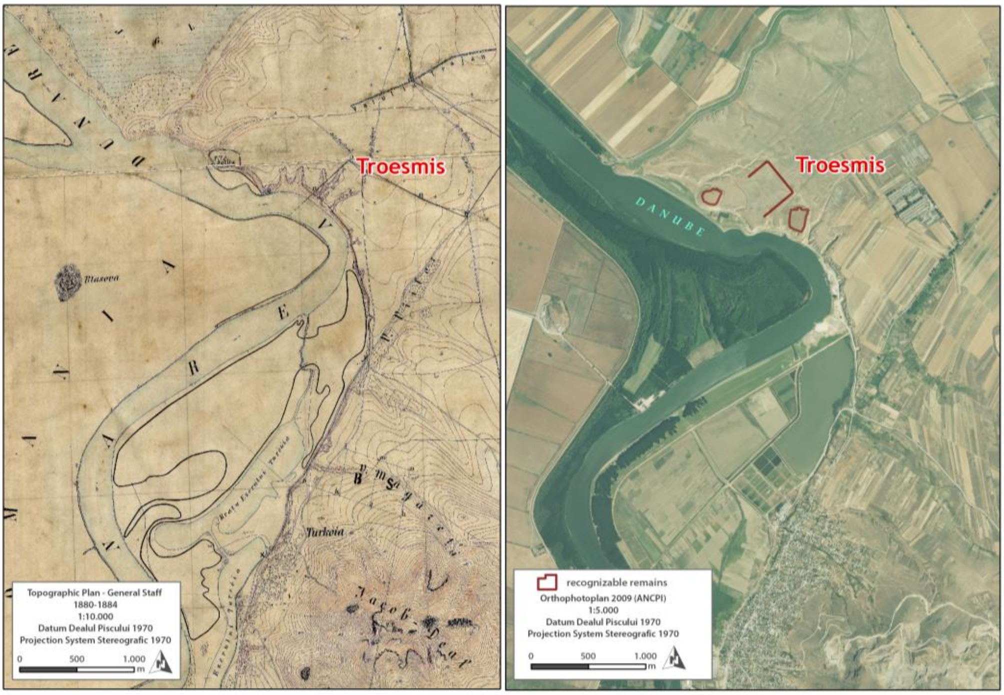

Fig. 10. Comparative details between the topographic plans from 1880-1884, scale of 1:10,000 and the orthophoto from 2009, scale of 1:5,000.

The erosion of the right river bank of Danube and the anthropogenic impact on the Troesmis ancient fortification

The Troesmis site is placed on a loessoid deposit varying between 20 and 30 meters, placed on the right river bank of Danube. We have previously shown that the necessary improvements of Insula Mare a Brăilei have not affected directly the evolution of the river bank. Not even the discharge fluctuations of the Danube, which rose after the improvements in the ’70s, made a significant contribution to the erosion.

Despite all these, there are clear signs of strong, long-term erosion in some areas. A first question would be why erosion appears only in some sectors of the loess cliff close to the Danube and not along the entire length of the river bank, where the river turns, as it would be the case if the erosion was caused by fluctuations in the Danube water flow?

Field observations and the research on the local activity from the last century have indicated stronger erosion produced by the anthropogenic impact. Otherwise, in the last two centuries, the forests in the Dobruja region suffered important retreats and changes in structure. The forest boundary retreated constantly, leaving room for the anthropogenic steppe[51]. Nowadays, the activities in the area include: granite exploitation (chopping, storage and shipping), grazing, fishing and transportation (transit area for trucks of different weights). The past activities included: limestone exploitation in open quarry (Iglița quarry[52]), quarry related activities: temporary storage place for the ballast, railway transportation (narrow-gauge railway), stone breaking[53], agriculture, grazing, zootechnical farm (pig farm), water pumping for agricultural activities, fishing.

Agricultural activities, grazing, as well as different constructions, some illegally placed near the ancient fortification, caused relief and landscape degradation over time. Thus, the Troesmis site area was affected by the pig farm built near the Eastern fortification, the hydrotechnical improvements, by the exploitations on the road that connects the quarries in Piatra Râioasă, those near the village Greci and those from Iacob-Deal with the river bank, the construction and maintenance of the narrow-gauge railway (20th century) and the grey limestone exploitation placed at the basis of the loess cliff, beneath the ancient fortifications (Fig. 11). The inadequate exploration and unsystematic investigation of the archaeological site in the past[54] as well as the intervention of the illegal metal detecting have damaged most of the Troesmis site area.

The total area that is assumed to include the ancient settlements of the Troesmis site is of approximately 506 hectares[55], of which 174 ha were affected by agricultural activities, 42 ha by the pig farm and 3 ha by quarry exploitation. Overall, 219 ha of the total of 506 ha were affected in one way or another.

From all the activities conducted in the area (Fig. 12), grey limestone exploitation in open quarries in the area between the Western Fortification and the Eastern Fortification, under the newly located legionary fortress, had the strongest

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[51] Rădulescu *et alii* 1969 (*apud* Velea 2012, 43-44).

[52] See note 61 below.

[53] After 1900, a stone breaker was installed on the plateau near the Eastern fortification, using materials from the ancient fortification. It was built for the stone quarry in Piatra Râioasă (Ionescu 1904, 115) opened 1920 by Negoiescu (Velea 2012, 127). Unfortunately, the picture of its remains is still presented as part of the ancient fortification - e.g. Gavrilă *et alii* 2012, Fig. 2; http://danubelimesbrand.ro/images/castre/Troesmis/cetateatroesmis2.jpg (08.03.2017).

[54] Between 1865 and 1883, archaeological excavations took place in the Troesmis antique fortification, but at the same time the owner of the land, Desire More, removed stones from the fortification for construction purposes, damaging some of the fortress walls (Brennecke 1870; More, 1882, 240-242; Alexandrescu *et alii* 2016, 30-32).

[55] Alexandrescu, Gugl 2014, 293, Fig.4. The surface was estimated using GIS analysis on the 2012 orthophotos. Prior to the ongoing research project in Troesmis it was known that the Troesmis site was not limited to the area of the still visible fortifications or to the so-called Eastern Fortification - see however the quite puzzling and erroneous discussion by Gavrilă *et alii* 2012.

impact, causing direct losses of archaeological material due to excavations in the loess deposits and from the settlement margins. The estimated volumes are[56]:

- 64,800 m^3 of extracted material from the big quarry on the western side of the legionary fortress;
- 34,020 m^3 of extracted material from the quarry south of the legionary fortress (where a house is placed at the moment);
- 44,100 m^3 of extracted material from the quarry where a sheepfold is located at the moment (east of the legionary fortress - Fig. 14);
- Total=142,920 m^3 of extracted material, including archaeological material from the legionary fortress area.

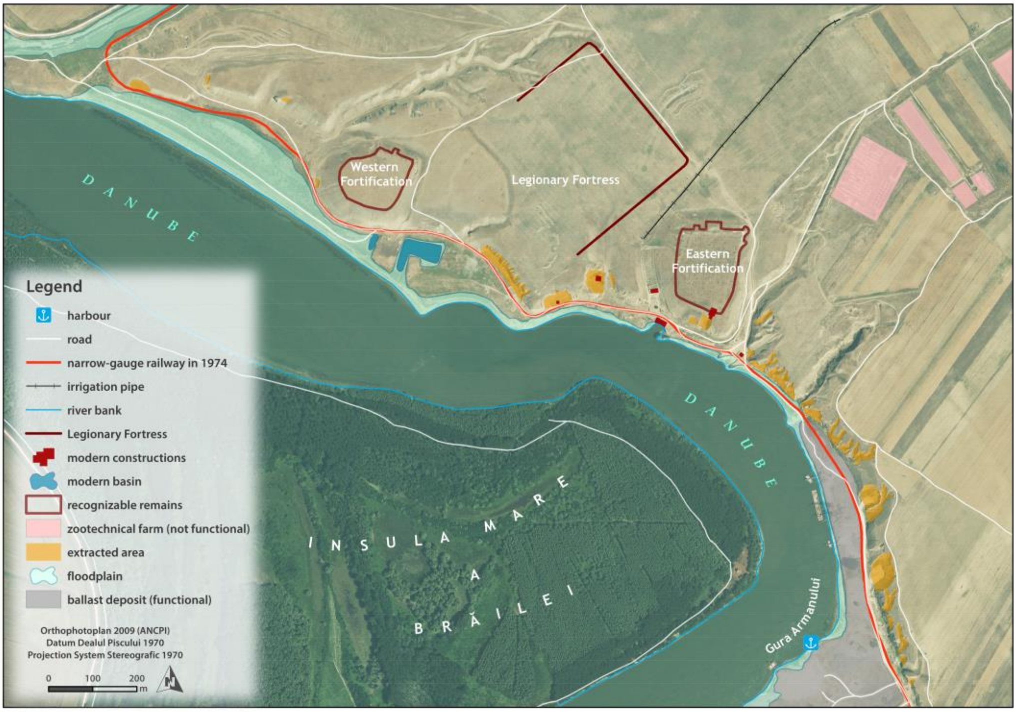

Fig. 11. Anthropogenic elements in the Troesmis site area.

One of the main start questions, regarding the transformations in the area considered to be the western side of the legionary fortress, towards the river, is to be answered only partially[57]. The large anthropogenic intervention, as well as the simple local building material used (not the valuable limestone blocks brought from other regions

[56] The calculations were based on field evaluations and area extractions from the orthophotos.

[57] See note 7 above.

within the province for the Late Roman Eastern Fortification)[58] offered no arguments for the registration of eventual finds, as they were available (and collected) on the river side.

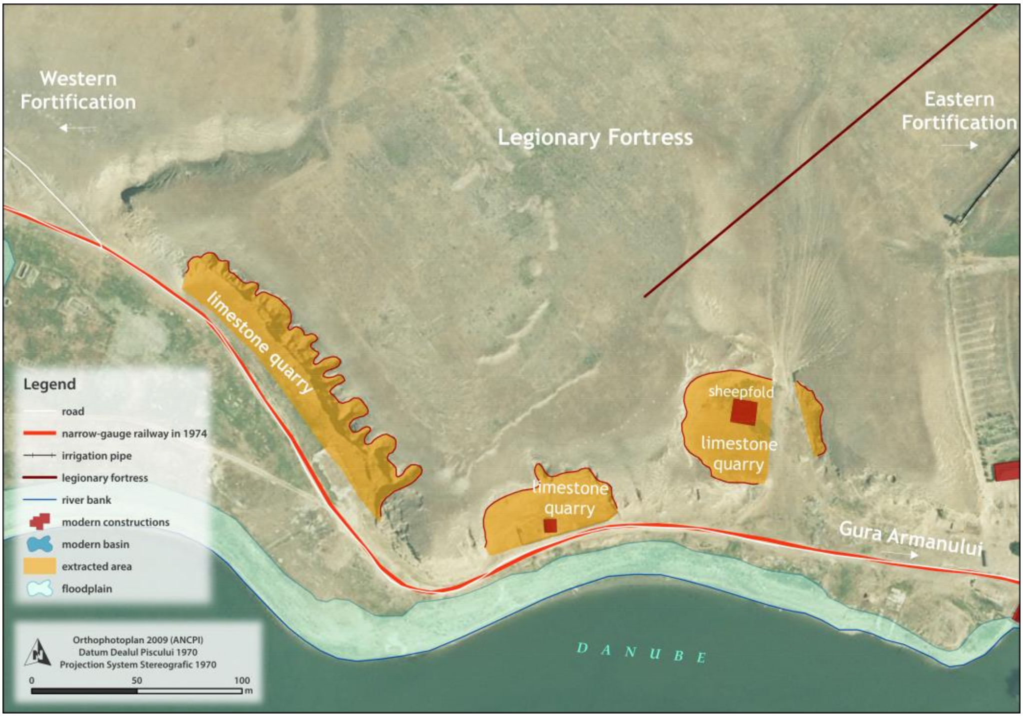

Fig. 12. Detail map of erosion near the area of the Troesmis site area (grey limestone quarries near the legionary fortress).

The Iglița quarry was situated near a hamlet called Iglița, now extinct, on the right side of the Danube river bank. There are no records of the first exploitations, only the mention of a visitor of D. More, W. Brennecke[59] describing the limestone as suitable for construction and for quicklime, but judging by the age of the nearby quarries, it is highly probable that occasionally exploitations would take place after 1877[60]. A later publication describes the rock from the quarry as a Palaeozoic grey-yellowish limestone, with compact, sugar like structure, exposed in thick beds of 0.50 to 0.80 meters[61]. The limestone used to be extracted manually and processed for raw and broken stone. The stone could be extracted in huge blocks for monumental and

58 Alexandrescu *et alii* 2016, 159-161.

59 Brennecke 1870, 66; Velea 2012, 120-121.

60 Velea 2012, 63 and 120.

61 Pîrvu 1964, 185.

decorative works. The quarry had good conditions for exploitation as the transportation was made by barges on the Danube[62].

Fig. 13. Photos of the modern time grey limestone quarries that damaged the sector near the legionary fortress.

After 1900, near the quarry, a narrow-gauge railway would be constructed[63], being extended alongside the quarry and the right river bank of Danube after 1940. In 1928, Iglița quarry was still active. From Iacob-Deal quarry gravel was transported on the narrow-gauge railway down to Gura Armanului in order to be loaded on the barge[64]. In 1940, Cantuniari publishes a series of photographs with the narrow-gauge railway from Iacob-Deal to Iglița, which would pass beneath the Danube's loess cliff; the line must have been extended in order to serve the grey limestone quarry from Iglița too[65] (Fig. 6 and 7). In 1981, the quarry was reportedly reopened[66], most

62 Pîrvu 1964, 185.
63 Velea 2003, 103.
64 Pascu 1928, 44.
65 Cantuniari 1940, 784.
66 Pîrvu 1964, 185; Mihăilescu-Grigore 1981, 333.

probably with occasional exploitation. Nowadays the limestone is no longer extracted from the quarry (Fig. 13 and 14).

Fig. 14. Photos of the modern time grey limestone quarries that damaged the sector near the legionary fortress.

The lithological characteristics are also important for the Troesmis area. The fortifications lie on a loessoid deposit that is 20 to 30 meters thickness (above the grey limestone deposits)[67]. The loess can resist for long if it is not sectioned. Once sectioned, it has the tendency to separate in plates/pieces (breaking vertically) and to erode due to surface erosion and water from precipitations[68]. At the moment, the area of the legionary fortress is endangered by the active erosion triggered by the limestone excavations (Fig. 15).

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67 Geologic Map, 1880, 1888, scale 1:200,000. See also Alexandrescu *et alii* 2016, Fig. 1 (Lithologic map of the Măcin-Greci-Cerna area, scale of 1:100,000).

68 Conea 1970, 43, 55.

Fig. 15. Archaeological materials falling apart from the loess cliff (Legionary fortress) as a consequence of quarrying activities and their short- and medium-term consequences

Part of the archaeological materials could have been lost as a consequence of the erosion and loess cliff degradation (Fig. 16). This process is continuing even today and it may risk producing even more damages to archaeological contexts in the future unless constant monitoring and protection measures are taken.

CONCLUSIONS

The analysis of landscape evolution in the area of Troesmis fortification reveals several successive stages of intervention during the last century. Changes to the limitrophe area had a minimum, indirect impact on the archaeological site area, transforming the environment and its further evolution, such as the Danube river course and discharges. The direct changes in the site area had a greater impact, causing losses of archaeological material and damages to the remaining structures. This was caused either by construction of new buildings or the constant activities of rock exploitation and livestock farming in the area.

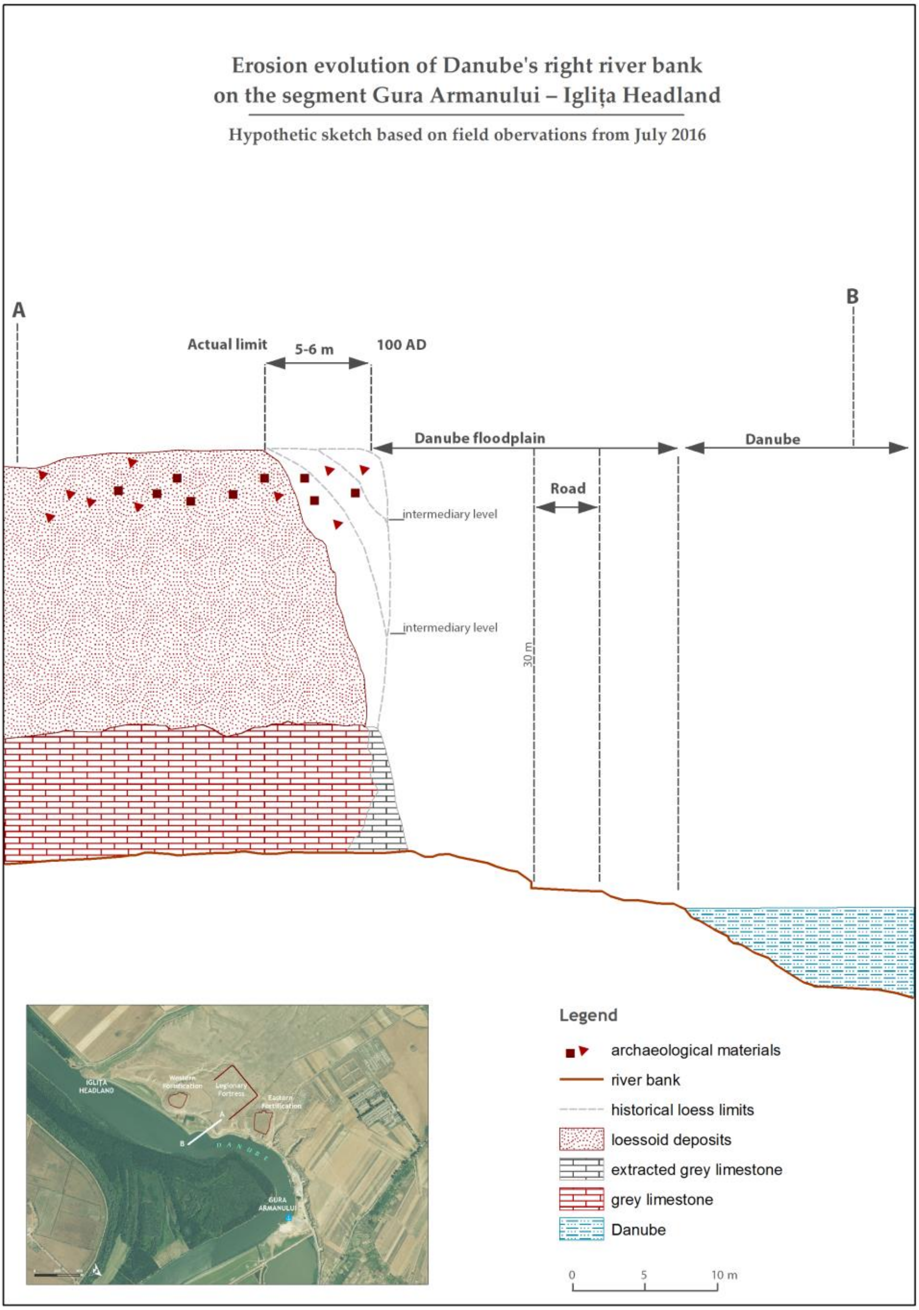

Fig. 16. Evolution of erosion on the Danube right river bank (hypothetical sketch).

Numerous changes and their determinants were verified and mapped using historical maps dated back to the first half of the 19th century. These maps provided support for sustaining the intensification of the activities in the area, including the impact on the archaeological site. Field observations validated the research done, confirming the actual high level of degradation of some segments of the loess cliff on the right side of the Danube, which require the adoption of measures to protect and preserve the archaeological objectives that still exist in the area.

Acknowledgement

This study was made under the project PNII-RU-TE-2014-4-2063: *Natural resources, landscape and ancient settlements in north-western Moesia - case study Troesmis*.

Annex 1. Cartographic materials used in the study.

No	Map/Image	Author	Year	Scale	Details	Fig.
1	Charta Granitelor Munteniei la Dunărea/ Planul linii Dunării (The Plan of Danube Line)	Karl Begenau	1843-1844	≈1:216,000	Library of the Romanian Academy, Maps collection H.II.545, Sheet 12: Brăila	2
2	So-called Szathmari Map	Carol Popp de Szathmári, using the data of the Second Military Survey of the Austrian Army from 1855-1857	1864	1:57,600	Col. XIII, r.3	4
3	Topographic Plan	General Staff	1880-1884	1:10,000	Dobruja, Series XXXV, Col. Y', SE Dobruja, Series XXXVI, Col. Y', NE	3, 10
4	Topographic Map	General Staff	1886	1:50,000	Turcoaia-Pecineaga; Brăila-Măcin	-
5	General Staff Map	General Staff	1887	1:200,000	Galați-Măcin sheet	-
6	Topographic Map	Army Geographic Institute	1900	1:50,000	Sheets: Turcoaia Series XVIII, Col. Z	4
7	Austrian Maps	The 3rd Military Mapping Survey-Habsburg Empire	1910	1:200,000	Galați sheet (46_45)	-
8	Topographic Map	Army Geographic Service	1916	1:100,000	Brăila Series X, Col. M	-
9	Romanian Atlas	Cartographic Institute "Unirea" Brașov	1928	1:200,000	Tulcea County	-
10	Planurile Directoare de Tragere (Romanian maps under 'Lambert-Cholesky' projection system	Army Geographic Service	1916-1959	1:20,000	5351 - Ezerul Turcoaia (1953); 5352 - Carcaliu (1940)	5

No	Map/Image	Author	Year	Scale	Details	Fig.
11	Topographic map	D.T.M.	1962	1:25,000	Turcoaia L-35-105-C-b Sheet	5
12	Aerial photographs	D.T.M.	1960-1970	1:5,000	Turcoaia area	8
13	Topographic Plan	D.T.M.	1970-1974	1:5,000	Sheets: L-35-105-C-b-1-II, L-35-105-C-b-1-IV, L-35-105-C-b-2-I, L-35-105-C-b-2-III,	-
14	Topographic Map	D.T.M.	1981	1:25,000	Sheet L-35-105-L-C-b	-
15	Geologic Map	Geological and Geophysical Institute	1980/1988	1:200,000	Sheets: L-35-105-A (Măcin), L-35-105-B (Niculițel), L-35-105-C (Peceneaga), L-35-105-D (Priopcea)	-
16	Orthophotoplans	ANCPI	2005	1:5,000	Turcoaia area	9
17	Orthophotoplans	ANCPI	2009	1:5,000	Turcoaia area	1, 8-12, 16

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