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USING GIS IN THE DIACHRONIC STUDY OF LATE ROMAN SETTLEMENT TRANSFORMATIONS: PRELIMINARY DATA AND POSSIBLE RELATIONS TO ENVIRONMENT CHANGE IN THE NORTH-EASTERN ADRIATIC

Abstract: In the paper the use of GIS to diachronically analyse the settlement pattern detected through archaeological research is illustrated on the case study of the island of Rab (NE Adriatic, Croatia) and correlated with a model of the island's economic output, its environmental features and available data on regional changing climatic conditions. The obtained results are then interpreted within a wider Adriatic setting and a current theoretical framework which allows to correlate socio-economic and environmental indicators in the interpretation of archaeologically detected changes in the use of the landscape.

Keywords: landscape archaeology, late antiquity, NE Adriatic, GIS, Island of Rab, climatic changes

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Introduction

Landscape archaeology has since long benefited from the use of Geographic Information Systems (GIS) to collect, store, analyse, interpret and present spatial archaeological data, such as that generated through survey and reconnaissance projects, while the growing availability of digital cartography and other environmental datasets allowed the development of more complex modelling methods aided by the application of different spatial technologies (Lock, 2003; Conolly, 2008; Verhagen, 2018). Several analytical techniques and methods are now commonly used to understand human-environment relationships and human interaction with space, such as visibility analysis, modelling of movement and site location analysis (Verhagen, 2018).

The use of GIS in eastern Adriatic archaeology was pioneered by the team of the *Adriatic Islands Project* in the late 1980s-early 1990s (Gaffney & Stančič, 1991), and has since been applied in various areas and research projects (e.g. Glavaš, 2014; Glavaš & Grilj, 2016; Čučković, 2017). From 2013 research within the project *Archaeological topography of the island of Rab* has made use of a GIS and an *ad-hoc* created database to manage spatial data collected during the project's fieldwork activities (Lipovac Vrkljan et al., 2014; Lipovac Vrkljan et al., 2017). Thanks to a number of cartographic layers this archaeological dataset can be placed within a wider environmental context and analysed both spatially and diachronically.

In this contribution we will focus on the case study of Rab island, attempting a diachronic site location analysis which will draw on previous research on Rab island's economic capacity in the Roman/late Roman and early Medieval period (Lipovac Vrkljan et al., 2017), and new data collected and generated through subsequent fieldwork (e.g. Welc et al., 2019; Konestra et al., 2019; Konestra et al., 2020). Rab island is located in the NE Adriatic, being a medium-sized island of the Kvarner archipelago (Fig. 1). Its location, just a few kilometres from the coastal belt of the Velebit mountain and few nautical miles from the neighbouring islands of Krk and Pag, assured excellent connectivity to its inhabitants from the earliest of times.

Fig. 1. Location of the island of Rab
Source: elaboration A. Konestra, basemap: Google Earth

The island's simple geological structure, composed of two anticlines and two synclines composed of Cretaceous carbonate rocks and overlain uncomfortably by Eocene carbonates, known as "flysch" (Marjanac & Marjanac, 1991; 2007), forms two inland ecological zones to which the coastal belt can be added, thus allowing the development of various types of subsistence activities. Developed surface hydrology is insured by the combination of higher precipitations and impermeable sediments; rain which infiltrates through carbonate rocks is confined within aquifers, while surface water is present in the form of springs, pools, waterholes and periodical torrents (Lončarić et al., 2011). Such karst aquifers, while being a valuable water source, are also a sensitive one, reacting quickly to changes in surrounding conditions (Lončarić et al., 2011). Sufficient water and location within Mediterranean climate zone (Köppen Csa) (Šegota & Filipčić, 2003) allowed typical Mediterranean agriculture to develop within several larger flysch fields at least from the Roman period onwards (Nedved, 1990). On the other hand, a large segment of the (pre-)historic economy must have relied on sheep (and possibly other animal) husbandry making use of the rocky pastures of the island's northern ridge. Shallow coastal lagoons, numerous on the island, were exploited as salt pans at least from the late Middle Ages (Piplović, 2003), while exploitation of other marine resources must have been at least a secondary activity in the Roman and prehistoric periods, as several but still scanty finds suggest (Konestra et al., 2021).

Data for environmental reconstruction for the Kvarner area is still very scanty, though a general trend has been evidenced by lacustrine sediments from Vrana lake on the island of Cres (Schmidt et al., 1999), and some comparative data is available for the wider Eastern Adriatic (e.g. Smith et al., 2006; Rudzka et. al., 2012; Welc, 2019). Nevertheless, recent studies, though dealing with later periods or predictive modelling, allow to infer the modes and levels of interdependency of human-environment interactions on the island (Benac et. al., 2006; Lončarić et. al., 2011; Ružić & Benac, 2016). Thus, environmental data, while not offering precise or complete datasets can still evidence certain factors that should be considered when trying to explain the changes that are evident from the archaeological record. Ongoing efforts to collect more precise and detailed environmental data will certainly allow a better reconstruction of the environmental conditions throughout the period dealt with. On the other hand, archaeological data for Roman period settling on Rab island is growing and allows to reconstruct a vibrant occupation of extra urban areas, mostly with residential-productive sites (generally termed *villae*), whose economy relied on resource exploitation, agriculture, craft production and trade (Rothe, 2018; Bowden, 2018; Lipovac Vrkljan et. al., 2017). While only one urban centre developed on the island in Antiquity – Roman *Arba* (modern Rab town) – rural settling occurred within the flysch fields of Lopar, Mundanije/Supetarska draga and Kampor, and along the coastal belt (Welc et al., 2019, Fig. 2). Such settlements thrived within roughly the first five centuries AD. Previous research, applying aoristic analysis to stone finds and architectural remains (features) for which a more or less accurate date could be inferred, allowed to determine several periods of intense construction activity on the island, followed by periods of stagnation. This was then related to the overall wealth and economic capacity of the island within a given time-frame (Fig. 2).

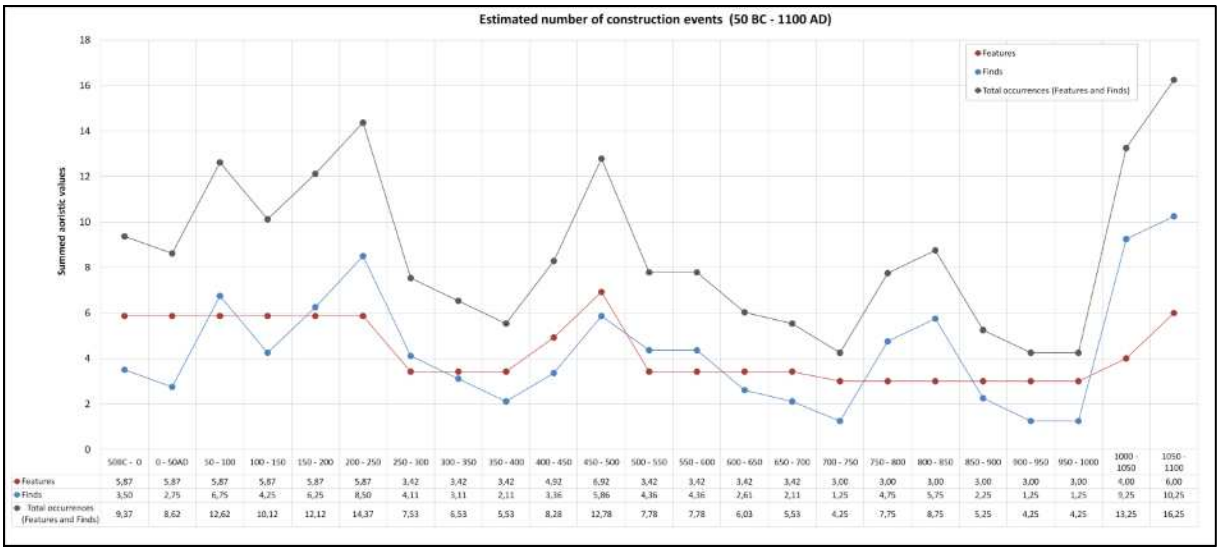

Fig. 2. Accumulated aoristic values for stone finds (red), architectural remains (blue) and total sum of values (gray)

Source: Adapted from: Lipovac Vrkljan et al., 2017, Fig. 4; data analysis by N. Šegvić

What has also been noted along with the fluctuation of construction activities, that is, investment in public and private architecture and furnishing, is a particularly marked shift of rural sites location and typology within the time-frame 500-800 AD (Lipovac Vrkljan et. al., 2017, Fig. 6, 7). While economic and social constrains for the afore-mentioned period can, at least partly and in general terms, be inferred on the bases of historical and other comparative data, changes in the spatial organisation of settlement should consider environmental factors as well. Thus, an attempt will be made to analyse settlement location in relation to several basic environmental factors, such as geological and pedological features and hydrography.

Data

The heterogeneous archaeological dataset acquired through various fieldwork activities, archival and literature sources, and find's cataloguing within the *Archaeological topography of the island of Rab* project required standardisation and unification to allow further manipulation and analysis. Therefore, a spatial database was created for the needs of the project. The relational GIS database is accessed and manipulated within open-source desktop-based software QGIS (https://qgis.org/en/site/) with a protected access, while viewing and basic queries are also possible within Quantum GIS Web Client. A bottom-up approach is based on an input of variety of data types into GIS ("Multi Input") defined by three core archaeological levels with spatial representations of "Sites", "Features" and "Finds". These core levels are further supplemented with subsidiary levels such as Archival, Literature Sources, and Survey conditions to mention a few. Most importantly, the archaeological levels are defined by their "Datation" which can be broadly defined as specification of main historical periods or related sub-periods restricted by their *terminus post quem* and *terminus ante quem* years (Lipovac Vrkljan et. al., 2017, p. 316, Fig. 1).

Digital cartography was acquired through the State Geodetic Administration of the Republic of Croatia (DGU), The Institute for Physical Planning of Primorje-Gorski Kotar County Public Institution, The Ministry of Culture and Media of the Republic of Croatia – Conservation Department in Rijeka for the area of the Primorje – Gorski Kotar County, Hrvatske Vode d.d., and local municipalities, while some data was georeferenced from digital images. The cartographic layers comprise:

- 1:25 000 topographic map
- 1:5 000 map
- Digital Orthophoto
- DEM (low resolution)
- Cadastre
- Georeferenced Franciscan cadastre (1820ies)
- Current vegetation cover
- Basic geology and pedology
- Current hydrology and flood potential

As digital hydrological data was of insufficient resolution, springs, watercourses and water bodies were digitised as three separate layers from the topographic map, the 1:5 000 map and the Franciscan cadastre either as points, lines or polygons. This approach allowed to consider both modern and the only historically available data, that of the Franciscan cadastre, the latter being also very detailed featuring, in fact, much more data that the modern cartography. For examples, the Franciscan cadastre shows a complex network of channels, probably intended for field drainage, within the Mundanijsko and Kamporsko polje fields. On the other hand, the predictive model of flooding is based on current hydrology.

During filed survey sites were mapped with the aid of handheld GPS recording maximum extension of architectural remains and/or areas with surface finds. These were then rendered as polygons within the GIS, but for the needs of these research they were transformed into points. Various degrees of certainty regarding the dating of the sites can be associated to each database feature, but for the purpose of this paper a grouping within major periods was applied: Roman (all sites date to the Roman period, including sites with continuity into late Antiquity), late antique (site where only late antique finds were recovered or features where detected, e.g. early Christian churches), early Medieval (sites with indications of early Medieval frequentation) and Medieval (sites with onset or frequentation during the Middle Ages) [Periods can roughly be dates as follows: Roman (1st c. – 7th c. AD), late Antique (5th c. – 7th c. AD), early Medieval (7th c. – 11th c. AD), Medieval (11th c. – 15th c. AD)]. In fact, without stratigraphical data, on most occasions a detailed per-site periodisation is impossible, thus only securely ascertained dates were considered. As some sites present two clear phases of frequentation/construction (e.g. two subsequent churches located within the same site), on such occasions these where recorded as separate features, but for this occasion, to facilitated rendering of continuity of use of a specific space, they were transformed into separate sites. Recorded sites belong to a wide typology as illustrated in Table 1., where all dating are also presented:

Table 1. Typology and dating of considered sites

ID	Name	Typology	Dating
1	Podšilo	Productive – residential	Roman
2	Zidine	Productive – residential	Roman
3	/	Unknown	Roman
4	Mahućina	Productive	Roman
5	Sv. Marija	Sacral	Medieval
6	/	Rural unknown	Roman
7	/	Rural unknown	Roman
8	Mirine	Rural unknown	Roman
9	Ćepulovo	Rural unknown	Roman
10	Mostir	Rural unknown	Roman
11	Lukovac	Sacral – fortification	Late Antique
12	Sv. Danijel	Sacral	Medieval
13	Solane	Productive	Medieval
14	Sv. Petar 1	Rural unknown	Roman
15	Sv. Petar crkva 1	Sacral	Late Antique

16	Sv. Petar Opatija	Sacral	Early Medieval
17	Sv. Petar 2	Rural unknown	Roman
18	Dumičići	Productive – residential?	Roman
19	Gonar	Productive	Roman
20	Kaštelina	Residential	Roman
21	Miral	Sepulchral	Roman
22	Boljfari	Rural unknown	Roman
23	Tafarije	Rural unknown	Roman
24	/	Sepulchral	Roman
25	Sv. Eufemija	Sacral	Medieval
26	Sv. Mavro	Sacral	Medieval
27	Sv. Ciprijan – complex	Rural unknown	Late Antique
28	Sv. Cirpijan – later church	Sacral	Early Medieval
29	Sv. Mara	Sacral	Medieval
29	Sv. Zenon	Sacral	Medieval
30	Sv. Franjo	Sacral	Medieval
31	/	Unknown	Roman
32	Arba	Urban	Continuous
33	Sv. Matej	Sacral	Medieval
34	Sv. Ilija	Sacral	Medieval
35	Sv. Anastazije	Sacral	Medieval
36	Za Markovićem	Sacral	Roman
37	Nad Matušani	Sacral	Roman
37	Sv. Marko	Sacral	Medieval
38	Sv. Marko – architecture	Rural unknown	Roman
39	Sv. Lucija	Sacral	Medieval
39	Sv. Dujam	Sacral	Medieval
40	St. Petri in Muchia	Sacral	Medieval
41	Sv. Lovro	Sacral	Late Antique
42	Sv. Kuzma i Damijan	Sacral – fortification	Late Antique
43	Sv. Lovro – later church	Sacral	Medieval
44	Sv. Kuzma i Damijan – later church	Sacral	Medieval
45	Sv. Antun	Sacral	Medieval
46	Sv. Stjepan – Opatija	Sacral	Early Medieval
47	Sv. Stjepan – earlier complex	Sacral – sepulchral	Late Antique
48	Sv. Ivan	Sacral	Medieval
49	Mirine	Rural unknown	Late Antique
50	Val Martina	Residential	Late Antique
51	Pudarica	Sepulchral	Late Antique
52	Kordići	Sepulchral	Roman
53	Fruga	Unknown – rural?	Roman

Source: Archaeological topography of the island of Rab project

A total of 139 sites related to all prehistoric and historic periods were so far recorded within the database. Of these, 53 are considered on this occasion, of which only three can be dated with a good degree of certainty to the early Middle Ages, 19 to the Middle Ages, 24 to the Roman period, nine to late Antiquity, while the town of Rab, due to its ascertained continued occupation is considered separately. In the next stage, the data concerning location of individual sites and their statistics were compared with the geological and hydrological structure of the island of Rab to capture the relationships between the development of local settlement and environmental conditions, so to allow their evaluation within changing environmental conditions recorded also in a wider regional context.

Results and discussion

As illustrated in Fig. 3–5, combined analysis of several of the aforementioned layers with the archaeological dataset allow to delineate the island's settlement pattern throughout the Roman, late Antique and early Medieval period, taking into consideration site's location in relation to natural features. Firstly, by observing sites' location in regard to the island's geology it is evident that the vast majority of Roman sites is located within the flysch fields, usually on slightly elevated positions and often on the edges of fields (e.g. Kampor, Lopar) (Fig. 3). This, along with finds from archaeological survey and excavations allows to interpret most of the sites as agricultural productive units exploiting the fields and slopes for different crops and related economic activities. Undoubtedly, apart from suitable soil, the basic factor enabling existence of permanent Roman rural settlements in these areas was the availability of water, which flowed in numerous streams from higher ground. In present times, similarly as in the past, on the Island of Rab there are a number of natural springs (Lončarić et. al., 2011; Kovačić, 2013; Welc et al., 2019) (Fig. 4). These water sources were strictly associated with local underground karst hydrological system located within carbonate rock formations. They were at the base of human occupation in the past and are still an important water source for the modern inhabitants (Terzić et al., 2010). Along with these, the importance of water management is evidenced by the network of channels present within all of the island's fields, being most evident in Supetarska Draga (Fig. 4, data from the Franciscan cadastre). The dating of these interventions is still elusive [Though of difficult dating, these earthworks are certainly earlier than the 19th c. (the Austrian cadastre dates to the 1820s), and might have been initiated in their current form at least from the early Modern period onwards, as examples in adjacent areas might suggest (e.g. Mlinarić, 2009). It should also be considered that a system of water canalization was necessary in order to allow functioning of the salt pans in Supetarska Draga bay, thus perhaps a part of this system could be dated as early as the 14th century (Piplović, 2003).], but they undoubtedly indicate the need for large scale interventions in water management, probably maintained in the long run, until the present.

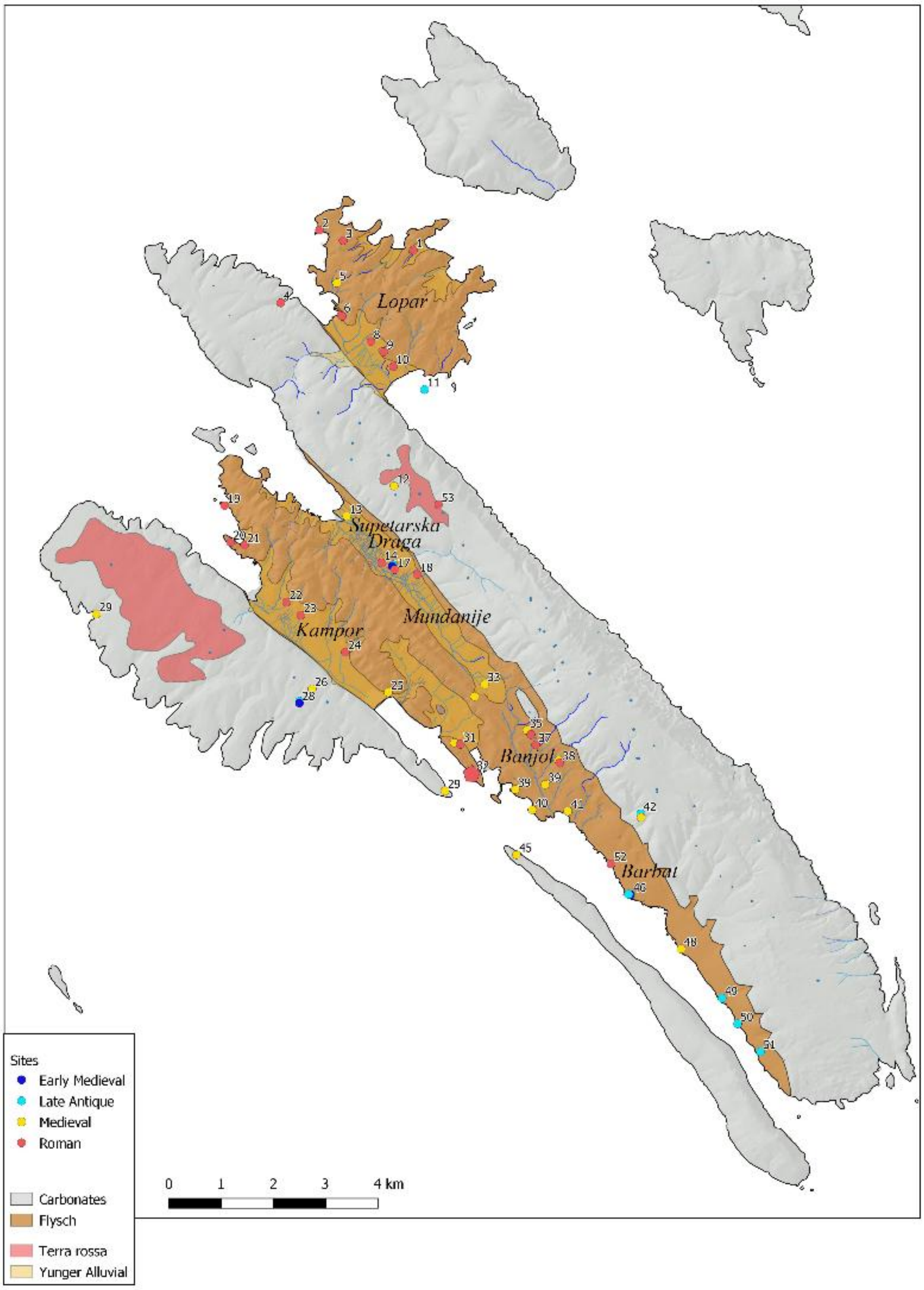

Fig. 3. Location of ascertained Roman, late antique and medieval sites on the island of Rab overlaid to basic geological features and hydrology with placenames of main island's settlements/areas; refer to Table 1 for site names
Source: Archaeological topography of the island of Rab project

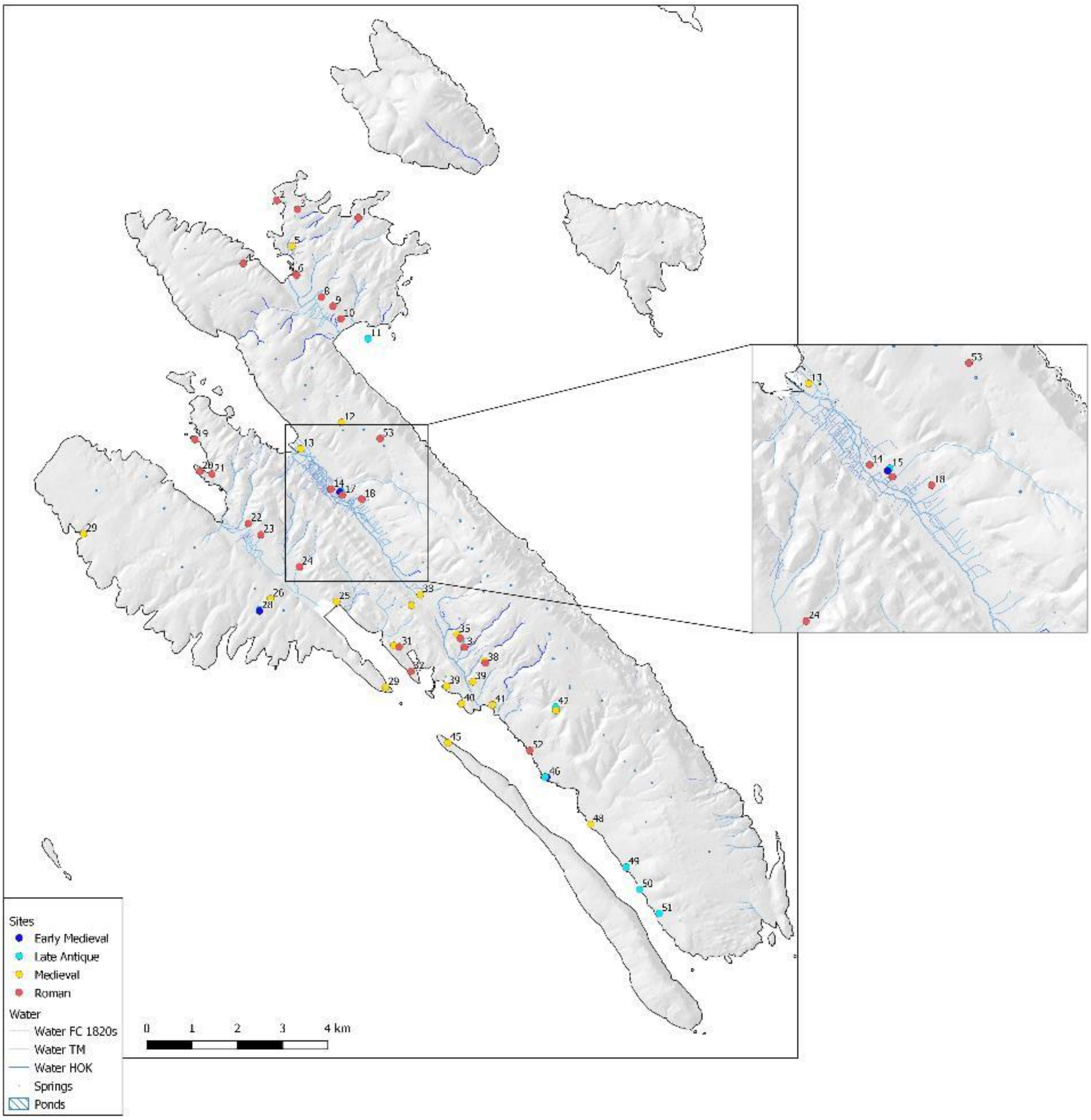

Fig. 4. Location of ascertained Roman, late antique and medieval sites on the island of Rab overlaid to hydrology and relief; in the evidenced rectangle: area of Supetarska draga with network of channels; refer to Table 1 for site names
Source: Archaeological topography of the island of Rab project

Only two sites – No. 4 and 53, are located on different terrain. Both might be linked to their diverse typology, or more precisely to specific resource exploitation, which in the first case is ascertained as the site consists of at least two pottery kilns, while the second one is still of unknown function, but possibly related to agricultural exploitation of the Fruga plateau, husbandry, or perhaps timber sourcing. A total of 11 sites, while still located within the flysch areas of the island are also located on the shore. These are mostly ascertained residential complexes. Due to their costal orientation, two more ascertained productive sites (sites No. 19 and 4) could be added to this group.

Justification of their placement could be sought in their typology (Lipovac Vrkljan et al. 2015; Lipovac Vrkljan & Konestra, 2018). Late Antique sites and those with continuation into late antiquity tend to follow the same principle, but now with the emergence of different and differently located sites (No. 11 and 44), which can be classified as fortifications.

When compared with the location patterning of the early Middle Ages, only two sites re-used previous Roman or late Antique positions (sites 15 and 27). Different typology of recorded early Middle Ages sites on the island could be the cause of the relocation of the sites. However, in both cases, sites No. 15 and 27, sacral complexes are recorded. Supeterska Draga (site No. 15) being an abbey which, while reusing the location of previous sacral buildings probably relied on the available resources through landownership known from historic sources (Mlacović, 2012, p. 181). This example indicates the only so far persisting evidence of use of a same rural location, but with a lesser extent and an overall different function and organisation. Recognised subsequent Medieval sites belong almost exclusively to sacral buildings, except for the Supetarska Draga saltpans (site No. 13), while no evidence of Medieval rural settlements is so far known.

The observed changes could signal out a different use of the rural landscape, which could in part be the consequence of hydrographic network reorganization within the landscape evolution (for a predictive model based on recent data see Fig. 5), resulting from environmental changes that took place from late antiquity onwards. The performed statistical analysis of building activity on the island (that is, erection of new structures and monumental features) in the first millennium AD showed a stasis in investment in both urban and rural areas between the 5th/6th and the 9th–10th c. (Fig. 2), which can have twofold interpretation, i.e. on the one hand it could indicate a steady settling, especially in the first part of the tackled period, but on the other a lack of means to invest in renovation and urban decor, possibly signalling a contraction of rural settling and its economic output (for a more detailed discussion see Lipovac Vrkljan et al., 2017).

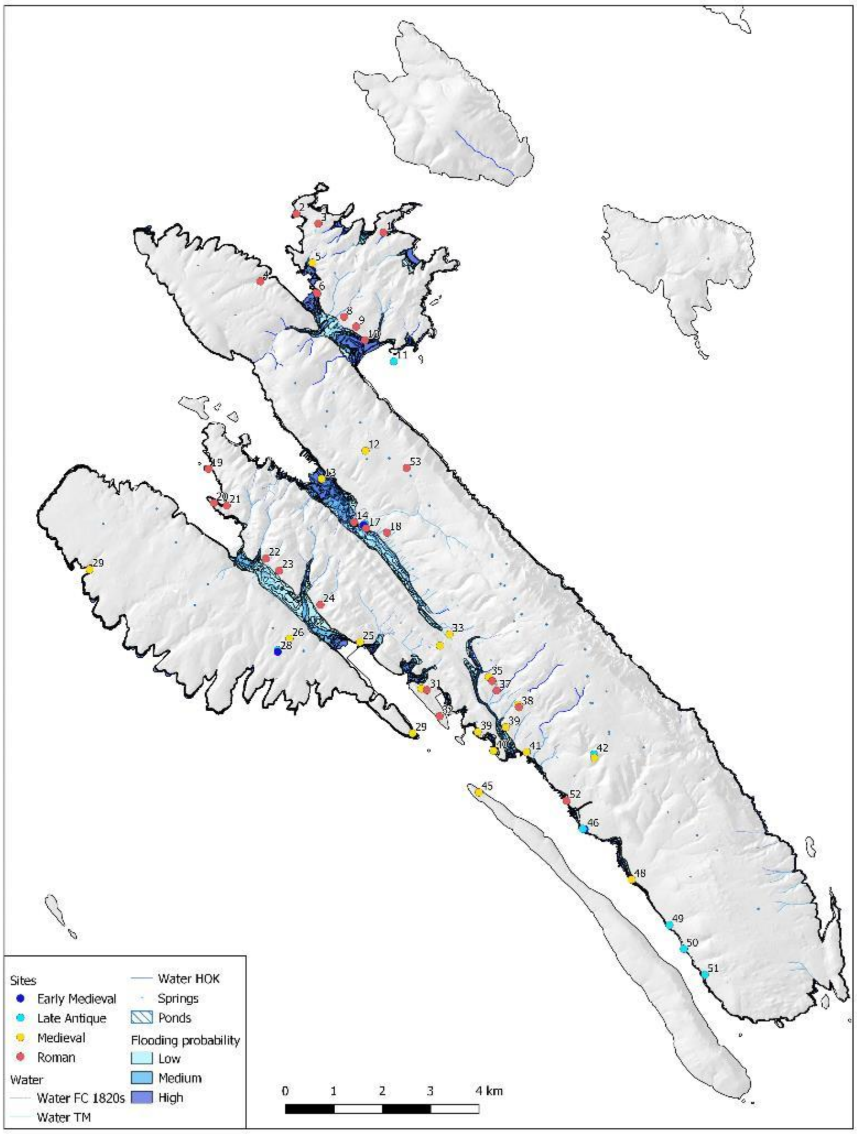

Fig. 5. Location of ascertained Roman, late antique and medieval sites on the island of Rab overlaid to hydrology, relief and predictive model for flooding; refer to Table 1 for site names
Source: Archaeological topography of the island of Rab project

Steady use of rural and coastal settlements well into 4th–5th c. with, on some occasions, possible further remodelling and additions, sees an abrupt change from the 6th c. onwards. Most settlements seem to end or contract, while new investments are marked only by the erection of churches (the peak noted between the 5th and 6th c.). Also, a different type of settlement develops, that is fortified and nucleated sites located on hilltop or islet positions, possibly to be connected with a system of Byzantine (?) control of the sea routes (for the latter see Gračanin, 2016, p. 83–84) or with different modes of rural landscape occupation. The period of the early Middle Ages is virtually imperceptible in the island's countryside, which might be a signal of radical changes in exploitation and settlement patterning, but an overall archaeological invisibility of early Medieval settling must be considered. The fact that virtually all rural sites datable to the early Middle Ages are monastic complexes, might confirm that the setup of a different model of economic organisation and exploitation of the agricultural land must be considered, also in the sense of different actors were now involved in rural investment and management. Further archaeological research will have to address the question if these apparently *long durée* sites were in fact used in continuity or whether a hiatus in occupation can be detected.

These observations could be interpreted within more general trends detected for the time-frame under scrutiny, but factors other than socio-political should perhaps be taken into consideration. The period in question can, in fact, be associated with a dry episode dated to ca. the 5th c. AD, followed by a wet and probably cold interval which occurred probably around the late 6/7th–8th century AD (Welc, 2019) (Fig. 6).

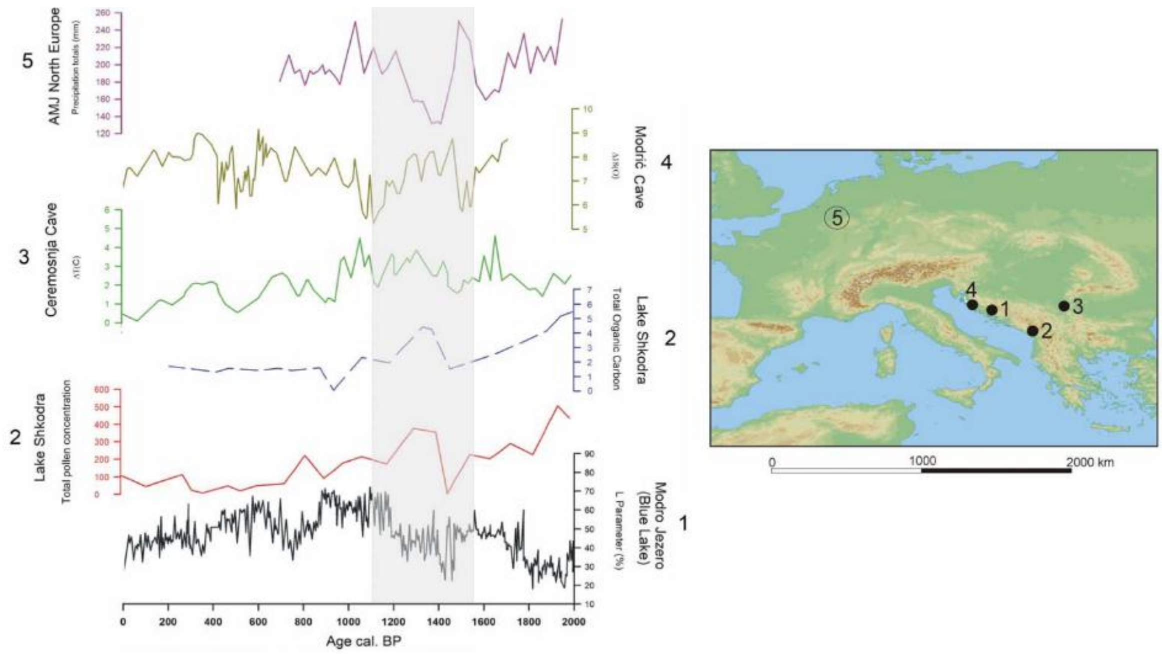

Fig. 6. Comparison of normalized composite proxy records from the eastern Adriatic region and north Europe. 1. Blue Lake (Modro Jezero): distribution of the L*parameter (After: Miko et al., 2015). 2. Core SK-13 from Lake Shkodra: total pollen concentration (After: Sadori et al., 2015). 3. Ceremosnja Cave: reconstruction of the average temperature based on isotope studies of the stalagmites (After: Kacanski et al., 2001). 4. Modrić Cave: interpretation of the stable isotope record based on studies of stalagmite MOD-22 (a) (After: Rudzka et al., 2012). 5. Reconstructed AMJ precipitation based on 7284 precipitation-sensitive oak ring width series mostly from Northern Europe (Germany and France) (After Büntgen et al., 2011)
Source: adapted from Welc, 2019

These two episodes are attested by studies of lake bottom deposits of the Blue Lake (Modro Jezero) in central Dalmatia (Miko et al., 2015). In the period between the 4th and the 7th c. the lake was characterised by intensive carbonate sedimentation, which may be correlated with frequent drought periods. After ca. the 7th c. AD, the lake became much deeper, mostly due to higher rate of water discharge. Other important data was obtained from lake Vrana on the island of Cres (Ilijanić & Miko, 2016). Paleoenvironmental reconstruction of the lake development stages recorded a significant fall of the water table between the 5th and the 7th c. AD. These data indicate that at the end of the discussed period, ca. 7th c. AD, all analysed parameters note opposite trends, indicating increase in rainfall in the vicinity of the lake. Palynological studies of lake bottom sediments of Lake Shkodra in Albania (Sadori et al., 2015) indicated that at ca. 5th c. AD the forest around the lake was drastically reduced possibly due to severe drought (Sadori et al., 2015). Described data can be supplemented by preliminary analysis carried out at Plemići bay (Zadar county). Here, the area occupied by a Roman (1st-2nd century AD) pottery workshop (Lipovac Vrkljan & Konestra 2018), was covered by immense soil-debris flows. Performed analysis indicates that these sediments were formed under conditions of relatively dry climate. In the next phase, mass of sediments was transported down slope and deposited on top of the Roman structures during an intensely wet interval. The dating of the complex at Plemići suggests that the intensification of the slope processes took place after its demise, roughly between ca. 5th and 9th c. AD (Welc, 2019). The dry episode diagnosed in Plemići bay seems to be confirmed by results of paleoenvironmental research carried out in the Istrian peninsula as well (Santa Marina Bay and the mouth of the Mirna river, north-western part of the region) (Faivre et al., 2011; Felja et al., 2015; Welc, 2020), suggesting it was not just a local phenomenon but an over regional climatic fluctuation. In the first case, a core drilled in Santa Marina Bay revealed a transition from marine-lagoonal to continental origin sediments deposited during the last two thousand years (Faivre et al., 2011). The lowermost unit represents marine sediments that are covered by slope deposits represented by red clays, whose features indicate their formation by intensive erosion of terra rossa during a very intense wet interval following a dry episode, sometime after late Antiquity (Faivre et al., 2011). In the second case, it can be supposed that extensive depositional phases of sediments detected along the Mirna River reflect peak flooding episodes dated to the period between late Antiquity and the early Middle Ages (Felja et al., 2015).

Conclusions

While only one urban centre developed on the island in Antiquity – Roman *Arba* (modern Rab town), rural settling occurred within the flysch fields of Lopar, Mundanije/Supetarska draga and Kampor, and along the coastal belt. The possibility to follow, on some occasions, property ownership and extension (at least on the level of buffer zones), indicates the formation of a vibrant rural economy and dense settling from the 1st c. AD onwards, if not before. Several periods of economic and political crisis followed from the 3rd c. onwards, culminating in widespread, empire wide movements of people from eastern and northern Europe towards the Mediterranean and the Roman west. Dalmatia was, nevertheless, mostly spared the destabilizing effects of these migrations, especially its coastal and insular zone (Gračanin, 2015, p. 84–85). The invisibility of subsequent, early Medieval features, while certainly depending on the state of research, consequently, also signals a radical change in sustenance strategies, intra-site organisation and inter-site morphology. A further indicator of subsequent spars settling of rural areas is the late formation of the current settlement pattern, which rarely reuses location of previous Roman or Medieval sites. Similarly, more intense use of the rural landscape from a somewhat later date could be indicated by the numerous late Medieval/early Modern rural chapels, mostly erected in proximity of communication pathways crisscrossing the island's field.

Thus, the changing settlement patterns, while following a general historic development of the wider Adriatic area, allows us, thanks to its particular micro-regional and environmental characteristics, to explore it from a different angle, that of environmental changes and their effects on the use of the landscape. Without incurring in deterministic pitfalls (e.g. Poblome, 2015, p. 105–106; Izdebski et al., 2016, p. 11–12), it could nevertheless be argued that the available archaeological data indicates that from late antiquity and throughout the early Middle Ages the intensity of use of rural productive areas was probably diminished, and without doubt structurally changed. Whether this was exclusively a consequence of socio-political turmoil and to which degree changing environmental factors influenced it will have to be studied in more depth by collecting different sets of proxies. Also, the ways in which rural occupation and economy was adapted to changing conditions, that is, whether what we observe is an indication that the societal power to mitigate extreme events was diminished, will have to be further evaluated and better understood through targeted archaeological research.

In recent years, thanks to the application of new methodologies and theoretical approaches (e.g. Kluiving et al., 2021), similar trends observed in various adjacent areas are now being evaluated from an environmental standpoint as well, and taking into consideration both rupture and resilience in landscape occupation (e.g. Brogiolo, 2015). Following these changes and evaluating their relationship within the local landscape with the aid of GIS allows a more precise and detailed analysis thanks to the possibility of combining various data sources, as well as different analytical tools. Further research on the evolution of the rural settlement pattern of Rab island will thus be developed through two strands of research, one dedicated to the collection of more detailed environmental data, and the other which will make further use of the analytical tools provided by geoinformation systems. Also, applying the same methods to a wider time-frame will allow to build a more robust and complete model of the islands' human-environment interaction, including adaptation and responses to changing environmental conditions and thus, perhaps, to better explain the here evidenced changes.

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