An insight into craft activities in rural areas of Dalmatia Province - First data on iron working at the Roman settlement in Lopar (Island of Rab)

KONESTRA, ANA; WELC, FABIAN; ANDROIĆ GRAČANIN, PAULA; WEKER, WŁADYSŁAW

ANA KONESTRA, FABIAN WELC, PAULA ANDROIĆ GRAČANIN, WŁADYSŁAW WEKER

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Within multidisciplinary research carried out at Podšilo bay in Lopar on the island of Rab (north-eastern Adriatic), on the bases of movable finds and, possibly, geophysical measurements, evidence of ironworking has been detected within a Roman rural site where ceramic building materials production was ascertained before. Preliminary analyses of several samples of slug, iron objects and nearby collected minerals support the presumption of metallurgical activities occurring at the site. An overview of regional and wider analogies allows to propose several scenarios of iron working setup, scale and organisation.

Keywords: Roman rural sites, Roman Dalmatia, iron working, multi-crafting, pottery production

Research on the economy and craft industry of ancient province *Dalmatia* (eastern Adriatic and its hinterland) is still scanty and geographically sparse, until now favouring areas rich with monumental and epigraphic evidence, such as the ore-rich hinterland of today's Bosnia and Herzegovina (Škegro 1999: 17–138 and Durman 2002 for metals; see also: Suić 1981: 261; Glisksman 2005: 209; 2007; Sanader 2006: 154–155, 161; Kurilić 2008: 21–25), while activities of processing and production within coastal settlements, especially the ones active in the rural areas, have yet to be fully understood (e.g. Lipovac Vrkljan, Šiljeg 2012: 12). Therefore, more attention should be given to such sites and other parts of the province, by applying new approaches and methods, considering both direct, material evidence of crafts and processing activities (such as remains of infrastructure) and indirect evidence (such as moulds, wasters or the products themselves), while applying not only archaeological but also multidisciplinary methods. A similar approach has recently been attempted in regard to pottery and ceramics production within the coastal part of the province, yielding several new paradigms for the study of not only this craft, but also for better understanding of the development and economy of rural areas, their production activities and their chronology (see: Lipovac Vrkljan, Konestra 2018).

Within the *Archaeological topography of the island of Rab* project[1] a different set of multidisciplinary research activities are being carried out continuously since 2013, focusing on all aspects of archaeological heritage dating to all periods. Attention is being paid to human-environment relationship, in particular to the human impact on its environment that is visible in the various use of the landscape throughout time. Thus, within the aforementioned project not only movable finds and evidence of structures, but also other traces indicating economic activities and the exploitation of raw materials are being documented. Among others, evidence of different diachronically disparate crafts has been evidenced including, for the Roman period, pottery/ceramics production and possible evidence for the processing of iron. It is the latter that will be tackled here in more depth, through archaeological and preliminary metallographic analysis of the evidence collected through reconnaissance and excavation at Podšilo bay in Lopar on the island of Rab.

1 The project *Archaeological Topography of the Island of Rab* is led by A. Konestra and F. Welc, based on a collaboration between the Institute of archaeology in Zagreb and the Institute of archaeology of Cardinal Stefan Wyszyński University in Warsaw, with the participation of the Archaeology Museum in Zagreb; funding has been granted by the Ministry of culture of the Republic of Croatia, the local municipalities and Lopar Culture Centre, and the leading institutions.

THE SETTLEMENT AT PODŠILO BAY AND EVIDENCE FOR CRAFT ACTIVITIES

Podšilo bay is a secluded cove located on the NE part of Lopar peninsula, the northernmost part of the island of Rab (Fig. 1). When observing its geological structure, the island is composed of two anticlines and two synclines composed of Cretaceous carbonate rocks overlain uncomfortably by Eocene carbonates also known as the 'flysch' (Marjanac, Marjanac 1991; 2007). In Lopar the oldest geological stratigraphic unit constitutes Eocene clastics (Lopar Sandstones) (Marjanac, Marjanac 2007). The Lopar sandstones succession is built by sandstones and sandy marls (Marjanac, Marjanac 2007), which thus characterize substratum of Podšilo bay as well. The small, temporary stream Tićevo flows here from its source located westerly in its hinterland, through the bay into the sea.

First archaeological research within Podšilo bay dates back to 2009 when a pottery kiln was excavated on its northern shores, just a few meters from the sea (Lipovac Vrkljan, Šiljeg 2010; 2012) (Fig. 2). Finds recovered from its infill and the surrounding area indicate it was most probably setup to produce ceramic building materials (tegulae and imbrices), while its highly eroded surroundings bare evidence suggesting the existence of other, mostly damaged kiln(s). Further research in the area, especially geophysical measurements conducted on a small flat plateau to the NW of the excavated kiln, proved this assumption (Welc 2018: 64–65), indicating the existence of a small, detached craft area (a workshop?) located at some distance from the residential part of the settlement evidenced within the bays hinterland.[2] In fact, as a result of systematic reconnaissance, multi-method geophysical measurements and trial trenching, a complex rural settlement comprising several buildings located on both slopes of the bay was detected (Fig. 2). Two of these structures were partially excavated through trial trenches at the sites Beli grad and Podkućine, yielding architectural remains and finds mostly datable to late Antiquity (Fig. 3), while ^{14}C dates suggest a timeframe of use spanning from the 3rd to the 6th c. AD (Welc et al. 2019; Konestra et al. 2020). Similarly, dates extracted from the excavated kiln place its use within the 3rd c. as well (Lipovac Vrkljan, Šiljeg 2012: 27).

Due to a strong erosion processes investing the whole Lopar area, and thus also Podšilo, surface archaeological material is usually found displaced either along the beds of periodical, storm associated flash floods or redeposited from higher ground, thus usually recovered below natural escarpments at the edges of terraces (Welc et al. 2017: 48, fig. 4). As standard surface finds' collection and documentation did not provide sufficiently precise location information, further mapping of all areas with hypothetically reconstructed erosion processes allowed the possible, more precise location of ancient architecture, always situated on flat terraces above the detected materials' concentrations (Konestra et al. 2019: 192–193, fig. 6). During these activities finds from such accumulations of eroded materials were collected, among which, especially along the bay's northern slope, lumps of ferrous materials were identified (Fig. 2). Similar lumps were also collected during excavations of Trench 1 at the Beli grad complex, along with several iron objects (mostly nails), while layers of ferrous (?) materials were identified in several areas near the shores of Tićevo stream. Furthermore, gradiometer survey of the area further north of the structures at Beli grad yielded interesting results as well. Two oval-shaped objects have been detected, with a diameter of about 2 m, which were characterized by a high value of the magnetic field strength (Fig. 4). The shape of the anomalies suggests either an elongated, possibly key-hole shaped or two smaller detached rounded structures, both allowing a possible association with blacksmithing furnaces (Munro 2020: 387). It remains to be seen what was the exact nature of these anomalies, as in a wider area around them no remains of structures or other features was detected either by gradiometer or GPR measurements.

All of the above sprung the need to analyse in more depth the collected evidence and the possibility of it being connected with some form of iron working, either smelting or smithing. Therefore, nine samples of materials deemed to be related to iron working or production were analysed at the Department of Conservation of the State Archaeological Museum in Warsaw, including samples deemed to be iron slag and iron-rich rocks collected from outcrops located near Tićevo stream (Pl. 1). The main aim of the research was to determine whether the samples are slags from the metallurgical process. In order to accomplish this task, the samples were visually inspected, cleaned of surface contamination, X-rayed, and macroscopically and microscopically examined. The results of these tests for each of the analysed samples are presented in the attached table (Tab. 1).

Overall, the analyses conducted on samples from Podšilo bay confirmed without any doubt that this site was associated with metallurgical activity. The slag lumps (samples 3, 4, 7, 9) assuredly evidence that within the site some kind of an

2 The local population calls the northern slope of the bay *Beli grad* (roughly translated as White city), probably due to the massive presence of allocthonous limestone blocks reused within the dry-stone terracing, clearance features and property fencing walls, whose original use was ascertained within the identified Roman structures (see: Lipovac Vrkljan, Šiljeg 2012: 21–22 with bibliography therein). Further microtoponymy provided by the local population includes the name *Podkućine* (roughly translated as Under the houses) for the area of the southern architectonic complex.

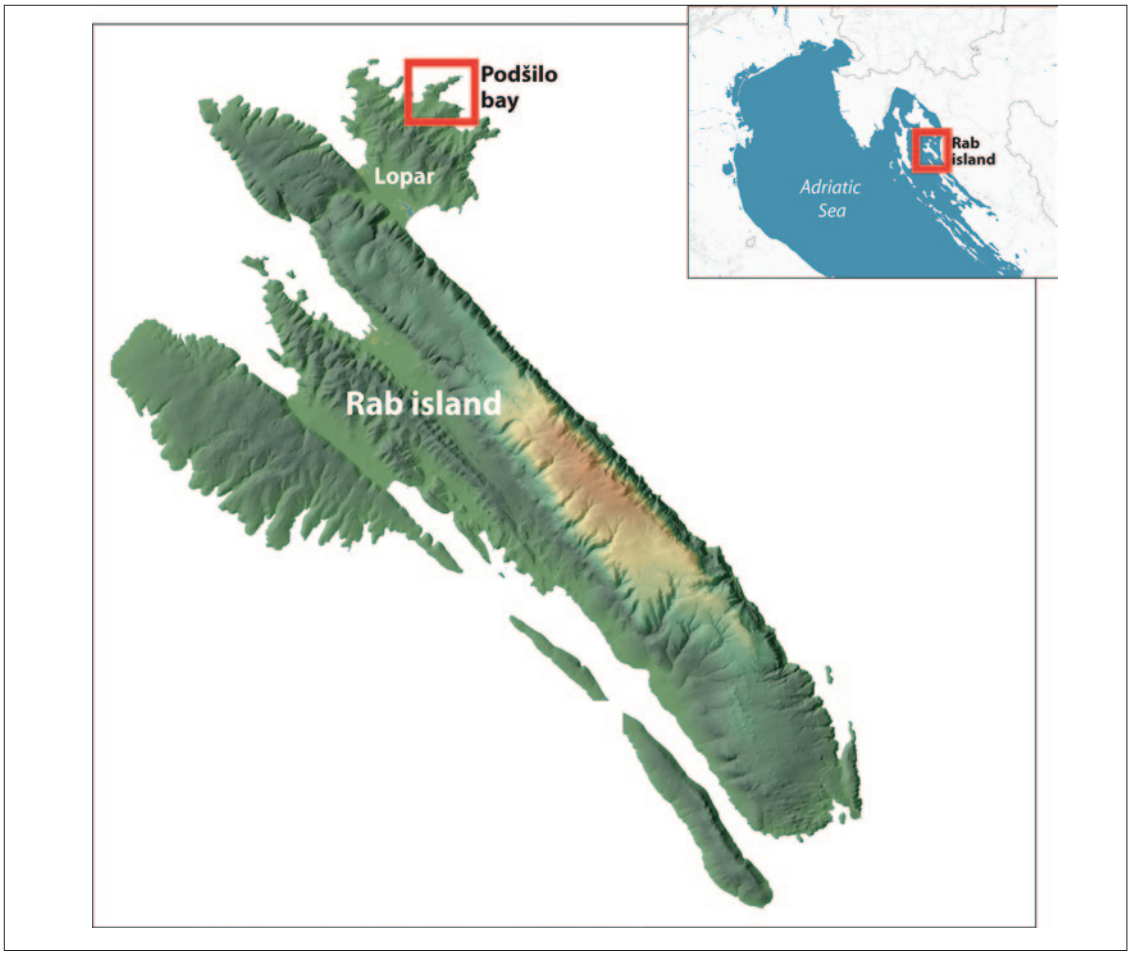

Fig. 1 Rab island with the location of Podšilo bay (basemap: DGU DEM; Google Maps/Snazzy Maps) (illustration: A. Konestra)

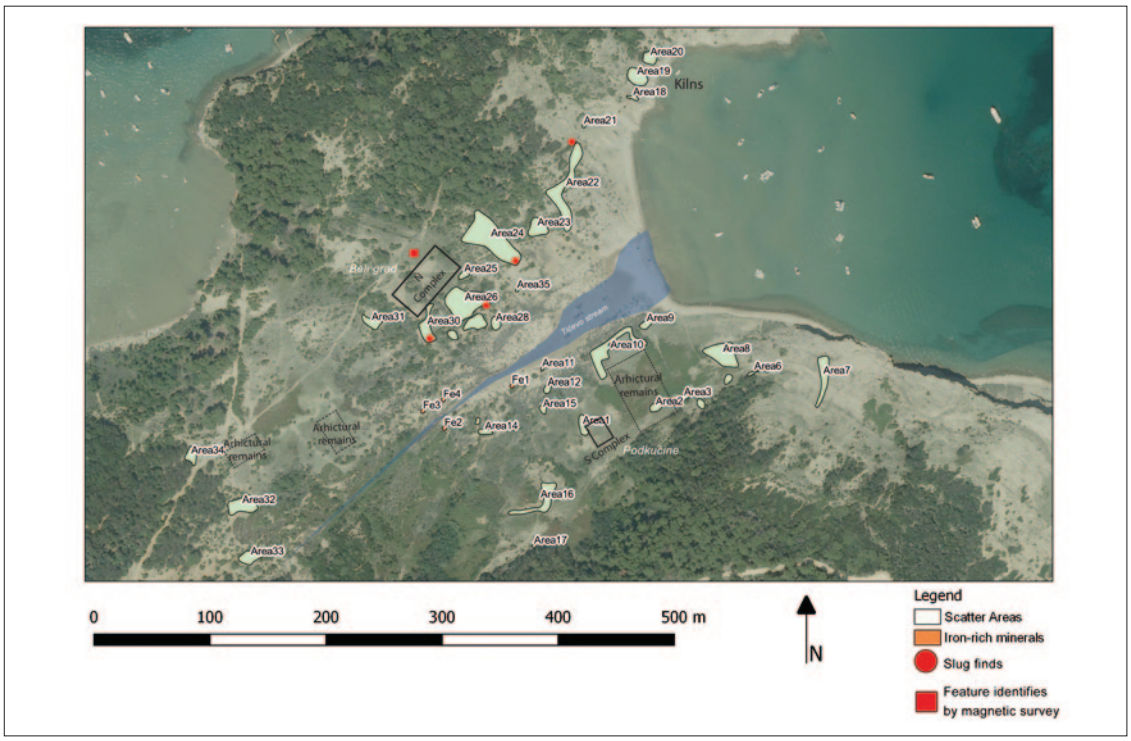

Fig. 2 Podšilo bay with locations of documented features (data collection and elaboration: R. Solecki, A. Dugonjić, F. Welc, A. Konestra; illustration: A. Konestra; basemap: DGU DOF)

Sample number	Tests performed	Observations	**Test results**
1	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	The structure of the lumps is porous, brittle, heterogeneous, easily crumbling. No visible traces of high temperature impact. Visible dripstones forms of iron oxides. On two fragments there are forms of crystallized oxides – similar to that formed on plant fragments. There are also large lumps made of black Fe oxides (magnetite?).	Fragments of lumps not derived from the metallurgical process. These lumps may have formed in the vicinity of the metallurgical site as a result of a reaction of minerals with iron oxides.
2	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	Compact, hard structure, no visible signs of re-melting, composed of black Fe oxides (magnetite?).	Mineral plate with high Fe content, needs further investigation (especially phase analysis).
3	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	Porous lumps structure, melted, hard, composed of fayalite.	A slag lump formed in a metallurgical process (probably Fe smelting).
4	Cleaning, washing, x-ray examination, preparation of the microsection, examination.	Porous, hard, melted structure, composed of fayalite.	A slag lumps formed during a metallurgical process (probably Fe smelting).
5	Macroscopic examination, X-ray examination, sieve analysis, water rinsing.	The sample was completely dissolved in water. Sieve analysis allowed to separate 2 fractions from the clay sample: very small number of fractions with average size of 0.75 - 1.2 mm in diameter and slightly bigger fractions with diameter over 1.2 mm (small stones, plant remains, small clumps of Fe oxides. Properties typical for clay.	A sample of clay soil not directly related to the metallurgical process. This could be clay used in the construction of a furnace, for example.
6	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	Porous structure of lumps, frangible, heterogeneous, easily crumbled. No visible signs of high temperature effects, composed of black Fe oxides (magnetite?).	A lump of mineral with high Fe content. Requires further study (phase analysis).
7	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	Porous, lump structure. Melted. Hard, composed of fayalite.	A slag lump formed during a metallurgical process (probably Fe smelting).
8	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	Visible outline of a longitudinal quadrilateral object.	A heavily corroded iron object.
9	Cleaning, washing, x-ray examination, preparation of the microsection, microscopic examination.	Porous structure, melted, hard, composed of fayalite.	A slag lump formed during a metallurgical process (probably Fe smelting).

Table 1 Results of preliminary metallographic analyses of samples from Podšilo bay (author: W. Weker)

iron-working activity was carried out. The attainment of high temperatures, necessary for the metallurgical process, is evidenced by the significant degree of liquefaction of the slag forming a homogeneous, in some places porous slag mass (sample 7, 9). In some places, the microsections show outlines of Widmanstetten structures formed during the solidification of fayalite ($2FeO\text{-}SiO_2$).

The irregular shape of the samples presented does not provide any basis for determining the iron reduction technique used at this site in the past, but might indicate smithing or recycling activities. They could have been formed both in earthen (cavernous) furnaces, as well as in the early stages of the process in vertical (shaft melting) furnace. There are no infiltration forms (icicles) characteristic of the smelting process, which could suggest the use of shaft furnaces or smithing.

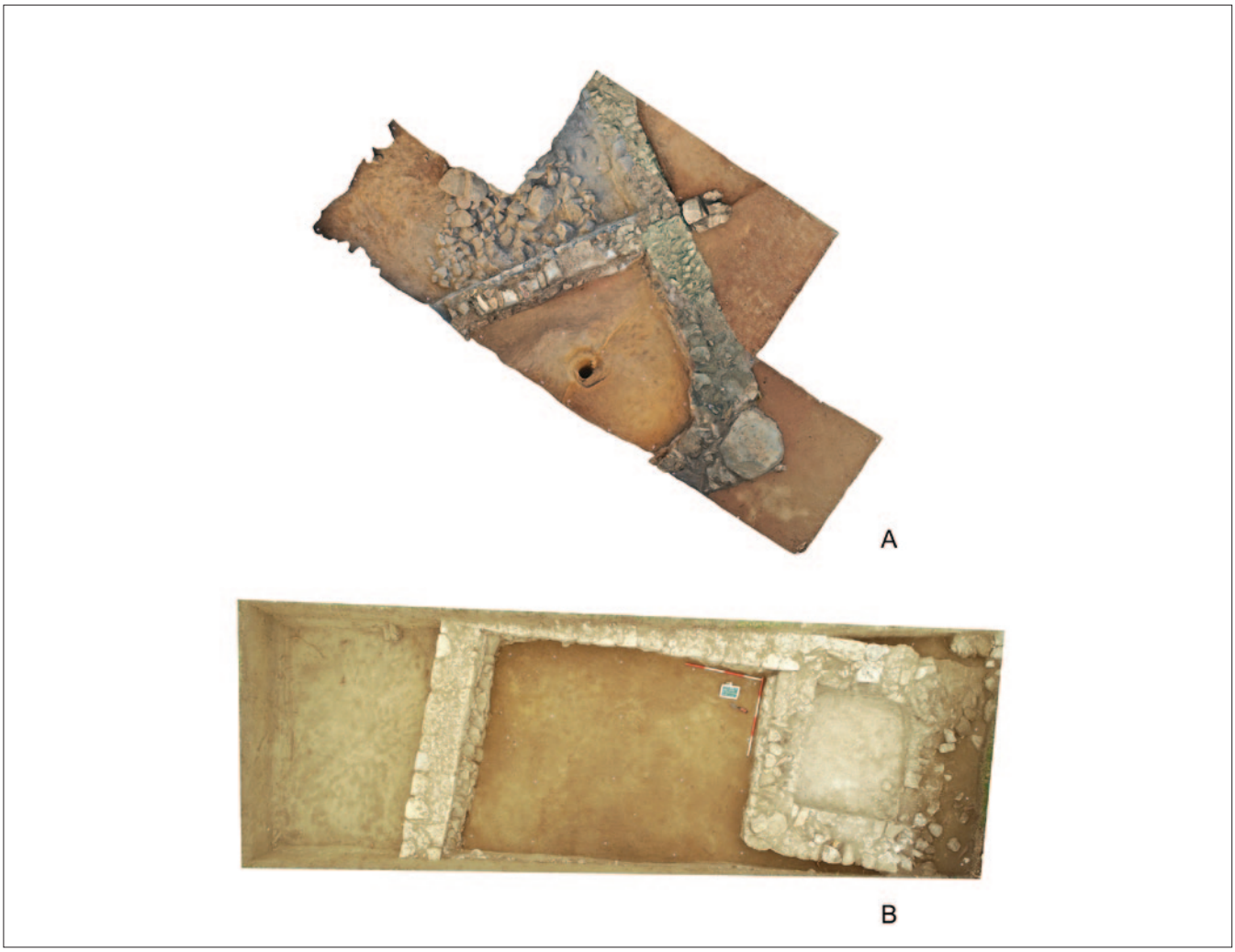

Fig. 3 Results of excavations in the trial trenches in Podšilo bay: A - Podkućine Trench 1; B - Beli grad Trench 1 (photos and DOF: K. Rabiega)

Sample no. 4 is a porous lump of slag containing grains of sand inside. This conglomerate may have already formed after the ore reduction process, when the largely liquefied slag came into contact and mixed with sand in the immediate vicinity of the furnace (e.g., sandy soil?). If sand had entered the forming slag during the reduction process (i.e. inside the furnace, at high temperature), the silica (found in the form of grains) would have reacted with the iron oxides to form fayalite - the main component of the slag and grains.

Sample 2 is difficult to interpret. The shape (plate) and cross-section (Pl. 1) suggest that it may be both a form of slag cooling on a flat surface and a mineral with high iron content (ore). A conclusive explanation of this will be possible after analytical studies are performed, particularly phase analysis.

Among provided slag fragments, there were two samples of lumps consisting of clumped grains of mineral (silica) with a spherical shape (samples 1 and 6) (Pl. 1). The dimensions of the grains are close to each other (they are about 0.2 mm). These lumps were probably formed from carefully sieved river or sea sand. Their role in the metallurgical process at this site is unclear and could be clarified by further analytical studies.

Sample no. 5 is a clay. It has a relatively low content of impurities. This clay may have been used during the construction of the smelting furnace, e.g. in the form of bricks or as a furnace lining.

IRON WORKING AT PODŠILO - MULTI-CRAFTING, RECYCLING OR OBJECT'S REPAIR?

Production and processing of not only foodstuff has been ascertained within a number of rural settlements spanning the whole of the Roman world. In fact, rural, but maritime villas as well where most often seats of activities such as pottery production, lime manufacture and/or iron working (Marzano 2007: 63–67; 2018: 128; Giannichedda 2008: 202–203; for

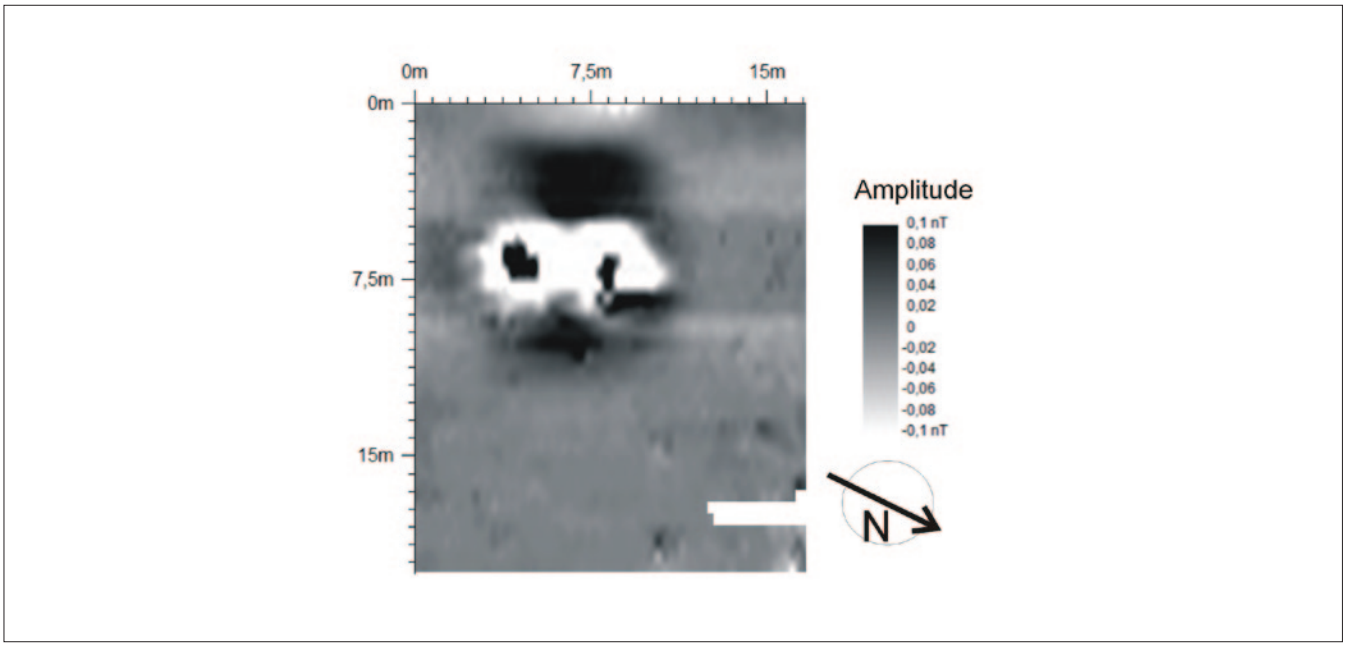

Fig. 4 Anomalies detected by magnetic survey on the northern slopes of Podšilo bay (measurements and elaboration: F. Welc)

types of rural craft settings see: Peña 2017: 206–207). Moreover, some of the products of such activities were deemed to be a *fructus* of the estate, similar to wine, olive oil or other foodstuff (e.g. for pottery: Aubert 1994: 204–205; Pelliccioni 2010: 22–23; Tchernia 2016: 10–12; for iron working see: Pleiner 2006: 149–151). Crafts organization can thus be presumed (as intended in Peña 2017) and, at least judging by the evidence from other provinces, output from these activities could have been highly lucrative (e.g. iron working in Britain, see: Bray 2010), while in other instances it might have been produced for self-supply and local consumption (Giannichedda 2008: 202–203; Peña 2017: 212, 227–228).

While the results of the first analytical approach to the evidence of iron working at Podšilo do confirm metallurgical production going on at the site, they do not speak of its chronology, scale or organisation, thus allowing only to infer on the possible products. At this point it is also difficult to assess whether smithing or also smelting was going on at site, although more secure evidence for the latter is still lacking. Some data can, nevertheless, be obtained through the analysis of the other structures discovered within the bay, and their mutual relationships.

A fairly certain date for at least one phase of usage of the excavated pottery kiln places it within the 3rd c. AD, a time-frame recognised also in the material culture and absolute dates obtained from the samples collected in the trenches at Podkućine and Beli grad (Welc et al. 2019; Konestra et al. 2020). On the other hand, the complex's architecture, and especially construction techniques, might indicate a somewhat earlier setup, with other evidence pointing to life on the site lasting at least until the 6th c. AD (Konestra et al. 2020). The destination of the products from the pottery kiln(s), due to its relatively small dimension and products' features (e.g. lack of stamps), is assumed to be mostly for self-consumption on the site or in any case locally, but still opened to a debate (Lipovac Vrkljan, Konestra 2018: 23).[3] If that is to be assumed, it is still unclear whether the setup of the kilns was related to a first construction phase or a renovation, as still no stamped tegulae (usually a common, chronologically indicative feature on similar sites) have been recovered, while some of the recovered ceramic building materials are with high probability local products.[4] Although pottery (see: Peña 2017: 214–216), but partly also architectonic ceramics production, are deemed to be a craft requiring both stable infrastructure, tools, a degree of specialisation and raw materials, instances of single kilns interpreted to have existed for limited time-spans are not a rare occurrence (e.g. Deltenre, Orlandi 2016).

One of the main questions that arises when scrutinising metalworking activates in the bay of Podšilo is its very location. It is still unclear if these activities could have been carried out within or in close proximity to what seems to be the main residential area of the settlement/estate, since most of the slug has been collected within the eroded sediment in the

3 Such an assumption might be further supported by the find of kilnworks in nearby Mahućina bay, located on the Sorinj peninsula closing from south Lopar Bay, and in front of another Roman rural site (Zidine) (Lipovac Vrkljan, Konestra 2018: 16).

4 A region-wide rebuilding within urban centres, proven by epigraphy at both *Rab* and mainland *Senia* (Lipovac Vrkljan et al. 2017: 328 with earlier bibliography; Zaninović 1981: 191), could also be proposed as a reason for a shortlived larger need for CBM.

northern slopes of the bay, which is in the vicinity and within the very structures at Beli grad (*villa*?). Possible pyrotechnical feature was also detected here by geophysics (see *supra*, Fig. 2, 4).

It is evident that the pottery kiln(s) were detached from the residential structures, probably in an attempt to separate a polluting and potentially dangerous craft from the living quarters of the site (e. g. Vennarucci et al. 2018: 594–595). A vicinity of an equally "undesirable" feature designed for metalworking seems therefore unlikely, especially if iron working is to be considered an organised and planned activity as CBM production seems to have been. This observation would speak, at least for the moment, against the possibility of multicrafting occurring simultaneously within the complex at Podšilo, and would indicate that reasons and modes of iron working setup might rather be sought elsewhere.

Possible explanations might be sought at sites boosting similar features, sites that comprise evidence of iron working within or in close proximity to a (former?) residential/productive unit of a rural settlement. On the eastern Adriatic examples are rare, mostly originating from nearby Istria (*X regio* of Italy) and pertaining to post-*villa* phases. The best evidence is perhaps that of Dragonera, in south-western Istria, where a smithy producing iron objects has been identified within the remains of an earlier *villa* (Starac 2010: 80–81). While the interpretation of the supposed smelting/smithing kiln is somewhat doubtful, in vicinity of this structure slugs and iron objects have been found, along with a heart located close to a base made of stone slabs (Starac 2010: 80–81; Koncani Uhač 2010: 244). Metallurgical activity at Dragonera has been dated in the 5th and apparently lasting until the 7th c. AD (Starac 2010: 113). Another similar, later setup of iron working within a rural *villa* was also found in the *ager* of *Pola*, at St. Cecilia near Guran, where within a space readapted from an earlier phase of the rural complex, layers of burnt soil, slug, pits and kilns/ovens/furnaces were established (Terrier, Jurković 2009; Marić et al. 2010: 338). As the associated movable finds have not yet been assessed, it is difficult to propose the exact function of these structures. Moreover, similar structures and metalwork activity traces have been discovered at St. Blek near Tar-Vabriga (in the *ager* of Parentium). This specific section of the site has been interpreted as a smithing workshop installed on the remains of a former food processing area (a kitchen?) (Konestra et al. 2021), but here again seemingly devoid of movable finds other than slag. The two latter examples do not present enough evidence for a secure dating of the iron working features, but those at St. Blek are certainly datable after the mid-Roman period. Lastly, in the hinterland of northern Liburnia (nowadays Lika region), a rural villa with a seemingly dedicated smithing/smelting area has recently been excavated at Lički Ribnik. The facility, dated to the 2nd-3rd c. AD phase of the complex, is located in a sector detached from the living quarters, close to a presumed kitchen (Ožanić Roguljić, Kolak 2018: 119–123). Finally, from the town of Rab, the discovery of a blacksmith's (?) heart and layers pertaining to the workshop within an area in close proximity to the (late Antique?) town walls (Jurković, Kranjec 2016) might indicate that new craft setup invested not only rural, but also the urban realm of the post-Roman eastern Adriatic, perhaps also as a recycling/recovery activity, as witnessed elsewhere (e.g. Tůmová, Cirelli 2019; Cirelli, Snyder 2021: 350–352; Murphy, Poblome 2021: 108–111).[5]

Further afield, similar situations are also well known from the Italian peninsula and beyond (Munro 2010; 2011; 2020; Castrorao Barba 2017; see also: Fleming 2012) indicating that, perhaps, iron working setup within rural complexes with the refunctionalisation of their spaces in late Antiquity is not such an isolated occurrence (Giannichedda 2008: 203). These structures, just as those pertaining to other productive activities are often connected to the recycling of materials from the very structures of the former villa (stone, glass, lead, iron etc.), especially when located within or at short distance from its residential quarters (Munro 2010: 227–229; 2011: 77; Bertoldi 2015; Deltenre, Orlandi 2016: 76). Such activities, to be seen as a stand-alone phase of post-*villa* occupation, indicate that recovering materials was a profitable endeavour certainly taken on by skilled craftsmen and not casual new inhabitants of the area, a practice that might by connected to a general trend of the late Antique economy (e.g. Marcone 2018; Giannichedda 2008), which at least in some areas sees a cessation of large scale extraction and production, but that was in fact carried out throughout antiquity (Giannichedda 2008: 192–193, 204; Munro 2010: 237–238; 2011: 77). Another instance of deconstruction of former architectural elements at Podšilo might be indicated by the column base found at Podkućine within a context of building abandonment (Konestra et al. 2018: 125). On the other hand, shaping and production of implements necessary for construction often occurred on-site during building phases, and it is precisely than that small-scale iron working might have been implemented, either during the first setup of the complex or during subsequent reconstruction (Munro 2011: 77–78, 85–86; 2020: 384). In the latter case repurposed and recycled materials from the previous building phases could have been used both onsite or off-site (Munro 2020: 385). To the first phase of construction on the site activities such as lime production might be linked, while it is still to be assessed whether the allochtonous limestone used for construction (and with all probability lime production) was acquired in

5 Evidence of iron smithing of earlier date are nevertheless known from several Roman towns (e.g. Quercia 2011: 206–208 for southern Italy), possibly including *Salona* (Ivčević 2019: 125–126 with earlier bibliography).

nearby areas (mainland Rab or nearby island of Goli and Grgur) by the construction team, estate workers or through trade.

Finally, another possibility might be pointed out, that is, the need of the estate to perform repairs to their tools and other iron implements, as small-scale finds of iron slug within *villa* assemblages might suggest (Pleiner 2006: 151; Kirigin et al. 2011), and as such part-time, small scale activity might have been located in closer vicinity to living/working quarters (e.g. Lički Ribnik, Ožanić, Kolak 2018: 119–123). If that was the case, a certain degree of crossover and shared knowledge between crafts, in this case pottery production and iron working, might be supposed (e.g. Dobres 2014: 201).

Being data still too scanty to draw definitive conclusions, the question as to whether Podišilo bay hosted a multi-crafting community (perhaps also engaged in other still archaeologically undetected crafts or productions) or CBM and iron production were connected to the erection, rebuilding or final demise of the architectural complex remains open. More information on the chronology of the latter activity will certainly aid a better understanding of crafts and production at this site, but possibly also island-wide, just as a better understanding of the architectonic complexes will allow to better define the activities conducted within each segment of the settlement.

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ANA KONESTRA
Institute of Archaeology
Jurjevska 15, HR-10000 Zagreb
ana.konestra@gmail.com

FABIAN WELC
Institute of Archaeology
Cardinal Stefan Wyszynski University in Warsaw
Wóycickiego 1/3 (23), PL-01-938 Warsaw
f.welc@uksw.edu.pl

PAULA ANDROIĆ GRAČANIN
Institute of Archaeology
Cardinal Stefan Wyszynski University in Warsaw
Wóycickiego 1/3 (23), PL-01-938 Warsaw
paula.androic@gmail.com

WŁADYSŁAW WEKER
State archaeological Museum in Warsaw
Długa 52, PL-00-951 Warsaw
wweker@poczta.onet.pl

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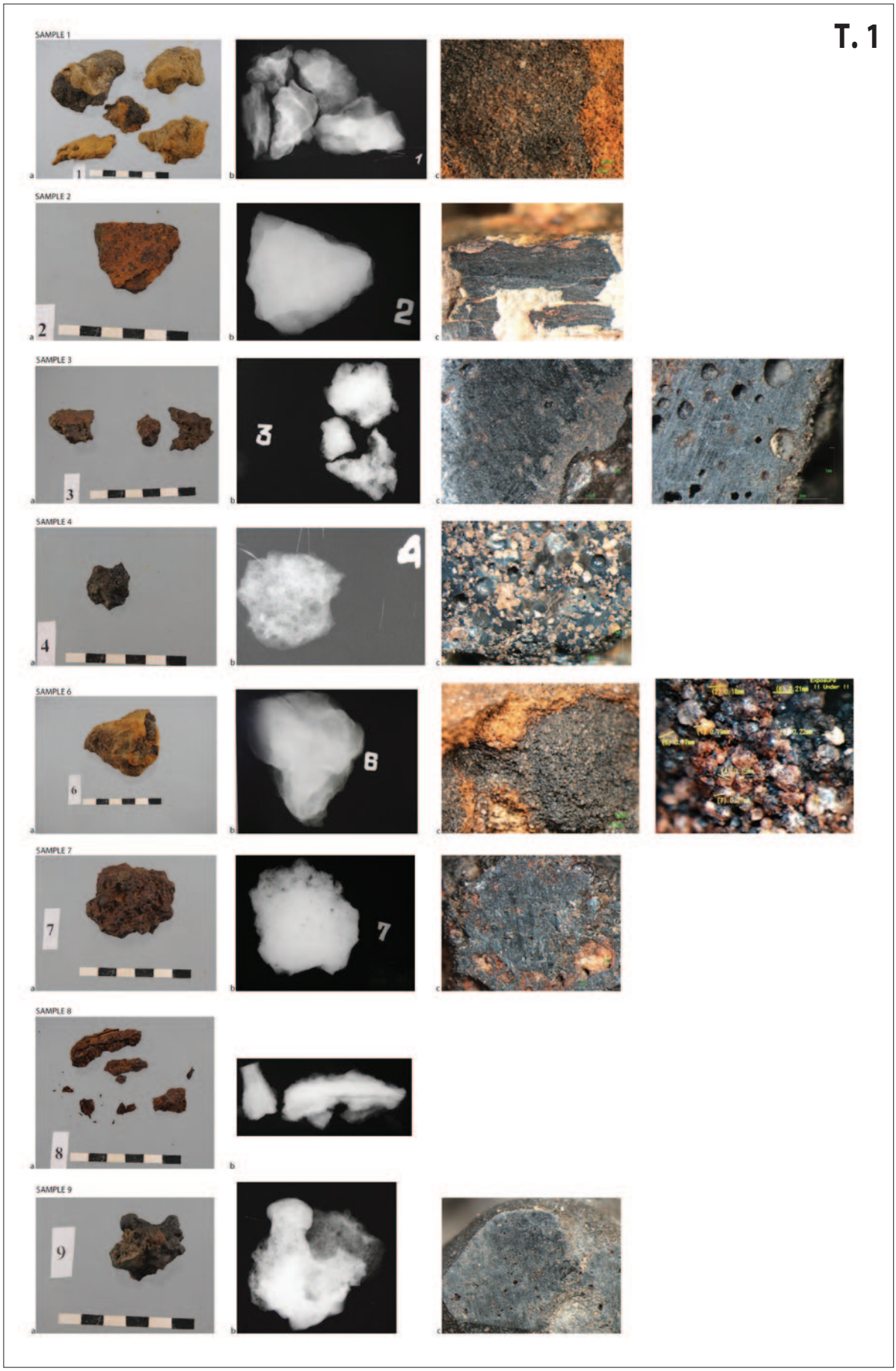

Table 1 Results of preliminary metallographic analyses of samples from Podšilo bay (author: W. Weker)