An integrated geoarchaeological approach to Late Iron Age settlement at the Kaštelina hillfort (Lopar, Island of Rab, Croatia) using Amplitude Data Comparison (ADC) method and trial excavation

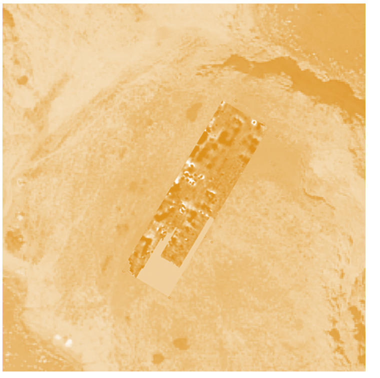
Androić Gračanin, Paula; Welc, Fabian; Konestra, Ana; Nowacki, Barosz

Source / Izvornik: **Polish Archaeology in the Mediterranean, 2020, 29, 447 - 467**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

https://doi.org/10.31338/uw.2083-537X.pam29.2.19

An integrated geoarchaeological approach to Late Iron Age settlement at the Kaštelina hillfort (Lopar, Island of Rab, Croatia) using Amplitude Data Comparison (ADC) method and trial excavation



Abstract: Geophysical prospection and small-scale archaeological excavation were undertaken on the site of Kaštelina, a Late Iron Age hillfort settlement located on the Stolac promontory in the northern part of Rab island (Kvarner Gulf, Croatia). Within the frame of the "Archaeological topography of the island of Rab" program, a Polish–Croatian team applied a series of multidisciplinary methods to study the occupational history of the site, its preservation, the nature of selected site features and future research potential. Ground-penetrating radar and magnetometer surveys, combined with the implementation of the Amplitude Data Comparison (ADC) method, led to the detection of remains of Late Iron Age building structures distributed over the northwestern side of the Stolac promontory. Archaeological excavations verifying the findings of the geophysical survey resulted in the discovery of a dwelling with associated outdoor features. A preliminary assessment of the outcome of a multidisciplinary approach to the study of the site of Kaštelina emphasizes the importance of the collected data for a general understanding of Late Iron Age settlements and their internal organisation in a wider context.

Keywords: Northeast Adriatic, hillfort settlement, Late Iron Age building structures, geophysical survey, Amplitude Data Comparison (ADC) method, archaeological excavation, ground penetrating radar, magnetometry, multidisciplinary research

Paula Androić Gračanin[1]
Fabian Welc[2]
Ana Konestra[3]
Bartosz Nowacki[4]

[1, 2] Cardinal Stefan Wyszyński University in Warsaw
[3] Institute of Archaeology, Zagreb
[4] University of Warsaw, Faculty of "Artes Liberales"

Polish Archaeology in the Mediterranean 29/2
Androić Gračanin et al. 2020: 447–467
https://doi.org/10.31338/uw.2083-537X.pam29.2.19

Acknowledgments
The research was carried out within the framework of the program “Archaeological topography of the island of Rab”, financed in 2019 by the Ministry of Culture of the Republic of Croatia. The project received funding from the Institute of Archaeology of the Cardinal Stefan Wyszyński University in Warsaw (UKSW), as well as the Lopar Cultural Centre, to which we hereby express our thanks for help in logistics, and the Institute of Archaeology in Zagreb, which covered the costs of sample analysis. Archaeological research on the island of Rab has been co-directed since 2017 by Ana Konestra (Institute of Archaeology, Zagreb) and Fabian Welc (Institute of Archaeology, UKSW), in collaboration with the Archaeological Museum in Zagreb (A. Dugonjić) and numerous external collaborators (P. Androić Gračanin, B. Nowacki, A. Kukela, M. Korić, I. Škoro), as well as PhD students (K. Rabiega) and undergraduate students from both Poland and Croatia. The authors would also like to thank the Artes Liberales Faculty at the University of Warsaw for cooperation in the implementation of the project.

INTRODUCTION

The Kaštelina hillfort occupies a site on Stolac, a small promontory in the northernmost part of Rab, a mid-sized island in the Kvarner archipelago, located in the northernmost inlet of the eastern Adriatic Sea [*Fig. 1*]. In the protohistoric period,[1] the area is considered to lie on the northernmost flank of two major communities: the Liburnian culture group with a core area in the Zadar–Ravni Kotari region, and the southwestern group of the continental Japodian culture. Specific regional characteristics, identified almost exclusively on the grounds of archaeological studies of attire and metal finds, point to the development in the Late Bronze Age of a distinct Kvarner cultural group, further influenced by relations with communities of the western and northern Adriatic and its hinterland (Blečić Kavur 2014: 165; for historical sources,

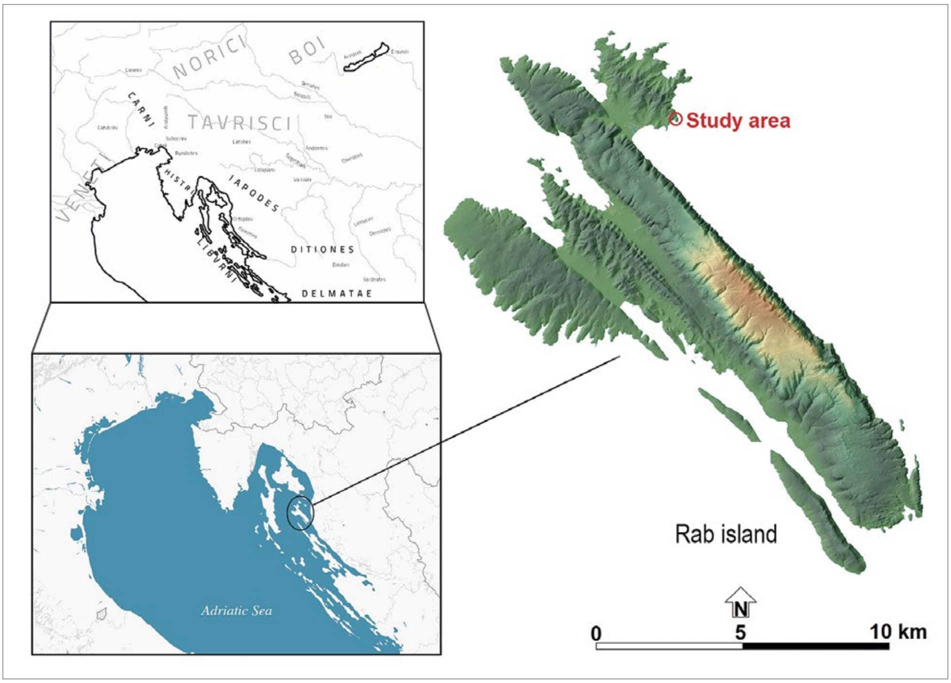


Fig. 1. The Island of Rab: right, altitude map of the island and its location in the Eastern Adriatic (bottom left); upper left, protohistoric cultural geography of the northeastern Adriatic in the context of southeastern and central Europe (Rab Island Project archive | altitude map based on DGU/JU ZPP-PGŽ, modified by A. Konestra; cultural geography map after Mihovilić 2014: 24)

1 The protohistoric period on the eastern Adriatic coincides with the Late Iron Age, i.e., a timeframe roughly encompassing the 4th–1st century BC. Thus, it coincides with the Central European La Tene (LtA–LtD), the Hellenistic in the Eastern Mediterranean and the Roman Republic in the west. In fact, Roman rule in the region was established effectively in the mid-1st century BC (times of Julius Caesar and Octavian).

see Barnett 2017; Čače and Milivojević 2017) [see *Fig. 1*]. However, despite the exceptionally large concentration of hillforts in the north(eastern) Adriatic, where they were the main type of settlement from the period in question (see Mihovilić 2013 with earlier bibliography), indeed a kind of hallmark of the Bronze and Iron Age landscape in the eastern Adriatic and its hinterland (Čučković 2017), the Kvarner area has been poorly investigated in this respect (Blečić 2002: 72; Glavaš 2014: 3).

Being the most common form of fortified protohistoric earthworks, these manmade features come in different size and shape. Their most frequent location is on conical hill summits, linguliform plateaus rising above valleys and on the sea coast, always in prominent positions seen from far and strategic with regard to natural resources and communication routes in the region. Typically, they consist of an oval area enclosed by one or multiple, concentric, drystone ramparts, except in places where the steepness of the terrain itself provides sufficient protection (Mihovilić 1979; Batović 1987b; Forenbaher and Rajić Šikanjić 2006: 467). Traditionally, all types of hillforts were recognised as settlements, often without clear evidence, but recently plural interpretations have emerged, putting forward different possible functions of the prehistoric fortified sites: refugia, cattle corrals, surveillance points, ritual places (Batović 1987a; Forenbaher and Rajić Šikanjić 2006: 467 with earlier references; Glavaš 2014: 3–4; Glavaš and Glavičić 2019: 123–124), and even, where possible, a beacon for maritime navigation (Čučković 2017 with earlier references). On the island of Rab several, mainly Bronze Age hillforts have been located, mostly on the karst anticlines, and some overlooking the Lopar field. Their evolution and possible relationship with Kaštelina are not known for lack of substantial research. With the dawn of Roman rule in the 1st century BC, some of the hillforts developed into urban settlements, probably as leading centers of larger communities, later gaining municipal status. This was the case of the island's only Roman urban center, today's town of Rab.

The Kaštelina hillfort lies on the margin of one of the three flysch plain areas on the island where alluvial deposits created suitable conditions for soil cultivation, unlike the central and southwesternmost anticlinal parts of Rab that are characterised by carbonates and, thus, karst (Welc et al. 2019: 485). More precisely, this protohistoric site is located within the so-called Lopar sandstone that consists of alternating sandstones and bioturbated sandy marls. The sandstones here occur as thin interbeds in marls, as packages of stacked sandstone beds and as several-meter-thick sandstone bodies, commonly capped by the sandy marls (Marjanac and Marjanac 2007: 495). Typical Mediterranean garrigue and macchia grows sporadically on Kaštelina's sandy, relatively flat surface, together with different types of halophytes.

Located on a relatively small promontory of 7000 m² that rises about 20 m asl, this protohistoric settlement had no real need for for a fully enclosed fortification. The steep slopes of the escarpment exposed toward the sea, especially on the eastern and southern sides, optimized the construction of the defensive structures. The only possible land access is from the northwestern side, where remains of a rampart, later reinforced with limestone mortar, are still faintly visible on the surface.

The position of the Kaštelina hillfort dominates the landscape, inevitably ensuring visual control over potential natural resources, like nearby arable land, pastures, as well as sea and land communications (see Glogović 1989; Mihovilić 2013; Glavaš and Glavičić 2017: 120; 2019: 123) [*Fig. 2*]. Its seaward orientation makes it easy to keep tabs on two important local sea routes, one passing through the Rab channel and the other through the Velebit channel (Gržetić 2002). The importance of these navigation routes is attested by two shipwrecks, one from the 3rd and the other from the 2nd–1st century BC, located respectively off Cape Sorinj (northwestern part of the island) and Cape Glavina (southeastern part of the island), bearing cargos of amphorae of the Greco-Italic and Lamboglia 2 types, as well as an array of stray underwater amphorae finds in the Velebit channel (Dautova-Ruševljan 1975; Miholjek 2007; Glavaš, Konestra, and Tonc 2020) [*Fig. 3*]. It is therefore possible that the Kaštelina hillfort setting served multiple roles, which could include acting as a visual reference from the sea, a form of sea beacon, but also as a node in the seaborne communication networks, or simply a landmark affirming possession of nearby land (see Čučković 2017; Čače 1981).

The hillfort settlement on the Stolac promontory was first discovered in 1984 during an archaeological survey of the island of Rab (Batović 1985: 13). The first indication of the archaeological potential of the site was the other name of the cape, which is also known as Kaštelina (Croatised toponym from the Latin *castellum*, fortress, castle, stronghold, refuge, citadel, but probably under Venetian influence). It could be proof that some of the features of the fortification could have still been visible as late as the early Modern period, and as such recognized in the local toponymy (Batović 1985: 15; Šimunović 1986: 141). Surface finds, like fragments of southern Italic and other Hellenistic fine wares, local coarse pottery together with a rim fragment of a possibly Hellenistic glass vessel, set the occupation of the area between the 4th and the 1st century BC (Batović 1987c; Mihovilić 2002). Remains of a rampart enclosing the only possible overland access to Kaštelina from the northwest, as well as scattered clay plaster fragments around the central plateau, are in line with the discovery of the hillfort settlement on the promontory (Batović 1987c; Brusić 1990). A repeated survey of the site in 2013 (Lipovac Vrkljan et al. 2014) corroborated earlier results, failing however to establish with certainty whether actual settlement remains could be expected on this highly eroded site. The first non-invasive geophysical survey in 2018 concentrated on an area near the supposed rampart, within the perimeter of the hillfort settlement (Konestra et al. 2019). Remains of several rectangular structures with associated features were traced and interpreted provisionally as possible settlement units together with storage and manufacturing areas (Konestra et al. 2019: 192; 2020).

Fig. 2. The Kaštelina promontory: top, aerial view from the west; bottom, arrow marks location of the archaeological trench dug in 2019, view of the promontory from the northwest (Rab Island Project archive | photos G. Skelac and K. Rabiega)

GEOPHYSICAL SURVEY AND AMPLITUDE DATA COMPARISON (ADC) METHOD ANALYSIS

The magnetic survey of a Late Iron Age hillfort settlement on the Stolac promontory applied a fluxgate-type gradiometer. Measurements were taken along lines set 0.50 m apart. The results of the survey are presented here in the form of greyscale distribution maps, where darker areas correspond to anomalies characterized by higher magnetic-field values, indicating a greater concentration of magnetic matter or ferromagnetic mineral in the soil.

Supplementing the magnetic survey were ground-penetrating radar measurements using a GPR MALA/ABEM – GroundExplorer system with a frequency of 450 MHz. As before, measurement profiles were set 0.50 m apart.

An innovative method of analysis was applied to the geophysical magnetic and GPR results in an effort to recognize the vertical and horizontal stratigraphy of the site. The results were compared with the Amplitude Data Comparison (ADC) method. The limitations of the magnetometry and GPR methods derive from the fact that both are strongly dependent on local geology, material composition and geometry of the buried features (Welc, Nebelsick, and Wach 2019; Welc, Rousse, and Benčić 2020). Ground-penetrating radar emits electromagnetic (EM) waves, which are reflected from boundaries between two archaeological layers characterized by significantly different electric properties. By contrast, the magnetic method measures the intensity of the local geomagnetic field. Applied alone, it is not suitable for understanding vertical archeological stratigraphic sequences because it provides only a plan of the site in the form of a distribution map of anomalies corresponding to concentrations of ferromagnetic matter in the soil (Welc, Rousse, and Benčić 2020). In turn, GPR profiles show objects and boundaries between layers without information about their material and chemical characteristics. Only when individual GPR reflection profiles are interpreted together with the corresponding magnetic values it becomes possible to define the types of materials visible in the GPR reflection profiles and these two

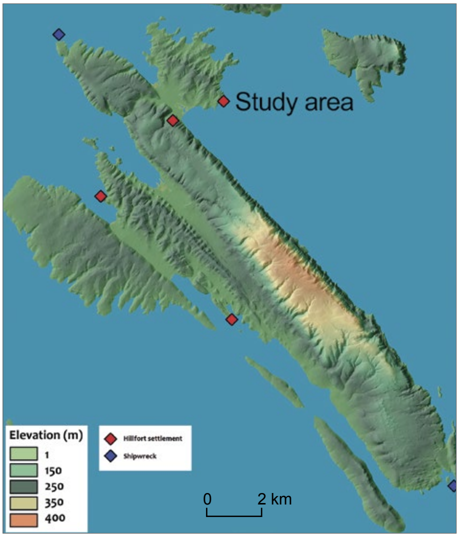


Fig. 3. Location of Late Iron Age archaeological sites: hillforts and shipwrecks (Rab Island Project archive/base map DGU/JU ZPP-PGŽ | image P. Androić Gračanin)

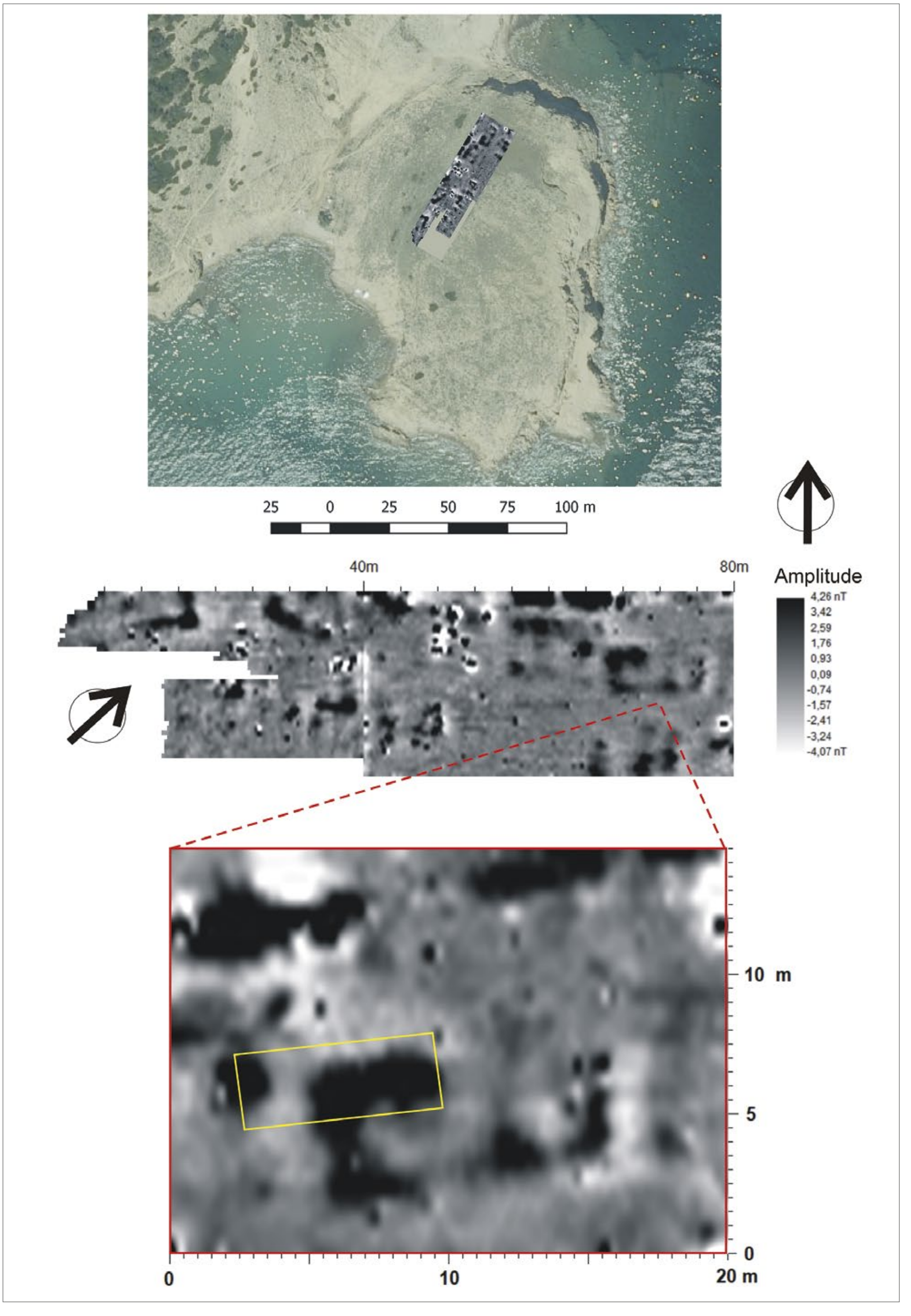


Fig. 4. Results of the geophysical survey: top, area surveyed by the magnetic method; bottom, section surveyed additionally by the GPR method; yellow rectangle corresponds to location of the archaeological trench (Rab Island Project archive | processing and drawing F. Welc)

datasets then become complementary to some extent. This is the main premise of the Amplitude Data Comparison (ADC) method (Welc, Nebelsick, and Wach 2019; Welc, Rousse, and Benčić 2020).

The magnetic survey was performed in the northwestern part of the promontory where numerous high amplitude anomalies were revealed (Konestra et al. 2019) [*Fig. 4*]. These features can be interpreted as the remains of a few rectangular buildings that have not been preserved in their entirety. The multiple rectangular structures that were detected were interpreted provisionally as severely damaged organic remains or negative imprints of possible structures.

In 2019, the geophysical survey was supplemented with a GPR survey to provide data for performing an ADC analysis. The GPR time-slices (GPR amplitude maps) recorded characteristic high-amplitude linear anomalies at a depth of about 0.60 m. Anomalies of this kind are generated most probably by buried stone debris [*Fig. 5*]. Oval GPR anomalies can be seen in several positions, coinciding with high values of the magnetic amplitude. This could be interpreted as the remains of a hearth filled with numerous burnt objects (potsherds, stones) [*Fig. 5:1*]. The remaining anomalies noted in the GPR image do not coincide with high-amplitude magnetic values, confirming the mostly organic nature of these features. The low contrast of the electrical properties of these residues compared to the surrounding soil explains why they were not visible to the GPR method [*Fig. 5:2*].

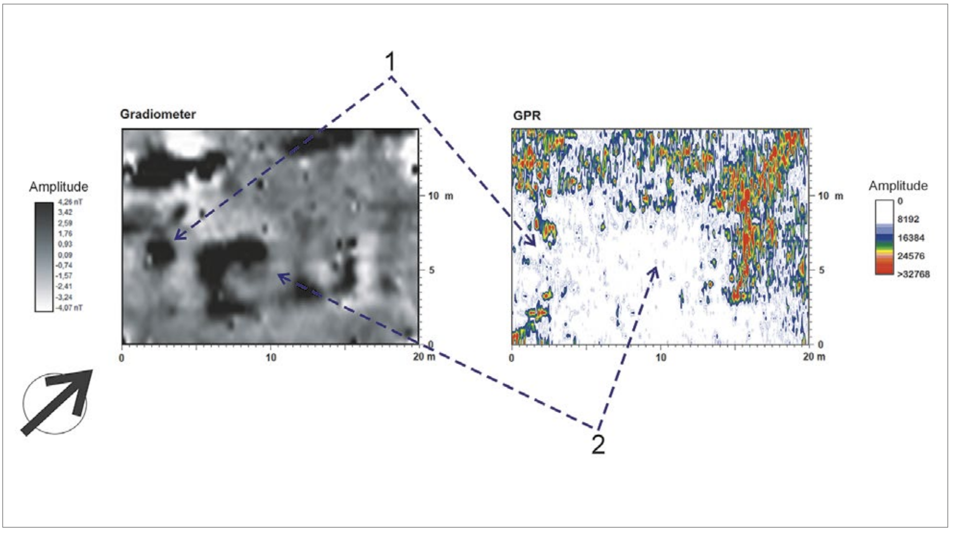


Fig. 5. Analysis of the magnetic and GPR survey results using the ADC method: left, section of the magnetic map from ***Fig. 4***; right, GPR timeslice (GPR plan) for the same area a depth of approximately 0.40 m: 1 – high amplitude anomaly corresponding to remains of a hearth; 2 – outline and interior of a building very well visible on the magnetic map and almost absent from the GPR image; (RAB Island Project archive | processing, interpretation and drawing F. Welc)

For the ADC analysis, a GPR reflection profile marked a–b was combined with the corresponding gradiometer readings [*Figs 5, 6*]. A shallow depression could be seen between the first and fourth meter of this profile and this corresponded to a high-amplitude magnetic value [*Fig. 6, No. 1*]. Consequently, the whole set of anomalies should be interpreted as a hearth with a number of burnt objects inside it. A wide and shallow depression noted between the fifth and the fifteenth meter on the selected GPR profile corresponds to a different magnetic value characterizing the northwestern edge of the building [*Fig. 6, No. 2*]. However, the northern edge (wall?) is visible on the GPR profile as an amplitude signal amplification zone, while the mapped magnetic field intensity values are both high and low (so-called dipole). This should be interpreted as heavily burnt matter, in this case also involving non-magnetic rock debris, which is reflected in the GPR results due to a sufficient electric contrast of these remains with the surrounding soil [*Fig. 6, No. 3*].

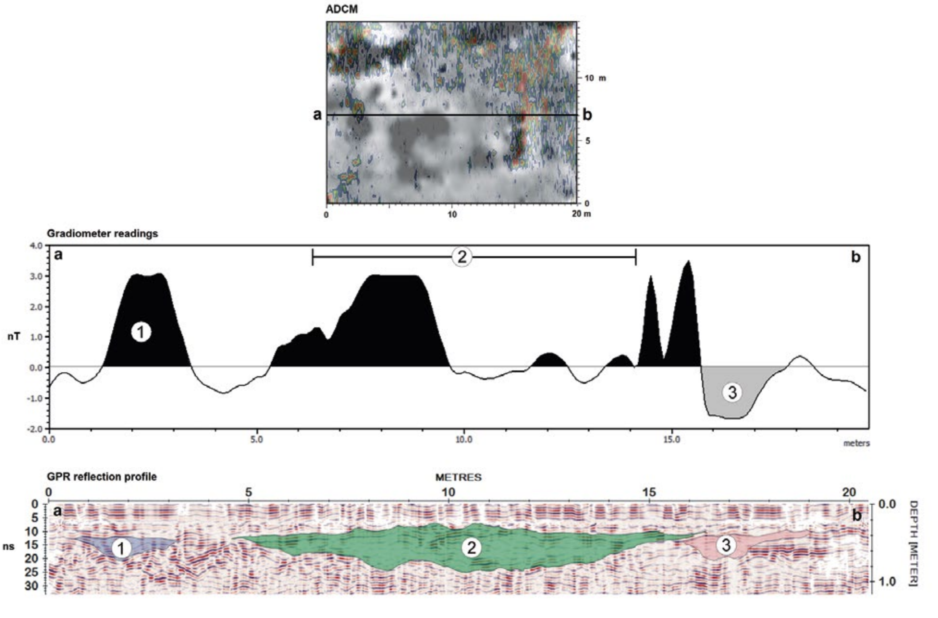


Fig. 6. Results of ADC analysis of a selected GPR profile and corresponding magnetic records (location of profile a–b marked on a map of superimposed magnetic and GPR results at top): 1 – highly magnetic sediments filling a small depression, corresponding to remains of a hearth; 2 – vast and shallow depression filled with diverse material, more magnetic on the outside corners (sand and stone rubble mixed with organics and ash); 3 – low magnetic amplitude values corresponding to GPR signal amplification zone, corresponding most probably to an accumulation of limestone rubble (Rab Island Project archive | processing, interpretation and drawing F. Welc)

ARCHAEOLOGICAL VERIFICATION

Subsequent archaeological trial excavations based on the geophysical outcomes were aimed at verifying the nature of the buried target of interest (see Theocaris et al. 1996 with earlier bibliography). The trench was set close to the northwestern limit of the hillfort, where rows of rectangular buildings were detected, fairly closely spaced and running parallel to the rampart [see *Fig. 4*].

The specific aim of this small-scale excavation was to explore one of the structures determined by the ADC method. The excavation was planned to cover a part of the interior and the adjacent exterior. Initially, a larger area was to be examined, but the depth at which the remains were found forced the excavated area to be reduced to 14 m^2.

Archaeological remains appeared under a layer of eroded sand up to 0.90 m thick and grass-overgrown topsoil. The sand and silt are practically sterile, reflecting a strong erosional force, quite the opposite of what was determined in earlier prospections (Konestra et al. 2019). Mechanical erosion of soil transported by water and evident all around the promontory, especially on the escarpments, led to this apparent third phase of the erosion process being overlooked (Morgan 2005). Control profile soil samples were sequentially collected every 5 cm from all the layers and their magnetic susceptibility measured with a kappameter. Once these measurements are analyzed, they will help to better understand the provenance of these sediments.

Another eroded layer lay below this upper layer, this time containing archaeological material, but once again showing strong erosional forces at work. The first archaeological context *in situ* was unearthed below this in the southernmost part of the trench. It consisted of fire installations and contexts probably related to food processing [*Fig. 7*]. Five simple, subcircular clay hearths were discovered. Different in size, varying from 15 cm to 30 cm in diameter, these small structures with a clay base were placed directly on the ground. Charcoal was found both inside the hearths and around them, but no ash or evidence of sediments exposed to high temperatures were noted (see Berna et al. 2007: 359–360). Subcircular perforated clay vessel stands were found in abundance, fragmented and mixed together with remains of daub and sandstone pebbles, tentatively suggesting a feature referred to in the literature as a pebble hearth (see Pisoni 2008; Gur-Arieh et al. 2014 with earlier references). The pottery uncovered here, relatively modest in quantity considering the context, represented a typical coarse, handmade Iron Age household ware.[2]

The corner of a rectangular building foundation was unearthed 2 m northeast of the hearths and fire installations, again fully confirming the usefulness of

2 Local coarse ware has hardly been studied (see Starac 2009: 41), hence there is no definitive typology, although parallels with neighbouring regions suffice to establish the main production features (see Šešelj and Vuković 2013; Vuković 2014; Barbarić 2016 for southern Liburnia; Mihovilić 2014: 304–312 for Histria).

Fig. 7. Fire installations and hearths in context (Rab Island Project archive | photo B. Nowacki)

Fig. 8. Remains of a dwelling: western corner of a dry-stone wall foundation and the interior filled with rubble (Rab Island Project archive | photo B. Nowacki)

geophysical data analysis using the ADC method. The foundation was built in the dry-stone technique, of large, irregular chunks of sandstone and chalk pebbles [see *Figs 5, 8*]. Construction material was evidently supplied from the nearest vicinity. Postholes were documented on the bearing surface of this western corner foundation, and the remains of carbonised beams and presumed posts, together with an abundance of plaster throughout the excavated interior, demonstrate the use of both perishable and long-lasting building material. Indeed, the condition of structural wood buried in the collapse filling the interior was surprisingly good despite the poor preservation of the foundation and a projected fire event, either by direct contact with fire or with live embers (see Gur-Arieh et al. 2012).

As expected, fragmented coarse household pottery was found here as well, together with a couple of fragments of imported, central Mediterranean fine ware pottery and several sherds possibly belonging to amphorae. A spindle whorl and a stone quern were discovered nearby.

INTERPRETATION OF RESULTS

The discussion will focus on the most plausible results concerning the remains of architectural structures from the Late Iron Age (roughly 5th to 4th centuries BC) discovered at Kaštelina hillfort thanks to a combination of conventional archaeological and geophysical methods (the rest of the results will be reported elsewhere). The results are threefold: a general plan of one segment of this protohistoric hillfort settlement and a detailed layout of a single settlement unit, preliminary exploration of this unit with associated exterior, and confirmation of the reasons for the termination of this zoned unit of the Kaštelina settlement.

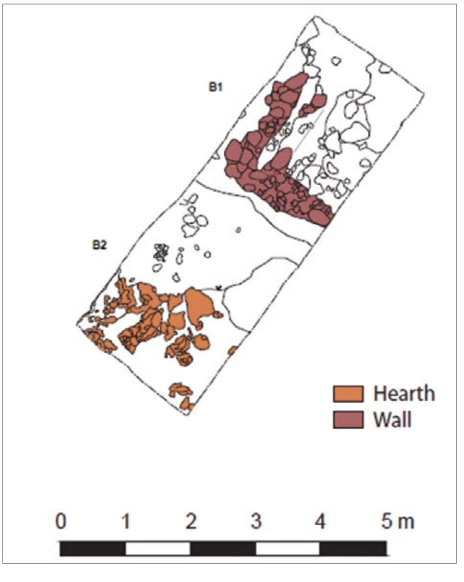


Fig. 9. Remains of a dry-stone wall settlement unit structure in context with fire installations and hearths (Rab Island Project archive | drawing K. Rabiega, processing A. Konestra)

Remote sensing revealed the general outline of the settlement. It corroborated the spread of dwellings close to the western and southern limits of the hillfort, following the natural curve of the promontory, as is frequent in similar protohistoric settlements (see Batović 1987a; Glogović 1989; Buršić-Matijašić 2007; Mihovilić 2013). All the buildings traced at the Kaštelina site are matched in size and layout, which usually denotes segregation of the same types of activities and functions (Guilbert 1975: 203–210).

A zoned plan, confirmed at least in the northwestern part of the settlement, could be a sign of a planned hillfort interior [see *Fig. 4*]. However, it will hardly be possible to ascertain whether the layout of buildings on an irregular site, like this one, was consciously arranged in view of the obvious need of adapting to the lie of the ground (Guilbert 1975: 203–210).

A multidisciplinary approach to the research identified the buildings at Kaštelina as typical, single-room, above ground, stand-alone rectangular dwellings (see Batović 1987a: 116). Even their size, 4 m by 10 m, meets the common standards of what has been defined as a so-called Liburnian house (Batović 1987a: 355; 2005: 25). However, the settlement units mapped by the magnetic survey and verified archaeologically show some distinctiveness when compared to features of similar layout, function and date. The first peculiarity concerns the setting of fireplace or hearths, in our case located outside the structures [*Fig. 9*]. On the eastern Adriatic coast and in its hinterland, they are almost without exceptions located in the interiors of simple Iron Age dwellings (Drechsler-Bižić 1986; Batović 1987b; Suić 2003: 128). Dwellings excavated at the sites of Beretinova gradina and Nin, both located in central Liburnian territory, have a stub wall stretching in front of the entrance, interpreted as a structure bearing a kind of canopy, sheltering that front yard (Batović 1987c: 110). Neither remote sensing nor limited trial excavation of the complex of hearths detected any clear evidence of structures carrying the canopy, but a similar concept could be expected at Kaštelina as well, possibly in the form of postholes, bearing in mind the activities in the area in question.

The second peculiarity noted on Kaštelina concerns the building material for the walls. An abundance of daub fragments was scattered all over the complex, alongside remains of timber beams and carbonised wood in the collapsed structure and impressions of stakes in the wall foundation. The evidence for wattle-and-daub being used as a composite building method is indisputable. The technique has been hypothesized often enough in the past, but not clearly reported from sites with excavated settlement architecture dating from the Iron Age that are still rare in the Eastern Adriatic (see Batović 1964; 1966; 1968; 1969; Čondić and Vuković 2017). This also refers to rarely excavated protohistoric settlements in Kvarner, where only limestone drywall structures were explored so far (Pavišić 1985; Faber 1977; 1980; 2018). Sporadic finds of daub in some of the Bronze and Iron Age hillfort settlements in Istria and Dalmatia suggest the use of this composite building method (Buršić-Matijašić 2007: 526–533; Barbarić 2010: 163); hence, the absence of clear evidence of use of perishable materials in wall construction on sites similar to this one can be interpreted in part as poor preservation rather than not using it in the first place. Thus, the results obtained at Kaštelina confirm the use of this building technique, offering further details on the modes of construction with stone and timber/daub, perhaps adjusted to the available raw materials, an aspect that should be taken into consideration as well.

Evidence of the conflagration at the Kaštelina hillfort was traced by the geophysical survey as well as trial excavation, thus showcasing the potential of the ADC method. Strong magnetic susceptibility recorded in all of the traced settlement units in the northwestern part of the hillfort was interpreted at first as remains of perishable construction material (in the form of carbonized wood), but subsequent archaeological trenching reported remains of permanent construction material as well. Whether the causes of the fire were anthropogenic or natural cannot be inferred from the mere presence of buried items (Alperson-Afil 2012: 112), but it surely meant the end of occupation, at least within this zoned unit of the hillfort, as no traces of rebuilding were detected here.

CONCLUDING REMARKS

The results presented in this paper are preliminary because the research at the hillfort settlement of Kaštelina is in a preliminary phase, but they demonstrate the benefits of a multidisciplinary approach combining geophysical and archaeological methods. Despite the limited extent and short duration of the surveys, the results proved complementary when analyzed in unison. The spacious plateau on the Stolac promontory appeared at first as an extensively eroded archaeological site which could not conceal at any great depth an abundance of relatively well preserved remains. The initial geophysical survey conducted in 2018, which aimed to test the efficiency of different geophysical techniques on an eroded flysch substrate, brought surprising results that made an extended remote sensing survey one of the priorities of the "Archaeological topography of the island of Rab" program. Field research in 2019 produced a surprisingly successful complementation of conventional archaeological techniques and applied geophysical methods. The properties of the topsoil ensuring preservation of the remains was probably behind the good results.

In the wider, both regional and overregional context, the data gathered at Kaštelina opens a more informed discussion of settlement layout and individual unit planning, as well as building techniques and consequently exploitation of natural resource. An analysis of the finds, still in progress, will shed more light on the latter aspect, as well as on the place of the site and island in the wider trade networks. On the local, island level, the data are crucial to understanding settlement patterns and their development (see Konestra et al. 2020), revealing an apparently rather short-lived settlement, but also calling for further research on its relationship to the other hillforts on the island.

A planned, although location specific layout of the settlement is certainly indicative of communal effort in its setup, while virtually identical single-space dwellings might suggest their multipurpose function (settlement, productive, storage, etc.) with no signs of specialization (see Guilbert 1975; for other regions Dietler 2010: 276–277, 280). Nevertheless, the presence of outdoor hearths, a feature again replicated several times within the settlement, does suggest a dedicated area for food processing or other fire-related activities, that is, a courtyard attached to each unit. Such data on dwellings was so far regionally absent, while in the wider northeastern Adriatic only sporadically and partly known, precluding further elaboration, but also more precise parallels relevant to our case.

Building materials, while pointing to local resource exploitation, suggest an optimisation in the use of each material, with the foundation being built of rocks and the wall of perishable materials and daub. The roofing has not been determined, but was in all probability of perishable materials as well. Small finds are indicative of wool processing and cereals being used in food preparation, while the import of certain foodstuffs is suggested by the presence of amphorae in the pottery assemblage. More data will come from continued excavation as well as finds processing, which should shed light on other aspects of the material culture, i.e., imported finewares, and models of appropriation, as the site seems to have functioned during a period of increasing import of foreign beverages (wine) and related consumption vessels, marking a shift in both cultural practices and, possibly, social structures (Dietler 1990: 389; Riva 2010: 221).

In conclusion, the combined methodology applied at the site allowed the extent of preserved settlement features to be determined, including their organisation and layout, while excavations offered a more in-depth look at construction and everyday activities and, crucially, offering data for the dating of the site, thus placing it within a wider Adriatic context.

Paula Androić Gračanin
https://orcid.org/0000-0001-6301-3704
Cardinal Stefan Wyszyński University in Warsaw
Institute of Archaeology
paula.androic@gmail.com

Assoc. Prof. Fabian Welc
https://orcid.org/0000-0001-6122-1884
Cardinal Stefan Wyszyński University in Warsaw
Institute of Archaeology
f.welc@uksw.edu.pl

Dr. Ana Konestra
https://orcid.org/0000-0002-7726-6515
Institute of Archaeology, Zagreb
ana.konestra@iarh.hr

Bartosz Nowacki
https://orcid.org/0000-0002-9900-6407
University of Warsaw,
Faculty of "Artes Liberales"
barteknowacki@gmx.net

How to cite this article: Androić Gračanin, P., Welc, F., Konestra, A., and Nowacki, B. (2020). An integrated geoarchaeological approach to Late Iron Age settlement at Kaštelina hillfort (Lopar, Island of Rab, Croatia) using Amplitude Data Comparison (ADC) method and trial excavation. *Polish Archaeology in the Mediterranean* 29/2) (pp. 447–467). https://doi.org/10.31338/uw.2083-537X.pam29.2.19

References

Alperson-Afil, N. (2012). Archaeology of fire: Methodological aspects of reconstructing fire history of prehistoric archaeological sites. *Earth-Science Reviews*, 113(3), 111–119

Barbarić, V. (2010). Gradina Rat kod Ložišća, otok Brač, 2007–2008 (The hillfort of Rat at Ložišća, island of Brač, 2007–2008). *Izdanja Hrvatskog arheološkog društva*, 26, 157–173 (in Croatian with English summary)

Barbarić, V. (2016). Indigenous pottery in Dalmatia during the last millennium BC. In D. Davison, V. Gaffney, P. Miracle, and J. Sofaer (eds), *Croatia at the crossroads: A consideration of archaeological and historical connectivity. Proceedings of a conference held at Europe House, Smith Square, London, 24–25 June 2013 to mark the accession of Croatia to the European Union* (pp. 123–138). Oxford: Archaeopress

Barnett, C. (2017). Rethinking identity, ethnicity, and "Hellenization" in pre-Roman Liburnia. *Miscellanea Hadriatica et Mediterranea*, 3, 63–97

Batović, Š. (1964). Beretinova gradina, Radovin—željeznodobno i antičko naselje (Beretin hillfort, Radovin—Iron Age and Roman settlement). *Arheološki pregled*, 6, 32–35 (in Croatian)

Batović, Š. (1966). Beretinova gradina, Radovin—željeznodobno i antičko naselje (Beretin hillfort, Radovin—Iron Age and Roman settlement). *Arheološki pregled*, 8, 49–53 (in Croatian)

Batović, Š. (1968). Istraživanje ilirskog naselja u Radovinu (Research at the Illyrian settlement in Radovina). *Diadora*, 4, 53–69 (in Croatian)

Batović, Š. (1969). Beretinova gradina, Radovin—liburnsko naselje (Beretinova Gradina hillfort, Radovin—Liburnian settlement). *Arheološki pregled*, 11, 56–61 (in Croatian)

Batović, Š. (1985). Rekognosciranje otoka Raba u godini 1984 (Reconnaissance of the island of Rab in 1984). *Obavijesti Hrvatskog arheološkog društva*, 17(1), 13–15 (in Croatian)

Batović, Š. (1987a). Liburnska grupa (Liburnian group). In A. Benac (ed.), *Praistorija jugoslavenskih zemalja* V. *Željezno doba* (pp. 339–391). Sarajevo: Svjetlost (in Croatian)

Batović, Š. (1987b). Ostaci nastambi željeznog doba na našem primorju (Remains of Iron Age dwellings on our coast). *Arheološki radovi i rasprave*, 10, 93–121 (in Croatian)

Batović, Š. (1987c). Prapovijesni ostaci na otoku Rabu (Prehistoric remains on the island of Rab). In A. Mohorovičić (ed.), *Rapski zbornik: Zbornik radova sa Znanstvenog skupa o otoku Rabu, održanog od 25. do 27. listopada 1984. godine* (pp. 147–170). Zagreb: JAZU; Skupština općine Rab (in Croatian)

Batović, Š. (2005). *Liburnska kultura* (Liburnian culture). Zadar: Arheološki muzej (in Croatian)

Berna, F., Behar, A., Shahack-Gross, R., Berg, J., Boaretto, E., Gilboa, A., Sharon, I., Shalev, S., Shilstein, S., Yahalom-Mack, N., Zorn, J.R., and Weiner, S. (2007). Sediments exposed to high temperatures: Reconstructing pyrotechnological processes in Late Bronze and Iron Age strata at Tel Dor (Israel). *Journal of Archaeological Science*, 34(3), 358–373

Blečić, M. (2002). Kastav u posljednjem tisućljeću prije Krista (Kastav in the last millennium BC). *Vjesnik Arheološkog muzeja u Zagrebu*, 35(1), 67–146 (in Croatian)

Blečić Kavur, M. (2014). *Na razmeđu svjetova za prijelaza milenija: Kasno brončano doba na Kvarneru / At the crossroads of worlds at the turn of the millennium: The Late Bronze Age in the Kvarner region*. Zagreb: Arheološki muzej u Zagrebu

Brusić, Z. (1990). Otok Rab: rekognosciranje gradina (Island of Rab: Reconnaissance of hillforts). *Arheološki pregled*, 29, 229–232 (in Croatian)

Buršić-Matijašić, K. (2007). *Gradine Istre. Povijest prije povijesti* (Istrian castellieri. History before history). Pula: ZN "Žakan Juri" (in Croatian with English summary)

Čače, S. (1981). Naselje i nekropola u prostoru zajednice (Settlement and necropolis in the community space). *Dometi*, 5, 35–40 (in Croatian)

Čače, S. and Milivojević, F. (2017). Roman Illyricum in the first century BC: A few remarks. *Vjesnik za arheologiju i historiju dalmatinsku*, 110(2), 425–450

Čondić, N. and Vuković, M. (2017). *U temeljima grada: Iz arheoloških slojeva liburnskoga Zadra* (In the city's foundations: the archaeological layers of the Liburnian Zadar). Zadar: Arheološki muzej (in Croatian)

Čučković, Z. (2017). Claiming the sea: Bronze Age fortified sites of the north-eastern Adriatic Sea (Cres and Lošinj islands, Croatia). *World Archaeology*, 49(4), 526–546

Dautova-Ruševljan, V. (1975). Zaštitno istraživanje podvodnog nalaza amfora na otoku Rabu (Rescue excavations of underwater amphora site on the island of Rab). *Diadora*, 8, 89–102 (in Croatian)

Dietler, M. (1990). Driven by drink: The role of drinking in the political economy and the case of Early Iron Age France. *Journal of Anthropological Archaeology*, 9(4), 352–406

Dietler, M. (2010). *Archaeologies of colonialism: Consumption, entanglement, and violence in ancient Mediterranean France*. Berkeley: University of California Press

Drechsler-Bižić, R. (1986). Naseobinski objekti na nekim gradinama u Lici (Settlement buildings in some forts in Lika). *Vjesnik Arheološkog muzeja u Zagrebu*, 19(1), 107–128 (in Croatian)

Faber, A. (1977). Arheološka topografija Krka (The archaeological topography of Krk). *Arheološki pregled*, 19, 74–77 (in Croatian)

Faber, A. (1980). Osor-Apsorus iz aspekta antickog pomorstva (Osor-Apsorus from the perspective of ancient seafaring). *Diadora*, 9, 289–316 (in Croatian)

Faber, A. (2018). Bajčić na otoku Krku: Pretpovijesno naselje s kontinuitetom. Uz osvrt na suhozidnu kamenu arhitekturu u priobalju Jadrana, međe ili gromače (Bajčić on the island of Krk: Continuity of a prehistoric settlement). In M. Ugarković (ed.), *Praetoria longe lateque lucentia: zbornik radova posvećen Vlasti Begović povodom 65. obljetnice života* (pp. 13–30). Zagreb: Institut za arheologiju (in Croatian)

Forenbaher, S. and Rajić Šikanjić, P. (2006). The prehistoric hillfort at Grad (Peljesac, Dalmatia)—preliminary results of intensive surface survey. *Collegium Antropologicum*, 30(3), 467–473

Glavaš, V. (2014). Viewshed analyses in the prehistoric Velebit landscapes. *Archaeologia Adriatica*, 8(1), 1–26

Glavaš, V. and Glavičić, M. (2017). Naseljenost sjevernog i srednjeg Velebita u prapovijesti i antici (The population coverage of northern and central Velebit in prehistory and antiquity). *Senjski zbornik*, 44(1), 117–128 (in Croatian with English summary)

Glavaš, V. and Glavičić, M. (2019). Transformation of prehistoric to historic landscape: The example of civitas Lopsica. *Senjski zbornik*, 46(1), 119–136

Glavaš, V., Konestra, A., and Tonc, A. (2020). Wine consumption in the Kvarner and sub-Velebit area (NE Adriatic) in the last centuries BCE: evidence from amphorae finds. In M. Ugarković and I. Kamenjarin (eds), *3rd IARPotHP Kaštela 2017. Exploring the neighborhood: The role of ceramics in understanding place in the Hellenistic world (pp. 271–286). Vienna: Phoibos Verlag*

Glogović, D. (1989). *Prilozi poznavanju željeznog doba na sjevernom Jadranu: Hrvatsko primorje i Kvarnerski otoci / Studies in the Iron Age of the northern Adriatic: Hrvatsko primorje and Kvarner islands*. Zagreb: Jugoslavenska akademija znanosti i umjetnosti, Zavod za arheologiju

Gržetić, Z. (ed.). (2002). *Peljar za male brodove* (Pilot for small boats). Split: Hrvatski hidrografski Institut (in Croatian)

Guilbert, G.C. (1975). Planned hillfort interiors. *Proceedings of the Prehistoric Society*, 41, 203–221

Gur-Arieh, S., Boaretto, E., Maeir, A., and Shahack-Gross, R. (2012). Formation processes in Philistine hearths from Tell es-Safi/Gath (Israel): An experimental approach. *Journal of Field Archaeology*, 37(2), 121–131

Gur-Arieh, S., Shahack-Gross, R., Maeir, A.M., Lehmann, G., Hitchcock, L.A., and Boaretto, E. (2014). The taphonomy and preservation of wood and dung ashes found in archaeological cooking installations: Case studies from Iron Age Israel. *Journal of Archaeological Science*, 46, 50–67

Konestra, A., Welc, F., Dugonjić, A., Androić Gračanin, P., Rabiega, K., Solecky, R., and Nowacki, B. (2019). Istraživanja projekta „Arheološka topografija otoka Raba“ u 2018. godini na području Lopara: Nova saznanja o prapovijesnim i kasnoantičkim lokalitetima (Research within the "Archaeological Topography of the Island of Rab" Project at Lopar in 2018: new data on prehistoric and late antique sites). *Annales Instituti Archaeologici*, 15(1), 187–194 (in Croatian with English summary)

Konestra, A., Welc, F., Androić Gračanin, P., Rabiega, K., Nowacki, B., and Kukela, A. (2020). Tipologija i organizacija otočnih naselja Raba kroz dijakronijski pristup – prvi podaci multidisciplinarnih istraživanja (Rab island settlement typology and organisation through a diachronic approach. First data from a multidisciplinary research). *Annales Instituti Archaeologici*, 16(1), 229–244 (in Croatian with English summary)

Lipovac Vrkljan, G., Šiljeg, B., Ožanić Roguljić, I., Konestra, A., Kostešić, I., and Šegvić, N. (2014). Projekt Arheološka topografija otoka Raba: Rezultati terenskog pregleda poluotoka Lopara u 2013. godini (The "Archaeological Topography of the Island of Rab" Project: The results of the 2013 field survey of the Lopar Peninsula). *Annales Instituti Archaeologici*, 10(1), 202–208 (in Croatian with English summary)

Marjanac, T. and Marjanac, L. (2007). Sequence stratigraphy of Eocene incised valley clastics and associated sediments, Island of Rab, northern Adriatic Sea, Croatia. *Facies*, 53(4), 493–508

Miholjek, I. (2007). Podmorsko arheološko nalazište kod rta Sorinj na otoku Rabu (The submarine archaeological site at Cape Sorinj on the Island of Rab). *Histria antiqua*, 15, 377–384 (in Croatian with English summary)

Mihovilić, K. (1979). Gradina Punta Kašteja kod Medulina. Prilog prahistorijskoj topografiji Istre (The fort of Punta Kašteja near Medulin. A contribution to the prehistoric topography of Istria). *Histria archaeologica*, 10(1), 37–56 (in Croatian)

Mihovilić, K. (2002). Grčki i helenistički nalazi u Istri i Kvarneru (Greek and Hellenistic finds in Istria and Kvarner Bay). In N. Cambi, S. Čače, and B. Kirigin (eds), *Greek influence along the east Adriatic coast. Proceedings of the international conference held in Split from September 25th to 26th 1998* (pp. 499–519). Split: Književni krug (in Croatian with English summary)

Mihovilić, K. (2013). *Castellieri-gradine* of the northern Adriatic. In H. Fokkens and A. Harding (eds), *The Oxford handbook of the European Bronze Age* (pp. 864–876). Oxford: Oxford University Press

Mihovilić, K. (2014). *Histri u Istri: Željezno doba Istre / The Histri in Istria: the Iron Age in Istria*. Pula: Arheološki muzej Istre

Morgan, R.P.C. (2005). *Soil erosion and conservation* (3rd ed.). Oxford: Blackwell Publishing

Pavišić, I. (1985). Omišalj, Krk—prethistorijski stambeni objekt (Omišalj, Krk – Prehistoric residential building). *Arheološki pregled*, 24, 57–58 (in Croatian)

Pisoni, L. (2008). L'utilizzo del fuoco nella cottura degli alimenti e nel riscaldamento degli edifici della Cultura di Fritzens-Sanzeno, del Gruppo di Magrè e della Valcamonica. *Preistoria Alpina*, 43, 75–86

Riva, C. (2010). Trading settlements and the materiality of wine consumption in the North Tyrrhenian Sea region. In P. van Dommelen and A.B. Knapp (eds), *Material connections in the ancient Mediterranean: Mobility, materiality and Mediterranean identities* (pp. 210–232). London–New York: Routledge

Starac, R. (2009). Povijest izrade keramičkih predmeta na Kvarneru. Arheološka keramičarska baština (The history of making ceramic objects in Kvarner. Archaeological ceramic heritage). *Novi Kamov*, 31(2), 35–44 (in Croatian)

Suić, M. (2003). *Antički grad na istočnom Jadranu* (Ancient city on the eastern Adriatic) (2nd rev. ed.). Zagreb: Golden Marketing (in Croatian)

Šešelj, L. and Vuković, M. (2013). Liburnsko naselje u Radovinu: Preliminarna analiza keramičkog materijala (Liburnian settlement in Radovin: preliminary report on pottery analysis). *Diadora*, 26–27, 333–350 (in Croatian with English summary)

Šimunović, P. (1986). *Istočnojadranska toponimija* (Toponymy of the eastern Adriatic). Split: Logos (in Croatian)

Theocaris, P.S., Liritzis, I., Lagios, E., and Sampson, A. (1996). Geophysical prospection, archaeological excavation, and dating in two Hellenic pyramids. *Surveys in Geophysics*, 17(5), 593–618

Vuković, M. (2014). Thoughts on Liburnian pottery found in archaeological Trench 63 at the Beretin hillfort in Radovin. *Diadora*, 28, 21–52

Welc, F., Konestra, A., Dugonjić, A., Androić Gračanin, P., Rabiega, K., and Nowacki, B. (2019). Multidisciplinary insight into late Roman rural settlement on the northeastern Adriatic coast of Croatia: Island of Rab case study. *PAM*, 28/2, 481–508

Welc, F., Nebelsick, L.D., and Wach, D. (2019). The first Neolithic roundel discovered in Poland reinterpreted with the application of the geophysical Amplitude Data Comparison (ADC) method. *Archaeological Prospection*, 26(4), 283–297

Welc, F., Rousse, C., and Benčić, G. (2020). Results of geophysical scanning of a Roman senatorial villa in the Santa Marina Bay (Croatia, Istria) using the Amplitude Data Comparison (ADC) method. *Studia Quaternaria*, 37, 79–90