

A changing landscape

Archaeological remote sensing of Medulin Bay, Istria, Croatia

Nives Doneus – Michael Doneus

Abstract Landscapes reflect societies and as such are highly dynamic. Social change can therefore not only be read in the emergence and decline of settlement patterns, finds or monuments, but also in everyday landscapes. This paper presents the interpretation of remote sensing data (aerial photographs and airborne laser scanning) of the Premantura Peninsula in the bay of Medulin at the southern tip of Istria (Croatia). Our diachronic analysis revealed numerous archaeological structures that do not fit into the typical archaeological concept of a ‘site’, such as a variety of agricultural remains from the Roman period and more recent times. The interventions of various military forces in the 19th and 20th centuries are also part of the regional landscape and have left their mark. In the case of Premantura, there is a clear link between the agricultural remains and the historical events, economic developments and armed conflicts. In this sense, the landscapes of Premantura reflect the eventful history of Istria on a small scale.

Keywords airborne laser scanning, aerial archaeology, Mediterranean archaeology, archaeological prospection, Roman land use

Introduction

Archaeological sites are embedded in landscapes. They are not isolated entities scattered across an otherwise unused or archaeologically empty space. Settlement activities cannot be spatially reduced to a ‘site’ as they are recognisable not only by the remains of buildings, but also by the traces left in the environment during the use for agriculture, burial, religious practices, or infrastructure. Settlements are consequently embedded in landscapes that are consciously or unconsciously shaped by their inhabitants in their daily lives. Landscapes can therefore be seen as a “reflection of society”¹ and are difficult to incorporate into “site and off-site” concepts². As Matthew Johnson puts it, “...to mark ‘archaeological sites’ as dots on a map ... would be to do its character

1 Meinig 1979a, 229.

2 Banning 2002; Bintliff 2000; Rossignol – Wandsnider 1991.

serious violence”³. Landscapes thus provide the essential context for our archaeological research to understand past human activities.

Whether and to what extent archaeologists can record landscapes with their diverse traces of human occupation depends not only on their adequate preservation, but also requires that we actually look for them. Although the study of (Roman) landscapes can imply a wide range of meanings for the term ‘landscape’, what many definitions have in common is that they see landscape as a spatial category⁴. The spatial dimension of a landscape is particularly well captured by archaeological prospection, giving us the opportunity to see ‘further and better’.

Personal interests are a key to understanding landscapes: people see and understand their contemporary landscape from completely different perspectives⁵. Günther Schörner also notes this when he states in his Vienna Orme and Pesa Valley project that “it has to be negated that there was ever a (single type of) Roman landscape *per se*”⁶. This also applies to archaeologists, whose specific professional interests and research perspectives shape the interpretation of ‘their’ archaeological landscapes. The case of Medulin Bay presented here is such an example.

Medulin Bay is the location of a wide range of human traces. However, so far it is mainly seen as a region with large Roman sites, located a few kilometres south of the town of Pula. The research of Roman monuments, epigraphic and written sources provide a fairly detailed picture of the Roman presence in Istria⁷. The bay of Medulin is best known for Roman architecture and the *villae maritimae* on the Vižula peninsula⁸. Vižula was also in the focus of the EU-funded project “Archaeological Park Vižula”⁹ with the aim of preserving and presenting the site to the public. The project has enabled the acquisition of remote sensing data by means of Airborne Laser Scanning of Medulin Bay. Overall, the interpretation of 24 km² of ALS-derived land and underwater terrain models revealed features ranging from prehistoric hilltop settlements to modern military installations. Due to this diversity and the large time span of the results, they are presented in separate publications. While the research results on the villa architecture of Vižula have already been completed¹⁰, the evaluation of Roman agricultural relics and their connection with the *villae maritimae* of the Late Republic and the early Imperial period will appear in a separate publication¹¹. The present publication focuses on a diachronic view that reveals the range of landscapes of the Premantura Peninsula, the western border of Medulin Bay.

3 Johnson 2007, XV.

4 E.g., Schörner 2022.

5 Meinig 1979b.

6 Schörner 2022, 190.

7 E.g., Matijašić 1998; Starac 1999; Marchiori 2010; Bowden 2018.

8 Doneus et al. 2020a.

9 European Regional Development Fund, Competitiveness and Cohesion OP 2014–2020.

10 Doneus et al. 2020a.

11 Doneus – Doneus 2024.

Case study area: Medulin Bay

Istria, the northern Adriatic Peninsula, lies between the Gulf of Trieste (Italy), Piran Bay (Slovenia) and the Kvarner Bay (Croatia). Along with the port of Pula and the Bay of Raša, Medulin Bay is one of the largest natural anchorages in Istria (Fig. 1). The bay is located at the southernmost tip of the Istrian Peninsula and divided into an outer and an inner part. Few small uninhabited islands are scattered in the bay.

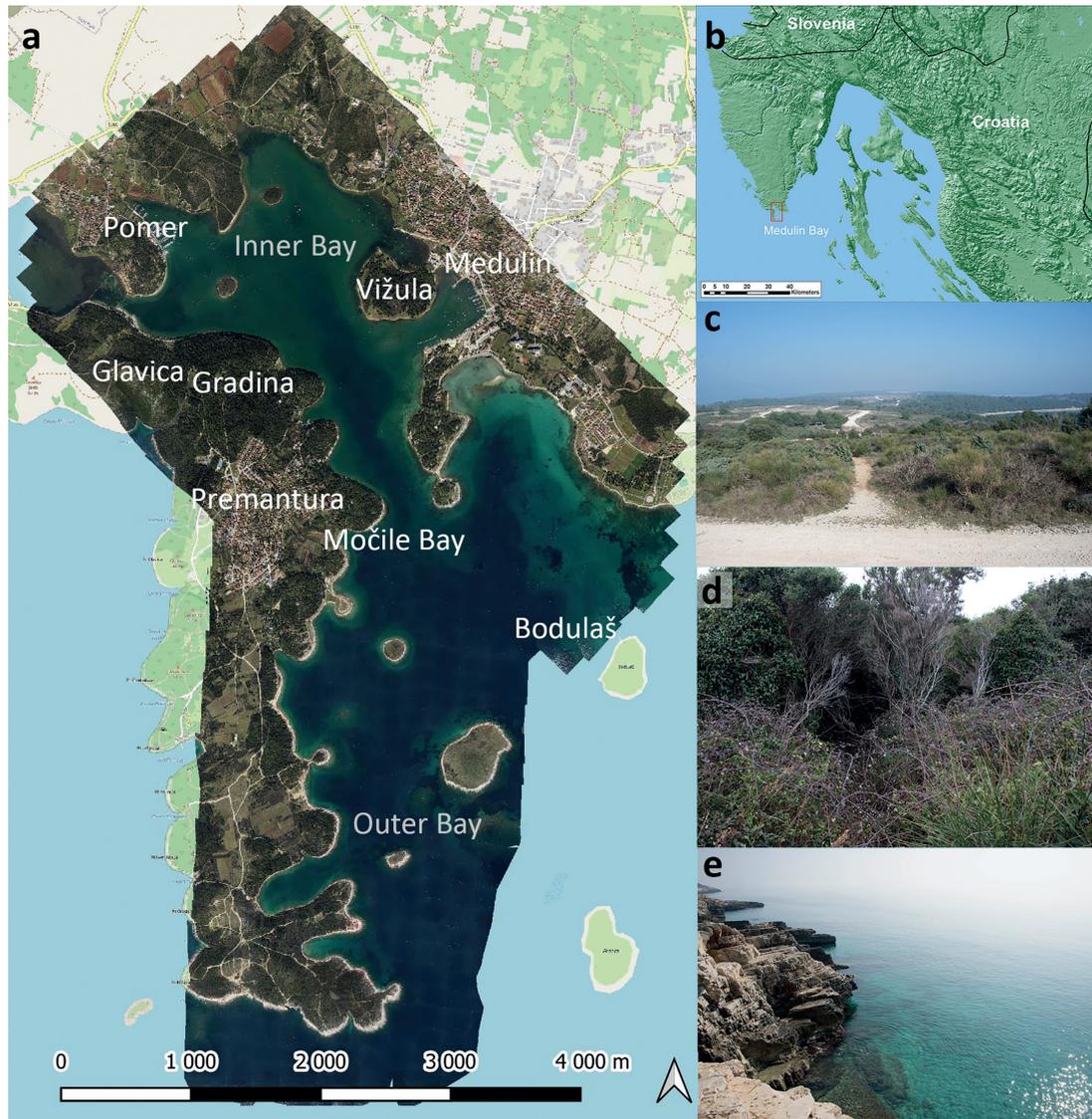


Fig. 1 (a) Orthophoto mosaic of the scanned area. The aerial photographs were acquired simultaneously with the laser scan in March 2018. Background map from Openstreetmap.org. (b) Map of the northern Adriatic coast indicating the location of the Medulin Bay (red rectangle). Data Source: SRTM. North is up. (c–e) On-site photographs of the scanned area from February 2019. (c) low to medium height macchia overgrowing large parts of the areas with interspersed fields (d) area with extremely dense and high macchia (e) coastal area with partly very steep slopes (M. Doneus, N. Doneus)

To the west, the Medulin Bay is bordered by the Premantura Peninsula (also called Kamenjak), and to the north and east by the settlements of Pomer and Medulin. With its length of approx. 6 km and width of approx. 1 km, Premantura is largely unbuilt. The relief is mostly flat with some elevations between 20 and 80 m above sea level. Limestone terraces and steep slopes towards the coast are characteristic for the southern part of the peninsula. The vegetation cover consists of open areas (agricultural and grassland), olive orchards, as well as dense and evergreen maquis vegetation.

Methodology: Airborne Laser Scanning

Airborne laser scanning works on the principle of Light Detection And Ranging (LiDAR). It is an active remote sensing technique in which laser scanners emit infrared (1064 or 1550 nm) or green (532 nm) light pulses onto a target surface, the backscattered echoes of which are recorded¹². A laser scan thus results in dense point clouds of the scanned surfaces. These are subsequently classified, whereby in archaeology the classes ‘ground’ (e.g., terrain points) and ‘building’ are of particular interest. The entire point cloud is reduced (e.g., filtered) to these two classes, which are used to calculate a so-called digital feature model (DFM)¹³.

The ability of laser scanners to detect surfaces even under dense vegetation has made them a viable tool for detecting archaeological and palaeoecological features in forests and dense maquis¹⁴. For coastal and/or submerged settlement sites, the use of scanners with green lasers and small footprints is necessary. While infrared light is absorbed by clear water, it is penetrated by green light and thus makes it possible to measure the underwater topography in high detail (= Airborne Laser Bathymetry, ALB). In the clear sea of the Croatian coast, this technique managed to reach an indentation depth of about 10 metres and made it possible to combine the topography of the underwater and land surfaces as well as the intertidal zone and to generate digital terrain models with a grid width of 0.5 m¹⁵.

As part of the “Archaeological Park Vižula” project, a 24 km² survey was carried out in March 2018 covering the entire Medulin Bay¹⁶ (Fig. 1). During the interpretation, historical information, different sets of (historical) aerial photographs and a range of available (historical) maps spanning the period from 1821 to today were used. The interpretation was accompanied by field visits in July 2018 and February 2019.

12 E.g., Grussenmeyer et al. 2016.

13 Štular et al. 2021; Pingel et al. 2015.

14 See e.g., for Istria Popović et al. 2021; Bernardini – Vinci 2020.

15 Menna et al. 2018; Doneus et al. 2013.

16 Details on the scanning and processing parameters can be found in Doneus et al. 2020b.

Results

The original intention of the large-scale ALS survey was to embed the architecture of Vižula in its landscape context. However, the prospection results have also yielded many other outcomes, including settlement remains of different periods as well as agricultural and military traces. These can be categorised functionally and chronologically but can also be seen as faint reminders of past landscapes on the Premantura Peninsula.

Hillforts and settlements

The Premantura Peninsula was settled in the Neolithic period at the latest, with settlement evidence generally comprising surface finds and shallow preserved archaeological layers¹⁷. In contrast, the Bronze and Iron Age settlements are clearly more tangible and include settlements in the low relief as well as hillforts¹⁸. The ALS survey was able

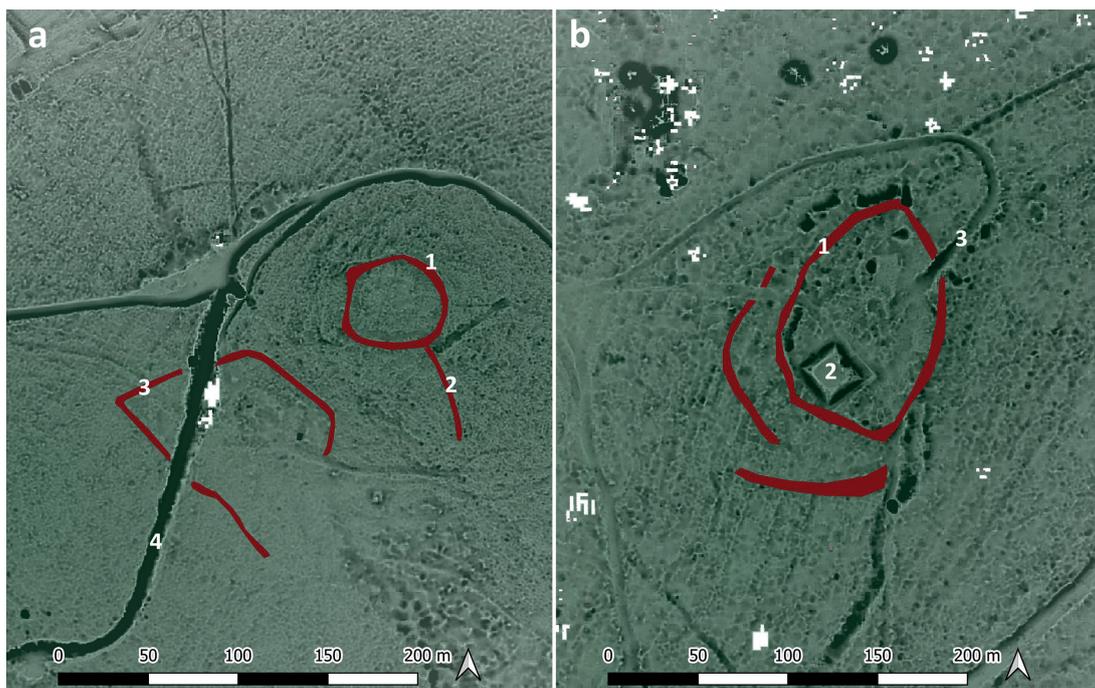


Fig. 2 Interpretation of hillforts. (a) Glavica. 1: rampart, 2: former dry stone wall, 3: D-shaped field enclosure, 4: military road build at the end of the 19th century. (b) Gradina. 1: Ramparts depicted as red lines. 2: modern military instalment along with (3) the associated road, which has caused partial destruction of the ramparts. Visualization: Positive Openness ($r = 20$) (M. Doneus, N. Doneus)

17 Komšo 2004.

18 Buršić-Matijašić 2013.

to document the two topographically most prominent hilltop settlements. The first one is situated at Glavica (Fig. 1a, 2a), 70 m above the sea level¹⁹. In the ALS-data, the roughly circular enclosure is well visible. The collapsed rampart or surrounding wall is today between 3 and 6 m wide, has a preserved height of 0.3 to 0.5 m and fortifies an area of approx. 2,500 m² with a presumed entrance in the SW (Fig. 2a-1). A linear structure adjoins the fortification to the SE and might be the remains of a former dry stone wall (Fig. 2a-2).

The second hilltop settlement is Gradina (Fig. 1a, 2b), located some 700 m to the east and almost 80 m above the sea level²⁰. The fortification ramparts are not completely preserved, as the construction of a modern military installation has greatly altered the relief (Fig. 2b-1). It seems that the fortification originally consisted of two ramparts. The inner rampart is oval in shape, with a maximum dimension of 125 × 85 m. To the SW, the inner rampart is preceded by another one.

Just as the hilltop settlements are a clear settlement feature of the Bronze and Iron Ages in the working area, the small and large estates of the Roman period are also unique in their character. Medulin Bay, like the entire Istrian coast, is characterised on the one hand by the emergence of large luxurious estates (*villae maritimae*) from the Late Republican period onwards²¹, as well as by the construction of numerous smaller estates, often specialised in the production of wine or olive oil²². Especially *villae maritimae* have sought the immediate proximity to the sea, either by building the architecture as close as possible to the shore²³ or by shaping the entire coastal section into the desired form²⁴.

Roman settlements on Premantura also fit into this picture. Several small *villae rusticae* are assumed to be located in the interior of the peninsula on the basis of surface finds, although none of them has been investigated so far²⁵. However, the newly discovered submerged architecture in Močile Bay (Fig. 1a) suggests that, following the sites in Pomer²⁶ and Vižula²⁷ (Fig. 1a), another *villa maritima* can be expected here.

19 Buršić-Matijašić 2013, 35.

20 Buršić-Matijašić 2013, 35.

21 E.g., Bowden 2018 quoting older literature.

22 Matijašić 1998.

23 Doneus et al. 2020a.

24 Bowden 2018, Fig. 20.1.

25 Matijašić 1988, 32–33; Jurkić-Girardi 1979.

26 Džin 2011, 98–101.

27 Doneus et al. 2020a; Girardi-Jurkić et al. 2012 and Miholjek 2012 with older literature.

Land parcelling and agricultural relics

Some remnants of former land use can be seen on the ground with the naked eye, e.g. overgrown gardens and abandoned farmland, apparently given up around the middle of the 20th century. However, most of the remaining traces of past land use are only recognisable from the survey data. The analysis of ALS data and aerial photographs reveals two groups of relics: small- and large-scale parcelling and traces of cultivation.

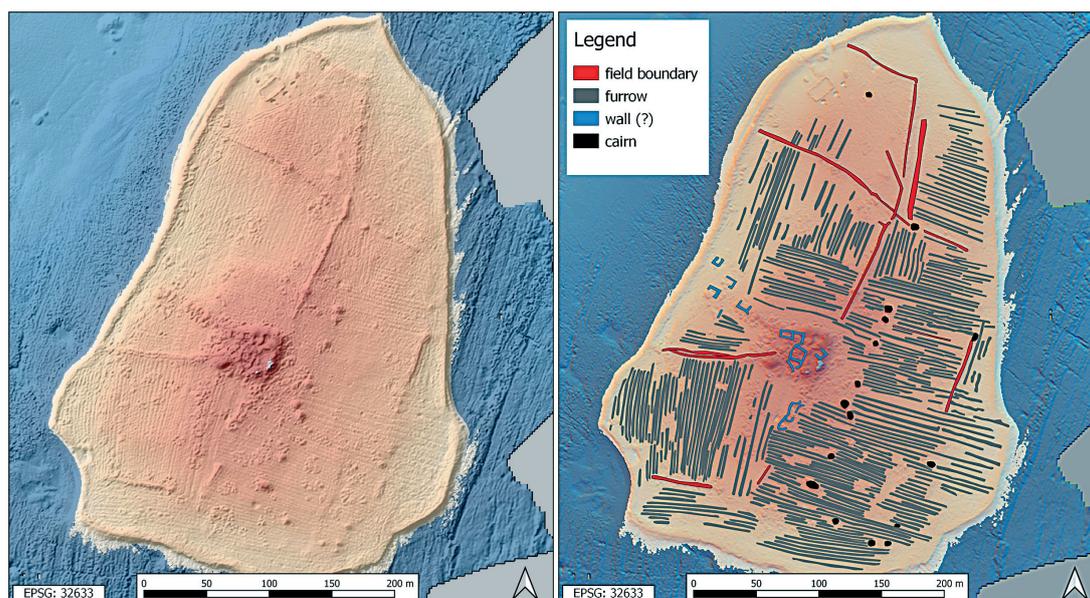


Fig. 3 Island of Bodulaš. The hillshade (overlay by a color-coded height data) shows numerous parallel linear furrows arranged in groups (M. Doneus, N. Doneus)

Traces of the small (single) and large-scale parcelling were found in several locations in the working area. As an example, we would like to mention only the roughly D-shaped enclosure next to the hilltop settlement of Glavica (Fig. 2/3). The elevation, 2 m wide and 0.1–0.25 m high, is probably the last remnant of a dry stone wall, which enclosed an area of approx. 74×100 m. Its topographical location in a valley between two hilltops rules out the function of a former fortification. Stratigraphically, it is the oldest feature being intersected by several paths including a road built at the beginning of the 20th century by the Austro-Hungarian Army. As further chronological indications are currently lacking, the enclosure cannot be dated precisely, which is often the case with single enclosures, as without the connection to a larger system, a dating approach is also missing.

Traces of cultivation have been preserved on the island of Bodulaš (Fig. 1a, 3). With an area of 0.12 km², it is a small island, now uninhabited, but occasionally used for grazing. Except for two small areas in the north and centre of the island, a pattern of parallel lines can be seen. These average about 1 metre wide, up to 150 metres long and

between 2.3 and 3.8 metres apart (measured from centre to centre). However, it is not clear from the ALS data whether the lines, which appear to be a combination of slight rises and depressions, actually represent narrow (1 m wide) ditches below the general relief, or wider (2 m wide) banks above the general relief, or both. According to the local relief model, the 'ditches' are only lowered by 5 to 10 cm, while the areas between the 'banks' are raised by 10 cm.

The linear structures are aligned north-south and east-west respectively in larger irregular blocks (similar to plots). The island also appears to be divided into several areas by other more massive linear features. These banks are between 1.5 and 3 m wide and have preserved heights between 10 and 50 cm. At first glance they appear to separate the irregular blocks from the ditches. On closer inspection, at least some of them intersect the ditches and are therefore younger. Stones were found along these lines during a field survey. It was not possible to determine whether these were stone markers or the remains of dry stone walls. In the eastern part of the island, several cairns with diameters of 5 to 10 m and heights of 0.3 to 1 m are arranged in a linear pattern. They also appear to be of recent origin.

The results bear a certain resemblance to ridge and furrow pattern found in large parts of Europe²⁸. However, a similar pattern was also found on the Vižula Peninsula, where it is possibly related to the Roman agrarian or horticulturally practices²⁹. Therefore, it is currently not possible to date the origin of the cultivation relicts on Bodulaš, even though Roman finds and features are assumed on the island³⁰.

Among the most interesting features of past land cultivation, however, are the numerous planting pits³¹ documented to the north, west and south of the villa maritima in Močile Bay (Fig. 1a). They are in some areas combined with grid-shaped parcelling and can be interpreted as relics of Roman agriculture in the form of orchards/lemon groves or tree nurseries³².

Military facilities and positions from the 19th and 20th centuries

From the middle of the 19th century, the town of Pula, situated some 10 km northwest of Medulin Bay, gained strategic importance for the Austrian Empire³³. In this context, the city harbour was assigned a significant military role, which in subsequent decades lead to the expansion of the harbour and building of military forts and accompanying facilities³⁴. These political developments had a formative influence on the entire region e.g., the population of Pula multiplied due to large construction projects and the

28 Sittler 2004.

29 Doneus et al. 2020a, Fig. 24.

30 Pers. comm. Kristina Džin.

31 Initial discovery and first publication by Matijašić 2012.

32 Detailed description in Doneus – Doneus 2024.

33 E.g., Piplović 1990.

34 E.g., Krizmanić 2009.

number of military personnel³⁵. The process of expanding military facilities in the region continued seamlessly into the period of World War I and left its mark also on the Premantura³⁶.

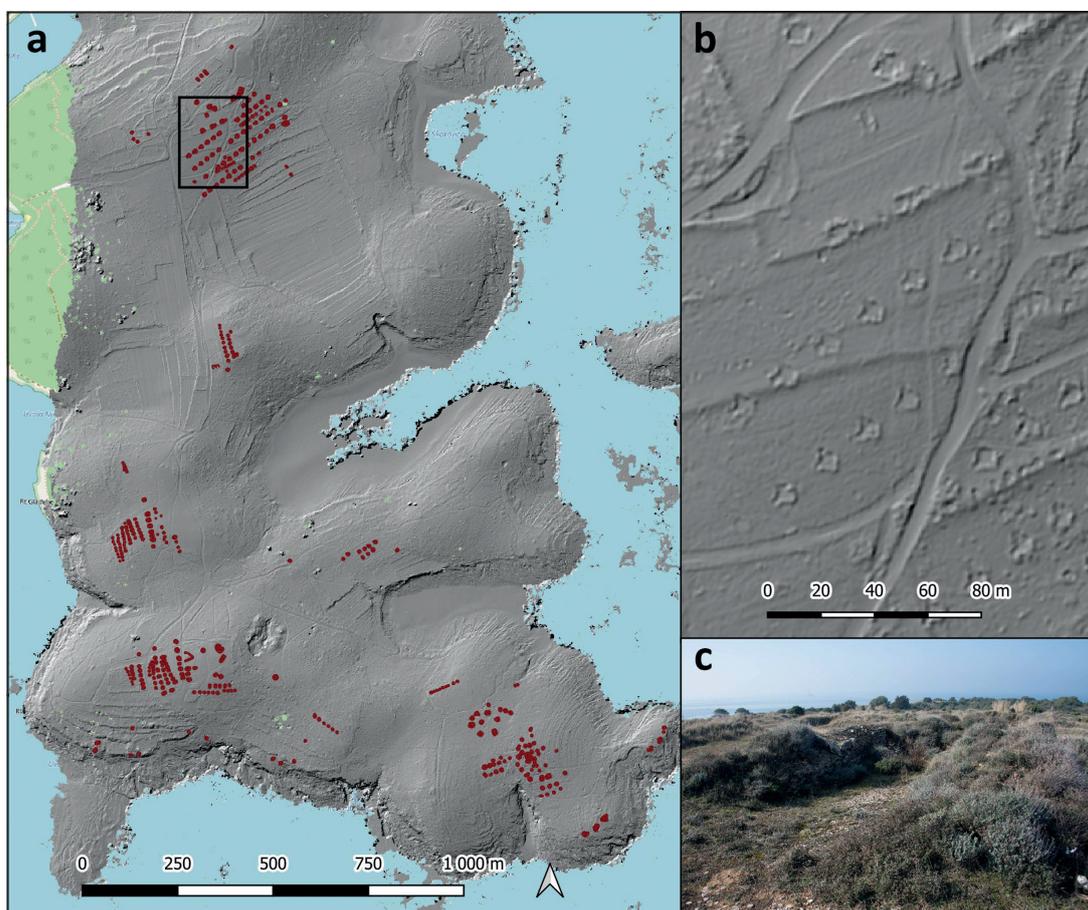


Fig. 4 (a) Artillery positions (red) from different periods cover large parts of southern Premantura. (b) Artillery positions from the 1960s as seen in hillshade. After the end of the exercises, the cannons were removed, but the landscape, shaped by military practices, was no longer usable for agriculture. Extent is marked by the black rectangle in (a). (c) On-site photograph of one of the artillery positions from February 2019 (M. Doneus, N. Doneus)

First military exercises were held on Premantura already in 1884, under the supervision of Emperor Franz Joseph³⁷. The first facilities were built before the outbreak of World War I and include military units like mortar or coastal gun batteries and infantry bunkers as on Gradina (Fig. 2b)³⁸. Military facilities and positions of the Austro-Hungarian

35 Perović 2006.

36 Bader 2017.

37 Bader 2017, 168.

38 Bader 2017, 128–151.

Monarchy continued to be used during the World War II and were in some cases expanded. After 1945, parts of the peninsula were used by the Yugoslav army for military exercises³⁹. As a consequence of these exercises, hundreds of cannons were dug in, which is still visible in the landscape today by pits measuring approx. 10 × 10 m (Fig. 4). Since the 1990s, the peninsula is also used by the Croatian armed forces for tactical exercises, most recently in April 2022⁴⁰.

Discussion

The results of the remote sensing data interpretation in combination with site visits and the already existing archaeological information show a slightly different picture of the region compared to the previous archaeological assessments. Numerous traces filling the so-called 'off-site areas' are evidence that the landscape of the Premantura Peninsula has been subjected to various regimes of uses. We can therefore assume – in the sense of the definition of landscape⁴¹ – a co-evolution between landscape and society, where each new generation sees and understands its landscape from a different point of view⁴². Diachronically, the following narrative could be constructed:

(1) The few data we have from Bronze and Iron Ages show a **fortified landscape** of hill forts. Fortified sites were not only found on hills in Premantura, but are a general phenomenon of that period, which seemed to dominate the landscape in Istria and far beyond. The elements of parcelling and demarcation of arable and pastureland could not be proven by the prospecting results, although other field methods are likely to provide this evidence in the future.

(2) In the Roman period the landscape of Premantura changes, as for the settlements the flat and coastal relief is preferred to the higher grounds. But even greater changes arise from a **landscape of industrial agriculture**. Large Roman estates (*villae maritimae*), dating from the 1st century BC to the 2nd century AD, resemble each other not only in the selection of the near-shore location for the main building, but also in the fact that the *villae* usually housed a variety of facilities that served the economic benefit. One of the most important products of this period in Istria was presumably olive oil⁴³, although agricultural relics that would prove such large-scale agricultural production have not been found. ALS results from Medulin Bay can now close this gap, after extensive traces of agriculture/horticulture were found on Premantura⁴⁴. Based

39 Bader 2017, 168–179.

40 <https://www.jutarnji.hr/vijesti/hrvatska/milanovic-na-rtu-kamenjak-pratio-vojnu-vjezbu-stit-22-gadali-su-se-ciljevi-u-zracnom-prostoru-15181970> (15. 08. 2023).

41 E.g., Schörner 2022; Doneus 2013.

42 Meinig 1979b.

43 Matijašić 1998.

44 Doneus – Doneus 2024.

on the current evidence it is assumed that thousands of planting pits in a regular pattern extend along the peninsula, sometimes combined with a dry stone wall grids. Here we are probably dealing with “the so-called villa system of agriculture, characterized by intensively cultivated estates that produced wine and other cash crops”⁴⁵. In Premantura, the orchards or nurseries, with a minimum total size of 20 ha, were most likely cultivated by the villa maritima in Močile Bay.

(3) It can be assumed that the agricultural production, as was possible in the first two centuries AD, could no longer be maintained from Late Antiquity onwards at the latest, as neither the required labour force, transport networks nor market regions were available to the same extent. Whether Premantura actually faced a decline in population from Late Antiquity onwards, or the lack of archaeological and historical sources is only misleading us into this picture, is unclear. Apart from underwater finds that indicate anchorages and the associated maritime traffic⁴⁶, a wrecked ship of the 5th century⁴⁷, and a presumed Byzantine settlement/fortress⁴⁸, there are practically no sources for the following centuries on Premantura. This also makes it impossible to ‘name’ the Premantura landscapes of the early Middle Ages. The early Middle Ages are described as a relatively peaceful period for southern Istria and M. Levak also suggests, that from the Late Antiquity onwards there is a tendency for farms to stop the agricultural overproduction for export, and instead pursue the cultivation of a wide variety of products, which were either used for personal consumption or sold in the region⁴⁹.

(4) The following centuries in Istria were marked by military conflicts, Turkish invasions, pandemics and famine, and the population of Istria suffered greatly. For the city of Pula M. Bertoša summarised the historical events between the 13th and 16th centuries under the title “Centuries of wars and decline”⁵⁰. All these events have led to a great loss of population, which also affected the Medulin region, as can be observed from written sources from the 12th century onwards⁵¹. M. Bertoša also assumes that around 1580 Premantura was not populated⁵², which can be seen as a result of the above-mentioned crises. From the 15th century onwards, the Republic of Venice increasingly attempted to settle new residents in Istria, which was also reflected in the founding of Premantura in 1585. This foundation, “as one of the greatest successes of the Venetian settlement policy in Istria”⁵³, also contributes to the development of an **agricultural landscape** with a focus on agriculture, viticulture and animal husbandry on a small-scale. It is quite possible that these traces are visible in the ALS-based terrain model,

45 Kehoe 2006, 300.

46 Vrsalović 2011, 67.

47 Boetto et al. 2022.

48 Matijašić 2007.

49 Levak 2013.

50 Bertoša, 2006, 45.

51 Bertoša 2013a.

52 Bertoša 2013b, 118.

53 Bertoša 2013b, 121.

without, however, revealing their true age. From the 18th century onwards, agriculture is evident on historical maps (Fig. 5). While in the oldest map from the 1820s (Second Military Survey of the Habsburg Empire 1821–1824) about 20% of the area of Premantura is classified as ‘woodland’, in the following years the wooded areas decrease in favour of agricultural land. The Third Military Survey of the Habsburg Empire 1869–1887 shows a slightly higher proportion of agricultural land (25%), with a maximum around the middle of the 20th century and a subsequent decrease. The extent of the built-up area has multiplied over the last 150 years. According to rough measurements in the GIS, the village of Premantura has expanded from about 5 ha around 1820 to its current area of 58 ha. Also, larger forested areas are used today as campsites.

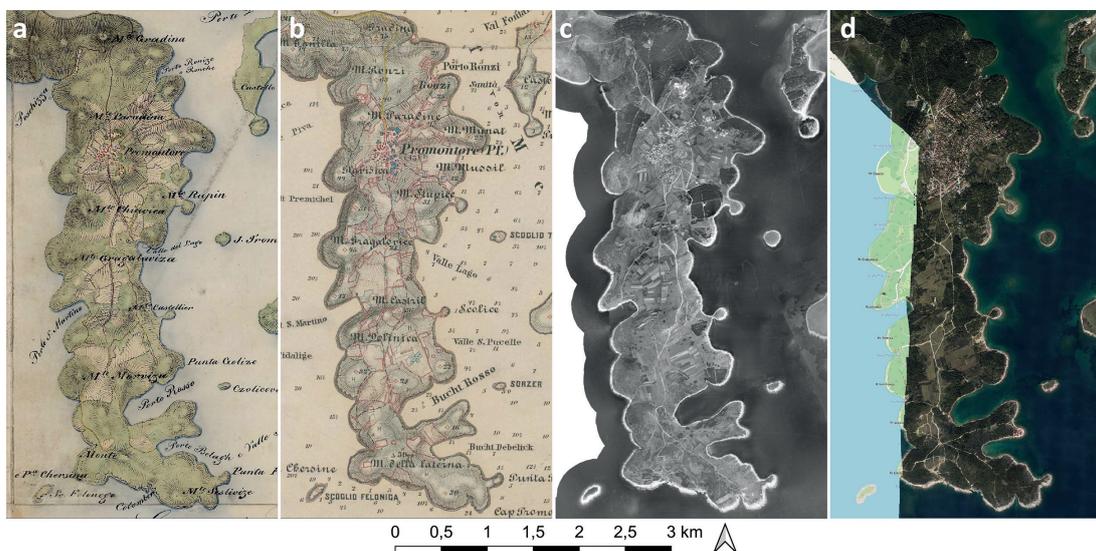


Fig. 5 Historical maps and orthophotographs of Premantura showing the changing extent of woodland and built areas. (a) Second Military Survey of the Habsburg Empire 1821–1824 (Austrian State Archives, GZ: 2024-0.115.664), (b) Third Military Survey of the Habsburg Empire 1869–1887 (Austrian State Archives, GZ: 2024-0.115.664), (c) Digital Orthophoto Map (photographs from the 1950s (State Geodetic Administration Geoportal/Geoportal Državne geodetske uprave – geoportal.dgu.hr), (d) orthophoto mosaic from 2018 (M. Doneus)

(5) Beginning with 1884 parts of Premantura became a **military landscape**. Starting with the Austrian military, positions and bunkers were built in the landscape at strategically important locations and used later during the World War II. Its end is in Istria also associated with an exodus of the local population, which led to a partly abandonment of agriculture. The military exercises that have been taking place on Premantura since the 1960s have contributed to the fact that agriculture has not been resumed, as numerous traces of gun emplacements, bunkers and trenches make such use today impossible.

(6) Today the area is largely a **landscape of tourism**. Part of the Premantura Peninsula has been protected since 1996, with a goal of coordinated maintenance and use in accordance with the principles of the sustainable use of nature⁵⁴. Although the area is close to the military training grounds, the protection may have contributed a little to the peninsula not being completely built over with infrastructures for the tourism industry. Premantura belongs to the municipality of Medulin, which recorded almost 3 million overnight stays in 2022. What these figures mean for the landscape around Medulin Bay and how diverse the interventions in the relief are, can easily be recognised in the ALS data. This is particularly evident in areas of camping sites and also, the highest elevation near Medulin is no longer of natural origin but marks the local waste disposal site. The structures resulting from the tourism industry will remain in the ALS data and remind us for a long time of its peak in the 21st century.

Conclusio

Landscapes are highly dynamic. Historical transformations in Istria can therefore be traced not only in archaeological and historical sources but also in small-scale landscapes like Premantura where a correlation between the agricultural relics and historical events, economic developments and armed conflicts can be seen. This can be achieved by evaluating all relics recorded in the ALS-based terrain models data, rather than just the so called archaeological 'sites'. In this way, the prospecting results are not reduced to finding new sites, but rather used to narrate a historical picture.

However, this is only possible if a diachronic interpretation is applied, although care should always be taken when using diachronic enumeration of different landscapes. The results of airborne laser scanning can vary, due to different aspects. The nature of the archaeological remains and the natural characteristics of the region play a decisive role in determining whether relevant data can be obtained at all. Additionally, the quality of the data itself is influenced by hardware, software and processing methods. As a consequence, remote sensing methods have important limitations that need to be considered when evaluating a landscape.

In ALS-based terrain and feature models, we can only see those structures that are preserved in the current terrain. This leads to a bias where not all site categories can be detected in the same way. In addition, post-medieval and modern structures are over-represented. We must therefore assume that only a fraction of the relevant remains has survived, and that only some of them have actually been recognised by us.

Therefore, we can only work with these obviously non-representative samples when interpreting landscapes. Additionally, we must be aware that, just as different societies at different times perceive and shape a landscape differently, so we in archaeology have different approaches to the past, too. These depend on the particular strategies

54 For more information visit <https://kamenjak.hr/en/> (15. 08. 2023).

of prospection and excavation, but also on ignorance and on our intellectual baggage, which includes many components, such as socialisation, education, or level of knowledge. Our image of the landscapes of Premantura will therefore change over time. This can be seen as a positive development because science has to evolve, and especially in the archaeological and historical disciplines, history has to be rewritten from one generation to the next.

Acknowledgements

This research was funded in part by the Austrian Science Fund (FWF): <https://doi.org/10.55776/I6039>. For open access purposes, the author has applied a CC BY public copyright license to any author accepted manuscript version arising from this submission.

We would like to thank the Municipality of Medulin for its commitment to supporting archaeological prospection and good cooperation during the project “Archaeological Park Vižula”.

We are very grateful to Kristina Džin, Igor Miholjek, Robert Matijašić and Sara Popović for many discussions about Roman Istria and for their practical help in finding relics and information.

Archaeological prospection always requires support on the site. Here we would like to thank the members of the terrestrial (Klaudija Bartolić Sirotić, Davor Bulić, Zrinka Ettinger Starčić, Ivan Okmaca, Aleksandra Paić, Monika Petrović, Marko Uhač and Elvin Zejnilhodžić) and underwater (Jerko Macura, Ana Skračić, Iva Stojević, Goran Trninić, Kristina Vodička Miholjek and Vesna Zmaić Kralj) excavation teams of Vižula.

During the evaluation of prospection data, we have received support from Gottfried Mandlbürger, Technical University Vienna.

Andrej Bader, the local historian from Medulin, should be thanked for sharing his knowledge about the history of the region with us. It was only with his help possible to correctly name and date the military relics on Premantura.

Bibliography

- Bader 2017** A. Bader, *Kaleidoscope of Premantura. Kaleidoskop von Premantura* (Premantura 2017)
- Banning 2002** E. B. Banning, *Archaeological Survey* (New York 2002)
- Bertoša 2006** M. Bertoša, *Pulska luka u doba Venecije (od XIV. do XVIII. stoljeća)*, in: M. Černi (ed.), *Iz povijesti Pulske luke* (Pula 2006) 44–69
- Bertoša 2013a** M. Bertoša, *Stoljeća Medulina. Od srednjeg vijeka do polovice XIX. stoljeća*, in: A. Bader (ed.), *Monografija Medulin* (Medulin 2013) 92–115
- Bertoša 2013b** M. Bertoša, *Južna Istra (1585.–1797.)*. *Populacijska kriza i naseljavanje*, in: A. Bader (ed.), *Monografija Medulin* (Medulin 2013) 118–141

- Bernardini – Vinci 2020** F. Bernardini – G. Vinci, Archaeological landscape in central northern Istria (Croatia) revealed by airborne LiDAR: from prehistoric sites to Roman Centuriation, *Archaeological and Anthropological Sciences* 12, 2020, 133, <https://doi.org/10.1007/s12520-020-01070-w>
- Bintliff 2000** J. L. Bintliff, The concepts of 'site' and 'off-site' archaeology in surface artefact survey, in: M. Pasquinucci – F. Trément (eds.), *Non-Destructive Techniques Applied to Landscape Archaeology* (Oxford 2000) 200–215
- Boetto et al. 2022** G. Boetto – V. Dumas – I. Koncani Uhač – P. Poveda – M. Uhač, Kasnoantička brodska konstrukcija u uvali Debeljak na rtu Kamenjak (Premantura, Istra), *HistriaA* 52, 2022, 155–186
- Bowden 2018** W. Bowden, Villas of the eastern Adriatic and Ionian coastlands, in: A. Marzano – G. P. R. Métraux (eds.), *The Roman Villa in the Mediterranean Basin: Late Republic to Late Antiquity* (Cambridge 2018) 377–397
- Buršić-Matijašić 2013** K. Buršić-Matijašić, Gradinska naselja, in: A. Bader (ed.), *Monografija Medulin* (Medulin 2013) 32–43
- Doneus 2013** M. Doneus, Die hinterlassene Landschaft – Prospektion und Interpretation in der Landschaftsarchäologie, *MPrähistKomWien* 78 (Vienna 2013)
- Doneus – Doneus 2024** N. Doneus – M. Doneus, Intensively Cultivated Roman Villae Estates: Case Study of Medulin Bay (Istria, Croatia), *Archaeological Prospection*. Special issue: Under-canopy Airborne LiDAR for Archaeological Prospections in the wooded Mediterranean Environment: challenges, best practices and future prospects, *Archaeological Prospection* 31/2, 2024, 75–97, <https://doi.org/10.1002/arp.1933>
- Doneus et al. 2013** M. Doneus – N. Doneus – C. Briese – M. Pregesbauer – G. Mandlbürger – G. Verhoeven, Airborne Laser Bathymetry – Detecting and recording submerged archaeological sites from the air, *JASc* 4, 2013, 2136–2151, <https://doi.org/10.1016/j.jas.2012.12.021>
- Doneus et al. 2020a** N. Doneus – I. Miholjek – K. Džin – M. Doneus – P. Dugonjić – H. Schiel, Archaeological Prospection of Coastal and Submerged Settlement Sites. Re-Evaluation of the Roman Site Complex of Vižula, Croatia, *AAustr* 104, 2020, 253–281, <https://doi.org/10.1553/archaeologia104s235>
- Doneus et al. 2020b** M. Doneus – G. Mandlbürger – N. Doneus, Archaeological Ground Point Filtering of Airborne Laser Scan Derived Point-Clouds in a Difficult Mediterranean Environment, *Journal of Computer Applications in Archaeology* 3/1, 2020, 92–108, <https://doi.org/10.5334/jcaa.44>
- Džin 2011** K. Džin, Rimske vile i uvjeti stanovanja na pulskom ageru. Neki primjeri, *HistriaAnt* 20, 2011, 91–107
- Girardi-Jurkić et al. 2012** V. Girardi-Jurkić – K. Džin – A. Paić – Z. Ettinger Starčić, Vižula kod Medulina. Rezidencijska maritimna vila: istraživačka kampanja 2011., *HistriaAnt* 21, 2012, 509–523

- Grussenmeyer et al. 2016** P. Grussenmeyer – T. Landes – M. Doneus – J. L. Lerma, Basics of Range-Based Modelling Techniques in Cultural Heritage 3D Recording, in: E. Stylianidis – F. Remondino (eds.), 3D Recording, Documentation and Management of Cultural Heritage (Caithness 2016) 305–364
- Johnson 2007** M. Johnson, Ideas of landscape (Oxford 2007)
- Jurkić-Girardi 1979** V. Jurkić-Girardi, Promontore antica, Atti Centro di ricerche storiche – Rovigno 9, 1979, 253–261
- Kehoe 2006** D. P. Kehoe, Landlords and Tenants, in: D. S. Potter (ed.), A companion to the Roman Empire. Blackwell companions to the ancient world (Kundli 2006) 298–311
- Komšo 2004** D. Komšo, Vrčevan – nalazište na otvorenom iz razdoblja ranog neolitika, *HistriaA* 35, 2004, 5–30
- Krizmanić 2009** A. Krizmanić, Pulska kruna: pomorska tvrđava Pula. Fortifikacijska arhitektura austrijskog razdoblja. Two volumes (Pula 2009)
- Levak 2013** M. Levak, Rani srednji vijek, in: A. Bader (ed.), Monografija Medulin (Medulin 2013) 79–91
- Marchiori 2010** A. Marchiori, Infrastrutture territoriali e strutture insediative dell'Istria romana: la divisione centuriale di Pola e Parenzo in rapporto ai grandi complessi costieri istriani. Il caso Nord Parentino (Diss. Università degli Studi di Padova 2010)
- Matijašić 1988** R. Matijašić, Ageri antičkih kolonija POLA i PARENTIVM i njihova naseljenost od I. do III. stoljeća. *Latina et Graeca*, VI (Pula 1988)
- Matijašić 1998** R. Matijašić, Gospodarstvo antičke Istre. Arheološki ostaci kao izvori za poznavanje društveno-gospodarskih odnosa u Istri u antici (I. st. pr. Kr. – III st. posl. Kr.), *Povijest Istre* IV (Pula 1998)
- Matijašić 2007** R. Matijašić, Još jednom o Kastrilu na premanturskom rtu Kamenjak (Medulin). Another Look at Kastril on the Premantura Cape of Kamenjak (Medulin), *PriloziZagreb* 24, 2007, 221–228
- Matijašić 2012** R. Matijašić, Još jedan primjer fosiliziranoga antičkog krajolika u Istri: Rt Kamenjak (Premantura, Pula), *Tabula: časopis Filozofskog fakulteta, Sveučilište Jurja Dobrile u Puli* 10, 2012, 75–89, <https://doi.org/10.32728/tab.10.2012.04>
- Menna et al. 2018** F. Menna – P. Agrafiotis – A. Georgopoulos, State of the art and applications in archaeological underwater 3D recording and mapping, *Journal of Cultural Heritage* 33, 2018, 231–248, <https://doi.org/10.1016/j.culher.2018.02.017>
- Meinig 1979a** D. W. Meinig, Reading the Landscape. An Appreciation of W. G. Hoskins and J. B. Jackson, in: D. W. Meinig (ed.), *The Interpretation of Ordinary Landscapes* (New York, Oxford 1979) 195–244
- Meinig 1979b** D. W. Meinig, The Beholding Eye. Ten Versions of the Same Scene, in: D. W. Meinig (ed.), *The Interpretation of Ordinary Landscapes* (New York, Oxford 1979) 33–48
- Miholjek 2012** I. Miholjek, Podmorsko istraživanje antičkih ostataka arhitekture na Vižuli – kampanja 2011, *HistriaAnt* 21, 2012, 525–531

- Perović 2006** B. Perović, Luka Pula austrougarskog doba (Odsjaj grada u zaljevu 1850. – 1918.), in: M. Černi (ed.), *Iz povijesti Pulske luke* (Pula 2006) 70–191
- Pingel et al. 2015** T. J. Pingel – K. Clarke – A. Ford, Bonemapping: A LiDAR Processing and Visualization Technique in Support of Archaeology Under the Canopy, *Cartography and Geographic Information Science* 42, Suppl. 1, 2015, 18–26, <https://doi.org/10.1080/15230406.2015.1059171>
- Piplović 1990** S. Piplović, Fortifikacijski sustav Pule iz 19. stoljeća – potreba detaljnijeg istraživanja i zaštite, *Godišnjak zaštite spomenika kulture Hrvatske* 14/1988–15/1989, 1990, 187–201
- Popović et al. 2021** S. Popović – D. Bulić – R. Matijašić – K. Gerometta – G. Boschian, Roman land division in Istria, Croatia: historiography, lidar, structural survey and excavations, *Mediterranean Archaeology and Archaeometry*, 21/1, 2021, 166–178, <https://doi.org/10.5281/zenodo.4394051>
- Rossignol – Wandsnider 1991** J. Rossignol – L. Wandsnider (eds.), *Space, Time, and Archaeological Landscapes* (Boston 1992)
- Starac 1999** A. Starac, Rimsko vladanje u Istriji i Liburniji I. Društveno i pravno uređenje Prema literarnoj, natpisnoj i arheološkoj građi. *Istrija, Monografije i katalozi Arheološkog muzeja Istre* 10/I (Pula 1999)
- Schörner 2022** G. Schörner, Changing Landscapes Under Roman Impact, in: M. Horster – N. Hächler (eds.), *The Impact of the Roman Empire on Landscapes. Proceedings of the Fourteenth Workshop of the International Network Impact of Empire* (Mainz, June 12–15, 2019), *Impact of Empire* 41 (Leiden, Boston 2022) 175–190, https://doi.org/10.1163/9789004411449_010
- Sittler 2004** B. Sittler, Revealing historical landscapes by using airborne laser scanning. A 3-D model of ridge and furrow in forests near Rastatt (Germany), in: M. Thies – B. Koch – H. Spiecker – H. Weinacker (eds.), *Laser-Scanners for Forest and Landscape Assessment* (Freiburg, October 3–6 October, 2004), *ISPRS Archives – Volume 36, Part 8/W2*, 2004, 258–261
- Štular et al. 2021** B. Štular – S. Eichert – E. Lozić, Airborne LiDAR Point Cloud Processing for Archaeology. Pipeline and QGIS Toolbox, *Remote Sensing* 13/16, 2021, 3225, <https://doi.org/10.3390/rs13163225>
- Vrsalović 2011** D. Vrsalović, *Arheološka istraživanja u podmorju istočnog Jadrana. Prilog poznavanju trgovačkih plovnih putova i gospodarskih prilika na Jadranu u antici*, Pomorska biblioteka 13 (Split 2011)

Nives Doneus, Vienna Institute for Archaeological Science, University of Vienna, Franz-Klein-Gasse 1, 1190 Vienna, Austria. Human Evolution & Archaeological Sciences (HEAS), University of Vienna, Djerassiplatz 1, 1030 Vienna, Austria.
nives.doneus@univie.ac.at

Michael Doneus, Department of Prehistoric and Historical Archaeology, University of Vienna, Franz-Klein-Gasse 1, 1190 Vienna, Austria. Human Evolution & Archaeological Sciences (HEAS), University of Vienna, Djerassiplatz 1, 1030 Vienna, Austria.
michael.doneus@univie.ac.at