



WOOD ANALYSES HELPED TO DETERMINE THE LOCATION AND APPROXIMATE CONSTRUCTION PERIOD OF THE ROMAN BRIDGE OVER THE DRAVA RIVER IN ANCIENT POETOVIO (PTUJ, SLOVENIA)

ANALIZA LESA JE POTRDILA LOKACIJO IN OKVIRNO OBDOBJE POSTAVITVE RIMSKEGA MOSTU ČEZ REKO DRAVO V ANTIČNEM POETOVIJU (PTUJ V SLOVENIJI)

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UDK 630*561.24:930.85(497.4 Ptuj)
Original scientific article / *Izvirni znanstveni članek*

Received / *Prispelo*: 5. 11. 2021
Accepted / *Sprejeto*: 19. 11. 2021

Abstract / *Izvleček*

Abstract: We present the results of a dendrochronological study and radiocarbon dating of the wooden piles of the bridge over the Drava River in Ptuj. The piles, together with stone elements (a fragment of an imperial building inscription and parts of the architectural decoration) were retrieved from the riverbed in 1913 and are now in the Regional Museum Ptuj - Ormož. Using dendrochronology, radiocarbon dating of carefully selected annual rings in the wood and calibration with the wiggle-matching method, the date of the last (outermost) annual ring on the pile was determined to be 161 ± 27 cal AD (1 σ) or 160 ± 32 cal AD (2 σ). Since the pile contained no sapwood, the dating approximately agrees with the date of the building inscription on the stone slab, which attributes the commission for the reconstruction or construction of the bridge to Emperor Hadrian in the last years of his reign (117-138 AD). The dating of the wood has thus confirmed that the remains examined do indeed belong to a Roman bridge, probably built or renovated during the reconstruction of the road network in the area of the colony of Poetovio under Hadrian or one of his successors.

Keywords: Roman bridge, Poetovio, Ptuj-Slovenija, archaeological wood, oak (*Quercus* sp.), dendrochronology, radiocarbon dating, wiggle-matching

Izvleček: Predstavljamo rezultate dendrokronološke raziskave in radiokarbonske datacije lesenih pilotov mostu čez Dravo na Ptuj. Piloti so bili skupaj s kamnitimi elementi (odlomek cesarskega gradbenega napisa in kamniti deli arhitekturnega okrasa) leta 1913 dvignjeni z rečnega dna in jih danes hrani Pokrajinski muzej Ptuj - Ormož. S pomočjo dendrokronologije, radiokarbonskega datiranja natančno izbranih branik lesa in kalibracije z metodo wiggle-matching, je bil na raziskanem pilotu brez ohranjene beljave določen datum zadnje branike 161 ± 27 kal. n. št. (1 σ) ali 160 ± 32 kal. n. št. (2 σ). Upošteva se manjkajoča beljava, datacija okvirno sovпада s časovno opredelitvijo rekonstruiranega gradbenega napisa s kamnite plošče, ki naročilo obnove oziroma novogradnje mostu pripisuje cesarju Hadrijanu v zadnjih letih njegove vladavine (117-138 n. št.) al. Datacija lesa je tako potrdila, da raziskani ostanki res pripadajo rimskemu mostu, domnevno postavljenem oziroma obnovljenem ob prenovi cestnega omrežja na območju kolonije Poetovio pod cesarjem Hadrijanom ali enim od njegovih naslednikov.

Ključne besede: rimski most, Poetovio, Ptuj Slovenija, arheološki les, hrast (*Quercus* sp.), dendrokronologija, radiokarbonsko datiranje, wiggle-matching

1 INTRODUCTION

1 UVOD

The Regional Museum Ptuj - Ormož (PMPO) in Slovenia holds in its collections a group of 8 wooden piles and several stone fragments which,

according to museum documentation, allegedly belong to the remains of a Roman bridge over the Drava River in Ptuj, ancient Poetovio. The epigraphy of Hadrian's building inscription and other architectural elements of the alleged bridgehead as well as urbanistic-historical aspects of the connection between the bridge and the centre of the Roman colony on the left bank of the Drava have recently been elaborated by Zsolt Mráv (Mráv, 2002, 2003), whose study provides an overview of documented Roman bridges in Pannonia. Findings

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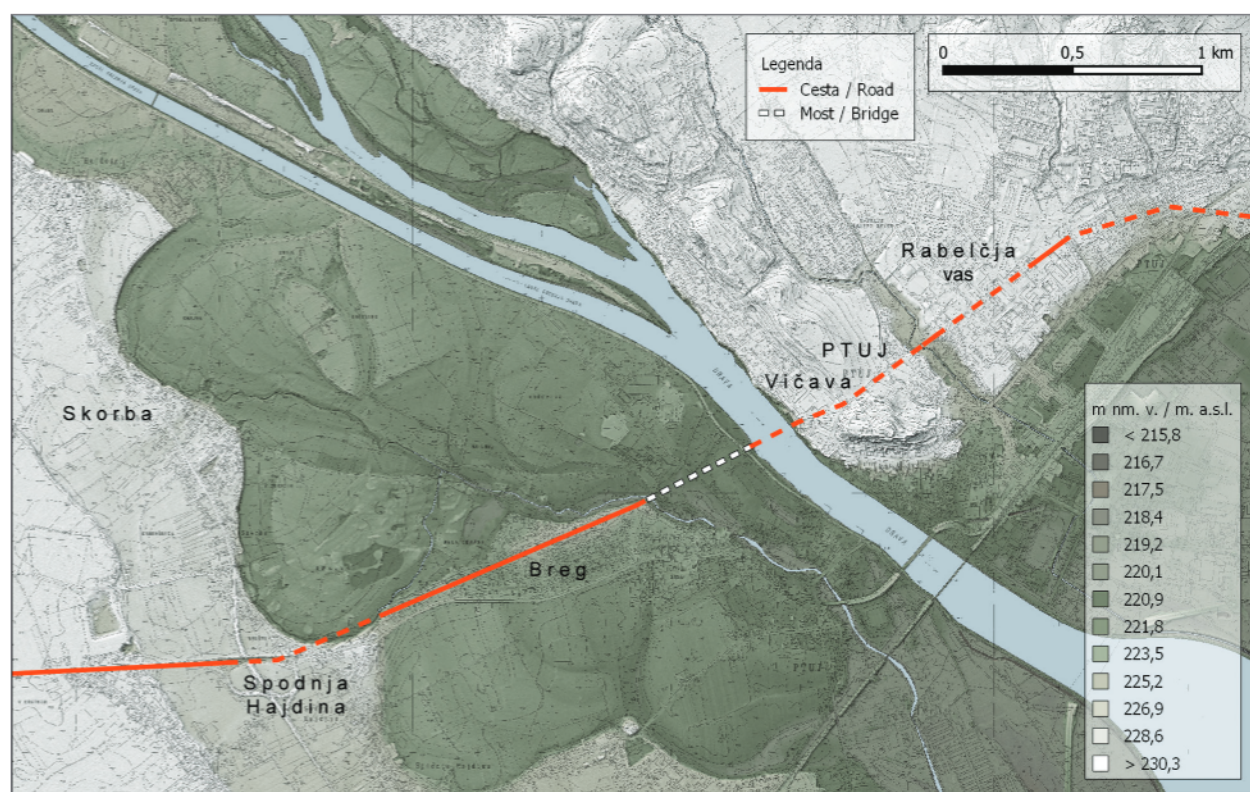


Figure 1. Lidar image of the wider surroundings of present-day Ptuj, with the clearly recognizable Pleistocene terraces of the Drava River and the southern slopes of the Slovenske gorice hills. The course of the Roman itinerary road (red) and the bridge (white) are marked. The reconstructed course of the bridge leads over the floodplain between the present right bank of the river and Studenčnica Stream (made by: Blaž Kumer).

Slika 1. Lidarski posnetek širšega območja današnjega Ptuja z jasno prepoznavnimi pleistocenskimi terasami reke Drave in južnimi obronki Slovenskih goric. Označena sta potek rimske itinerarske ceste (rdeče) in mostu (belo). Rekonstruiran potek mostu prečka poplavno ravnino med današnjim desnim bregom reke in potokom Studenčnica (izdelal: Blaž Kumer).

and assumptions about the structural characteristics and topography of the bridge in Ptuj (Figure 1) are synthesized in an article by the co-author of the present paper (Gaspari, 2001), and Andrej Preložnik made an important contribution to the history of the research supplementing the information on the observations at the beginning of the 19th century (Preložnik, 2020).

The earliest references to stone elements and wooden piles in connection with the Roman bridge over the Drava in Ptuj come from observations made by the local resident Leopold Schickelgruber in 1798 (Skrabar, 1914). Beneath the water surface near the right bank, in the company of friends, he observed stone blocks, mostly of “white and black marble”, allegorical representations, and massive

wooden piles standing in a row, from which he inferred the existence of a colossal building. The report of Ritter von Rittersberg (Ritter von Rittersberg, 1818) probably refers to the same site. The blocks are said to occur in an area of about 19 x 19 m, at a depth of a little more than 2.5 m. Twenty years before his visit, the Drava River flowed through the site, which, according to the accounts of boatmen and fishermen, created a strong whirlpool at the spot. Locals observed the stones from anchored boats in the water, the highest of which was 2.4 m below the surface. According to Klein, a local brewer, several stones bore inscriptions in metal letters (Ritter von Rittersberg, 1818; Preložnik, 2020).

The remains of the Roman bridge on the Cella - Poetovio road, which are said to be visible

near the right bank of the river above the Dominican monastery, were again reported by Professor Franc Ferk in 1893. The worked stone blocks, visible again in 1896, were attempted to be lifted by the Museum Society, but they proved to be too heavy. The 1903 high water level caused the blocks to be covered by debris again (Skrabar, 1914; Gaspari, 2001), although the remains were again exposed by the extremely low water level in January 1912, when the tops of vertically driven wooden piles and a mass of smaller and larger worked stone blocks were exposed in a small bay on the right bank of the Drava, just opposite the command building of the old barracks complex (now the building of the Historical Archive and the Slovenian Institute for the Protection of Cultural Heritage) and 580 m upstream of the old Ptuj bridge at a depth of 2–3 m (Figure 2: site 1). The recovery of the remains, which took place in two campaigns in the summer of 1912 and in March 1913, was carried out by military engineers under the direction of the jurist, conservator and archaeologist Viktor Skrabar.

Published reports of the find mention a cracked part of a marble column, several limestone blocks with grooves for iron clamps, part of a massive relief slab with an ornate border and the remains of a representation of a bundle of lightning bolts in the claws of an eagle, an attribute of Jupiter (see Skrabar, 1914; Mráv, 2002), a part of a white marble slab with the remains of a four-line building inscription (AIJ 361) and some “charred” wooden piles.¹ Among the latter, Skrabar mentions a 3 m long oak pile of square cross-section with 25 cm long sides (Skrabar, 1914).

The first three lines of the building inscription bear part of the imperial titulature, while the fourth bears a remnant of the word *[p]onte[m]*, on the basis of which Skrabar had already established the undoubted connection of the epigraphic find with the Drava Bridge (Skrabar, 1914). Based on the size of the letters and the arrangement of the titulature, he considered it likely the emperors

between Hadrian (117–138 AD) and Septimius Severus (193–211 AD) were the patrons. In view of the correspondence of the preserved titulature in the third line with the corresponding parts of the inscriptions on Hadrian’s three milestones on the Norican and Pannonian part of the Amber Road, it is generally assumed that the reconstruction or even the new construction of the Drava Bridge took place at about the same time or even in connection with the reconstruction of the above-mentioned road section between 10 December 131 and 9 December 132 (Skrabar, 1914; Mráv, 2002, 2003).

According to Zsolt Mráv (Mráv, 2002), the reconstructed inscription, carved on the original slab, about 5 m long, reads as follows: *[I]mp(erator) C[ae]s(ar) divi Traiani Parthici fil(ius) / divi [Nervae] nep(os) Traianus Hadrianus Aug(ustus) / pon[t]ifex max(imus) trib(unicia) pot(estate) XVI co(n)s(ul) III p(ater) p(atriciae) proco(n)s(ul) / [p]onte[m] ---*.

Skrabar also excavated in the nearby meadow in the direction of the presumed course of the bridge, belonging to Mrs Kreuzwirt (Figure 2: site 2), where he found at a depth of 2 m the remains of charred piles similar to those in the channel along the right bank. He considered that they either belonged to a bridge on wooden piers (German: Jochbrücke), which was replaced by a stone bridge, or that they had served as part of the foundation for the construction of a bridge with stone piers. No remains were observed during a boat survey of the riverbed in February 1914, leading Skrabar to conclude that the site in the riverbed represented the Roman left bank and that the remains themselves represented the remains of the northern bridgehead with exposed cult images and an imperial building inscription (Skrabar, 1914). The size of the complex of ruins on the present right bank, reported by Rittersberg in 1818, could correspond to the dimensions of a bridgehead with a single-arched structure (on the dimensions of monumental arches at the entrances to bridges (see Roth Congès, 2011); it is also possible that another building stood right next to the entrance to the bridge. According to Mráv, the monumental gate with an arch bearing the imperial inscription marked the sacred boundary of the narrower urban space (*pomerium*) and thus functioned both as a triumphal arch and *arcus pomeriale*. For the passage of the gate, users paid a fee (*portorium*), which went into the

¹ Most likely, the blackened condition of the piles can be explained by the environmental conditions in the river sediments. It is also possible that Skrabar’s observation refers to some deliberately burnt piles to ensure their longevity in water, but among the material preserved in the PMPO there are no such piles.

city treasury and represented a significant and reliable source of revenue, as it was a river crossing to which there was no alternative on the Amber Road (Mráv, 2002). The spatial connection between the town centre of Poetovio and the bridge (and thus the course of the itinerary road) is undeniable, with the main connection to the northern bridgehead most likely lying to the east of the forum area. The demolished walls of Roman buildings on the edge of the Vičava terrace (Figure 2, 3) and the finds of washed-out marble blocks, stone sculptures and gravestones in the riverbed, even far from the left bank (Skrabar, 1914; Horvat et al., 2003), indicate that the Lower Terrace with the forum of Poetovio and the early medieval "Lower Town" extended southwards over a good width of the present-day

riverbed of the Drava (Curk 1999; Lubšina Tušek & Erič, 2012). It is assumed that the river washed away two thirds of the town centre on the left bank (Mikl-Curk & Tušek, 1985).

The approximate location of the southern bridgehead on the ancient right bank of the Drava, which in this section may have been in roughly the same position as the present Studenčnica stream, was thought to be east of the Švabov mlin (mill). A block of masonry found 60 m downstream of the mentioned mill in the stream bed was cautiously interpreted by Skrabar as the remains of an eroded bridge abutment (Figure 2: site 4). He noted that the location of the block was opposite the meadow belonging to Mrs. Kreuzwirt (Skrabar, 1914). The approximate location of the right bridgehead

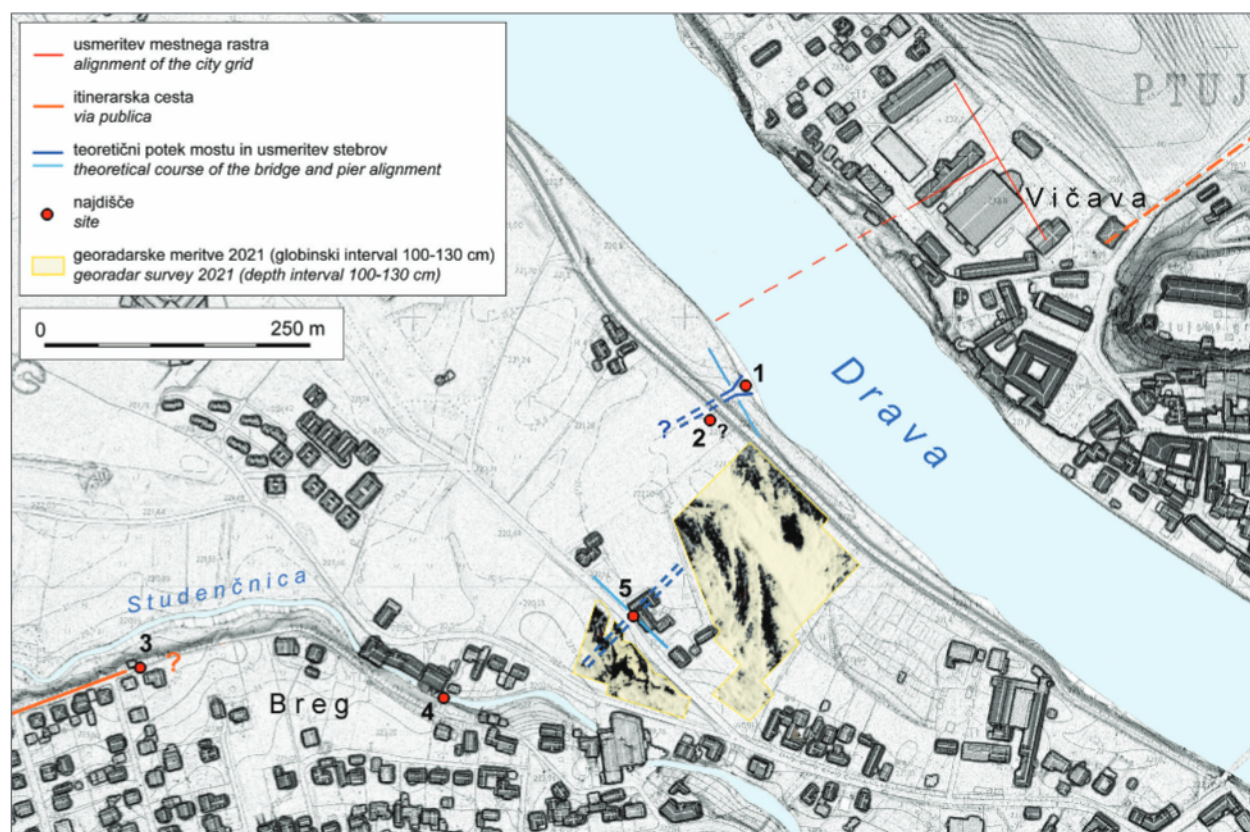


Figure 2. Ptuj: (1) presumed northern bridgehead (1913); (2) approximate location of piles on the meadow belonging to Mrs. Kreuzwirt (1913); (3) place where the itinerary road disappears from the terrace; (4) block of wall in the Studenčnica riverbed; (5) group of piles (1975) (made by: Andrej Gaspari); the results of the georadar survey: Branko Mušič, courtesy of Primož Stergar).

Slika 2. Ptuj. Drava in poplavno območje med Zgornjim Bregom in Vičavo z obravnavanimi najdišči. (1) domnevna severna mostna glava (1913); (2) približna lokacija pilotov na travniku gospodične Kreuzwirt (1913); (3) mesto, kjer itinerarska cesta izgine s terase; (4) blok zidu v strugi Studenčnice; (5) skupina pilotov (1975) (izdelal: Andrej Gaspari); rezultati georadarskih meritev: Branko Mušič, z dovoljenjem Primoža Stergarja).

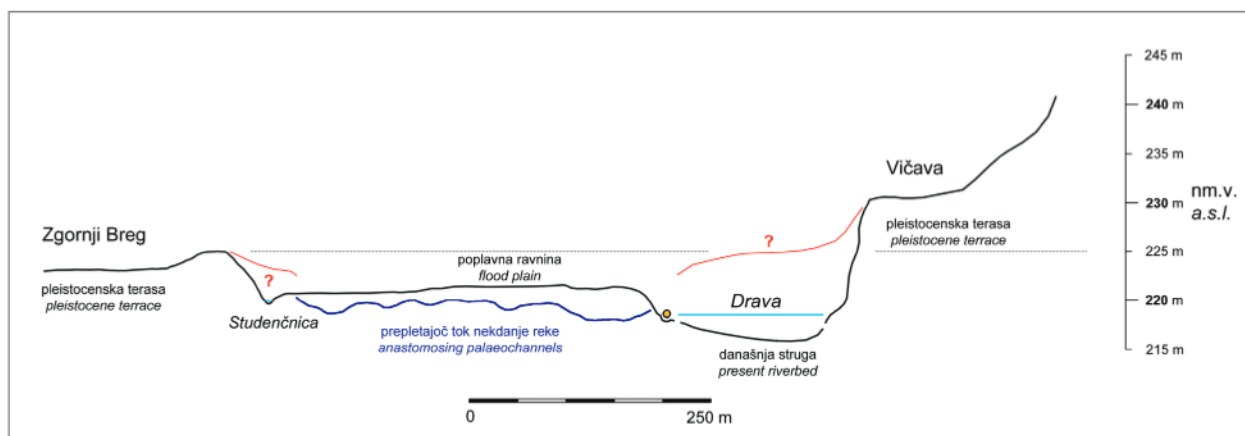


Figure 3. Ptuj. Schematized cross-section of the area in the presumed axis of the Roman bridge between Vičava and Zgornji Breg. The reconstructed parts of ancient terraces and banks (red); presumed elevations of the ancient riverbed with anastomosing channels (dark blue); the present level of the river (light blue); the location of the stone remains and piles (yellow dot) of the presumed northern bridgehead in the Figure 2: site 1; the elevations are exaggerated in comparison with the longitudinal extent of the cross-section (made by: Andrej Gaspari).

Slika 3. Ptuj. Shematizirani presek območja v domnevni osi rimskega mostu med Vičavo in Zgornjim Bregom. Rekonstruirani deli antičnih teras in bregov (rdeče); domnevne višine antične struge s prepletajočimi tokovi; lokacija kamnitih ostankov in pilotov (rumena pika) na Sliki 2: mesto 1. Višine so pretirane v primerjavi z dolžinskim obsegom preseka (izdelal: Andrej Gaspari).

is confirmed by the section of the road identified in Zgornji Breg, which runs along the raised northern edge of the terrace almost to the end of the upper part of the flat ridge, where it turns east into the floodplain. The continuation of the road disappears at the edge of the terrace (Figure 2: site 3). The access or even entrance to the bridge itself is associated with the 3rd century altars dedicated to Dravus Avgustus (AIJ 267) found in the eastern part of Zgornji Breg (Skrabar, 1914; Horvat et al., 2003).

Assuming that the remains on the right bank of the present river-bed do indeed represent the northern bridgehead, and that the southern one was somewhere to the north-east of the said part of the terrace-ridge of Zgornji Breg, and that the bridge crossed the narrowest part of the floodplain in a straight line perpendicular to the main riverbed, we indeed obtain the axis of the bridge (Figure 2), which corresponds almost entirely to the documented grid of the street network of the Poetovio city centre at Vičava (Mikl-Curk & Tušek, 1985); for recent research and discoveries of a possible module, see Janežič and Lazar (2015) and Lazar (2013). This would mean that urban planning was guided by the course of the riverbed at that time, whose

axis (NW-SE) had a slightly smaller deviation from the north than today (Figure 2). Because of the uncertainty about the width of the floodplain and the length of this bridge, we can only estimate it to be about 350 to 400 m. It should be noted again that these assumptions are based on the premise of a straight axis of the bridge perpendicular to the river bed, but this is not the only possible solution given the presumably braided river-channel with islands and dunes.² After all, after a straight crossing of the main riverbed on such an island or a major dune, the bridge could change its direction by diverting the axis downstream, as is the case with Roman bridge over the Danube in Aquincum; see (Mráv, 2002).

In the middle of the floodplain south of the presumed axis of the bridge in question, a group of 8 piles with a round cross-section was discovered along the Mlinska cesta (Figure 2: site 5) during the

² The course of the palaeochannels and point bars of anastomosing river south of the reconstructed bridge axes was identified by geophysical surveys and test excavations carried out by Primož Stergar, an independent contractor, and the company Gearh in 2021.

control of the canalization excavation to the Recreation and Tourism Centre in 1975. The head of the archaeological control, Blagoj Jevremov, conditionally assigned them to the bridge over the Drava in his field report (Jevremov, 1975). Contrary to the statement in our earlier study that the remains found most probably do not belong to the construction of the ancient bridge (Gaspari, 2001), after re-examining the field report we believe that this cannot be ruled out. The described and sketched arrangement of the piles suggests that they are the remains of an elongated group, about 5 m long, with the longer axis pointing in the NW-SE direction, indicating the direction of flow and identical or very similar to the alignment of the present riverbed. The piles are not arranged in an orthogonal grid and do not have the usual square or octagonal hewn sides, but the extreme north-western three form a characteristic triangular breakwater. If they are indeed the remains of a pier, it probably belonged to another Roman bridge, either an older or a younger one.

From the surviving remains and Skrabar's description of the site on the present right bank of the Drava, it appears that the construction of the northern bridgehead was a massive stone structure on a wooden foundation, consisting of vertically driven oak piles and a horizontal beam framework filled with stones. Given the importance of the Ptuj bridgehead and the assumed width and strength of the river, we might expect the piers of the bridge in the riverbed itself to have been constructed in a similar manner. Bridges with wooden piers required

frequent repairs due to increased exposure to the damage at the contact between water and air, as well as by ice and floating wood. After the middle of the 1st century AD, they were replaced on a larger scale at important crossings in the northern provinces by structures with stone piers on a wooden foundation with a pentagonal plan and with a wooden superstructure (Figure 4; Cüppers, 1969; Mensching, 1981; Goudswaard, Kroes & Van der Beek, 2001). The very massive piers of the bridge over the Drava at Mursa (Osijek, Croatia), probably built at the end of the 1st or in the first half of the 2nd century and later renewed several times, were also built on a foundation of densely driven piles with tips, fitted with iron shoes. Six piers, originally more than 7 m high, have been reported, tapering in steps towards the top. The distances between the piers in the middle of the river (about 24 and 20 m) were greater than those closer to the bank, which distinguishes the bridge from most bridges of mixed construction in the northern provinces of the empire, which usually have equal distances between the piers. Judging by the monumental dimensions of the piers, fences and slabs, the structure over the Drava at Mursa is one of the few Roman bridges with a stone superstructure outside the Mediterranean (Gardaš, 2003).

In assessing the type of the construction to which the Roman bridge in Ptuj belonged, it should be emphasized that no stone remains are mentioned either from the location of the piles in the meadow slightly west of the present right bank (Skrabar, 1914; Figure 2: site 2), or from the vicinity

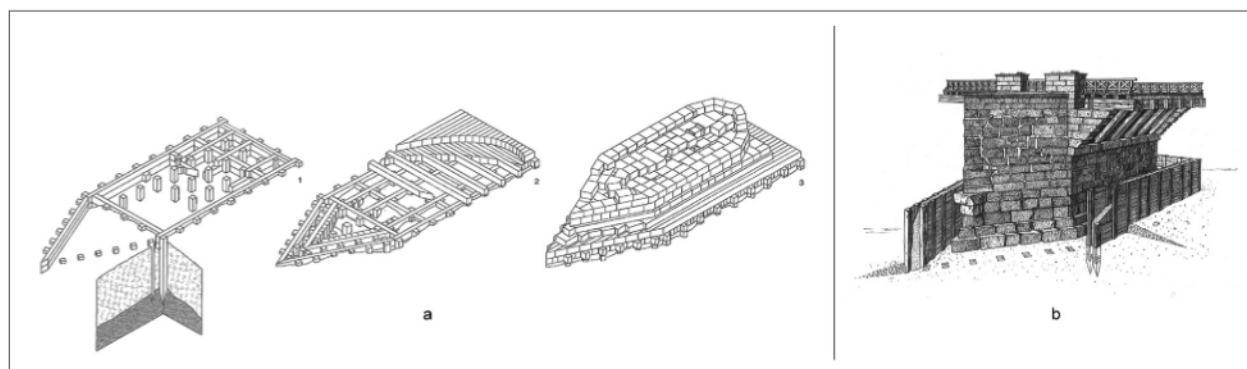


Figure 4. Structural analysis of the Late Roman bridge over the Meuse in Cuijk (a); reconstruction of the bridge pier over the Moselle in Trier (b) (a after Goudswaard, Kroes & Van der Beek, 2001; b after Cüppers, 1969).

Slika 4. Analiza konstrukcije poznorimskega mostu čez reko Meuse v Cuijku (a); rekonstrukcija stebra mostu čez reko Mozelo v Trierju (b) (a po Goudswaard, Kroes & Van der Beek, 2001; b po Cüppers, 1969).

of the piles discovered in 1975 (see Footnote 2; Figure 2: site 5). The stone blocks might otherwise have been washed away because they were more exposed to the rising water during storms, perhaps also because of the less massive structure of the piers in the middle part of the watercourse compared to the bridgeheads. However, the absence of stone remains in the central part of the former riverbed also supports the assumption of a bridge structure with piers built entirely of wood. These usually consisted of three parallel types of vertical piles, but a more durable box construction (caisson) of bridges of the so-called transitional type, consisting of horizontal beams and internally reinforced with vertically driven piles; see (Dumont, 2011; Dumont & Bonnamour, 2011) cannot be excluded either. At the same time, we reiterate that the remains found at the narrowest part of the floodplain probably belong to the construction of an older or younger bridge with a different alignment, a question that can only be answered by targeted research or accidental discoveries.

According to the museum curators, the remains of 8 wooden piles came from Skrabar's intervention in 1913. The wood remained undated and for a long time there was no confirmation that the piles came

from a Roman bridge. In January 1999, Tom Levanič, then an employee of the Department of Wood Science and Technology at the Biotechnical Faculty of the University of Ljubljana, in collaboration with Andrej Gaspari and curator Ivan Žižek, carried out sampling for wood identification and dendrochronological analyses. The analyses revealed that all the piles were made of oak, while the dendrochronological analysis did not lead to their absolute dating for objective reasons, and it was not possible to confirm whether they belonged to the Roman bridge. The aim of the current study is to re-examine the wooden piles using dendrochronology, radiocarbon dating and wiggle-matching analysis.

2 MATERIALS AND METHODS

2 MATERIAL IN METODE

The remains of 8 piles underwent re-examination in early 2019. In collaboration with the museum's curator, Aleksandra Nestorović, we examined the remains of all eight piles in the museum's depot on 20 February 2019. We focused on their suitability for dendrochronological dating, which depends on the number of tree-rings and available reference chronologies. The remains were labelled



Figure 5. Wooden piles from the collection of the Regional Museum Ptuj - Ormož were cut at the widest part of the pile during sampling for dendrochronological and radiocarbon analysis in 1999 (photo: Andrej Gaspari)

Slika 5. Leseni piloti v hrambi Pokrajinskega muzeja Ptuj - Ormož, ki so bili prežagani ob odvzemu vzorcev za dendrokronološko analizo na najširšem delu pilota v letu 1999 (foto: Andrej Gaspari)

with codes RMO-01 through RMO-09, which were assigned during the 1999 study (Figure 5).

An approximately 3 cm thick section of each pile was available for analyses. Surface preparation of the samples was carried out in the Department of Wood Science & Technology, Biotechnical Faculty, University of Ljubljana. The surface of the section was ground smooth so that the cell structure could be examined under a stereomicroscope at up to 100x magnification and wood identification could be verified. The width of the annual rings was

measured for all samples using a RINNTECH LinTab TM5 measuring stage and TsapWin 4.81 software. The tree ring series of the samples were cross-dated with each other and with the existing reference chronologies of the Department of Wood Science (Čufar et al., 2019).

In addition, two piles, PMO-08 and PMO-09, with the largest number of rings were studied in detail and finally PMO-09 was selected to sample exactly defined tree rings for radiocarbon dating (Figures 6, 7). After measuring the tree rings in

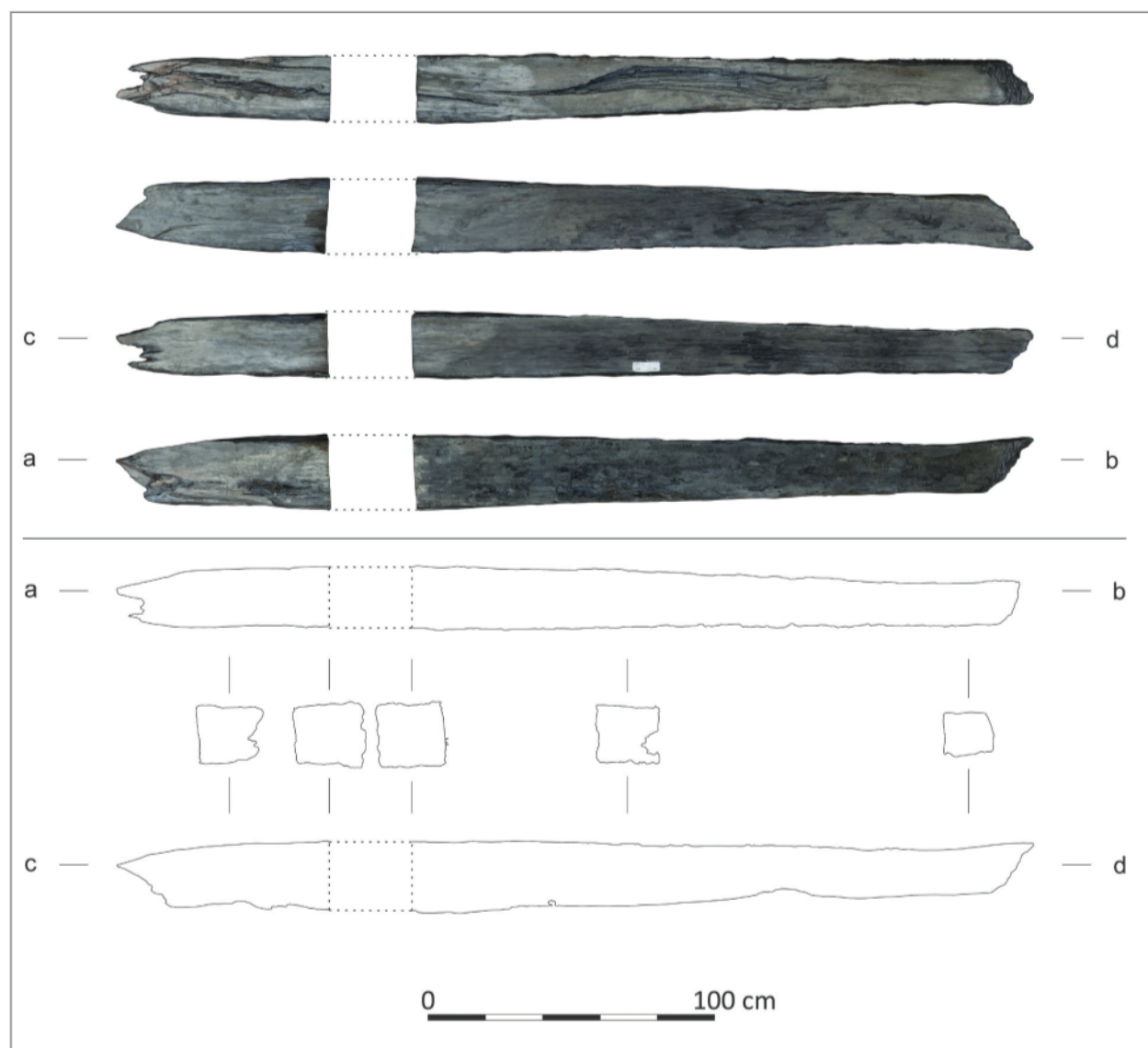


Figure 6. The oak pile RMO-09 with the highest number of annual rings was selected for dendrochronological and radiocarbon analysis.

Slika 6. Pilot iz lesa hrasta RMO-09, ki je imel največje število branik in je bil izbran za dendrokronološko in radiokarbonsko analizo.



Figure 7. Cross-section of sample RMO-09; marked longest measured timeline (red line) and sampling spots for radiocarbon dating (blue frame).

Slika 7. Prečni prerez vzorca RMO-09: označena smer meritve najdaljše časovne serije (rdeča črta) in označena mesta odvzema vzorcev za radiokarbonsko datacijo (moder okvir).

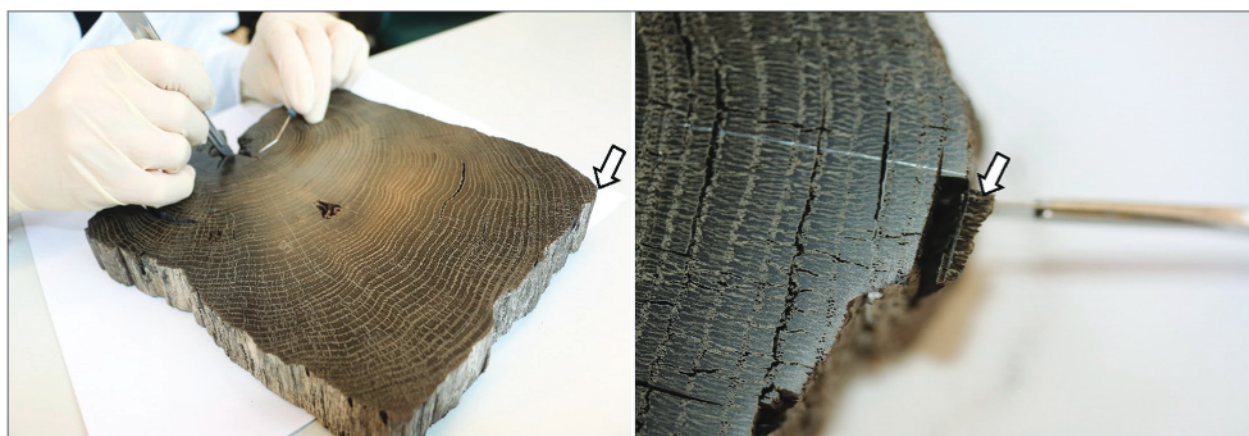


Figure 8. Sample RMO-09: Isolation of annual rings for radiocarbon analysis near the pith (left) and the youngest (outer) annual ring (arrow on both images).

Slika 8. Odrezek RMO-09; izolacija branik za radiokarbonsko analizo ob strženu (levo) in odvzem najmlajše (zunanje) branike (puščica na obeh slikah).

RMO-09, we collected two subsamples for radiocarbon dating and calibration by wiggle matching (Čufar et al., 2010). The RMO-09-P subsample contained two tree rings near the pith, and the RMO-09-B subsample consisted of the last (outermost and youngest) tree ring (Figure 8). Finally, the dry samples were sent to Beta Analytic, Miami, Florida, USA, for radiocarbon dating using the Accelerated Mass Spectrometry (AMS) method, which allows radiocarbon dating of small quantities of wood. When Beta Analytic provided the radiocarbon dates for the two samples, calibration was performed with the Wiggle matching method using the OxCal v4.4.4 program (Ramsey, 2021) and the IntCal 20 atmospheric curve (Reimer et al., 2020).

3 RESULTS AND DISCUSSION

3 REZULTATI IN DISKUSIJA

We confirmed that all piles were oak (*Quercus* sp.), possibly pedunculate oak (*Quercus robur*) or sessile oak (*Quercus petraea*), which cannot be distinguished by wood anatomy alone (Merela & Čufar, 2013). The piles did not contain sapwood.

The remains of the smaller piles RMO-01 through RMO-07, ranging in length from 105 to 233 cm, appeared to be composed primarily of low-grade, rectangular-hewn logs, ranging from 9 x 10 to 14 x 14 cm (Gaspari, 2001). These piles contained between 19 and 31 growth rings, which is considered too low for successful tree-ring analysis (Čufar et al., 2015).

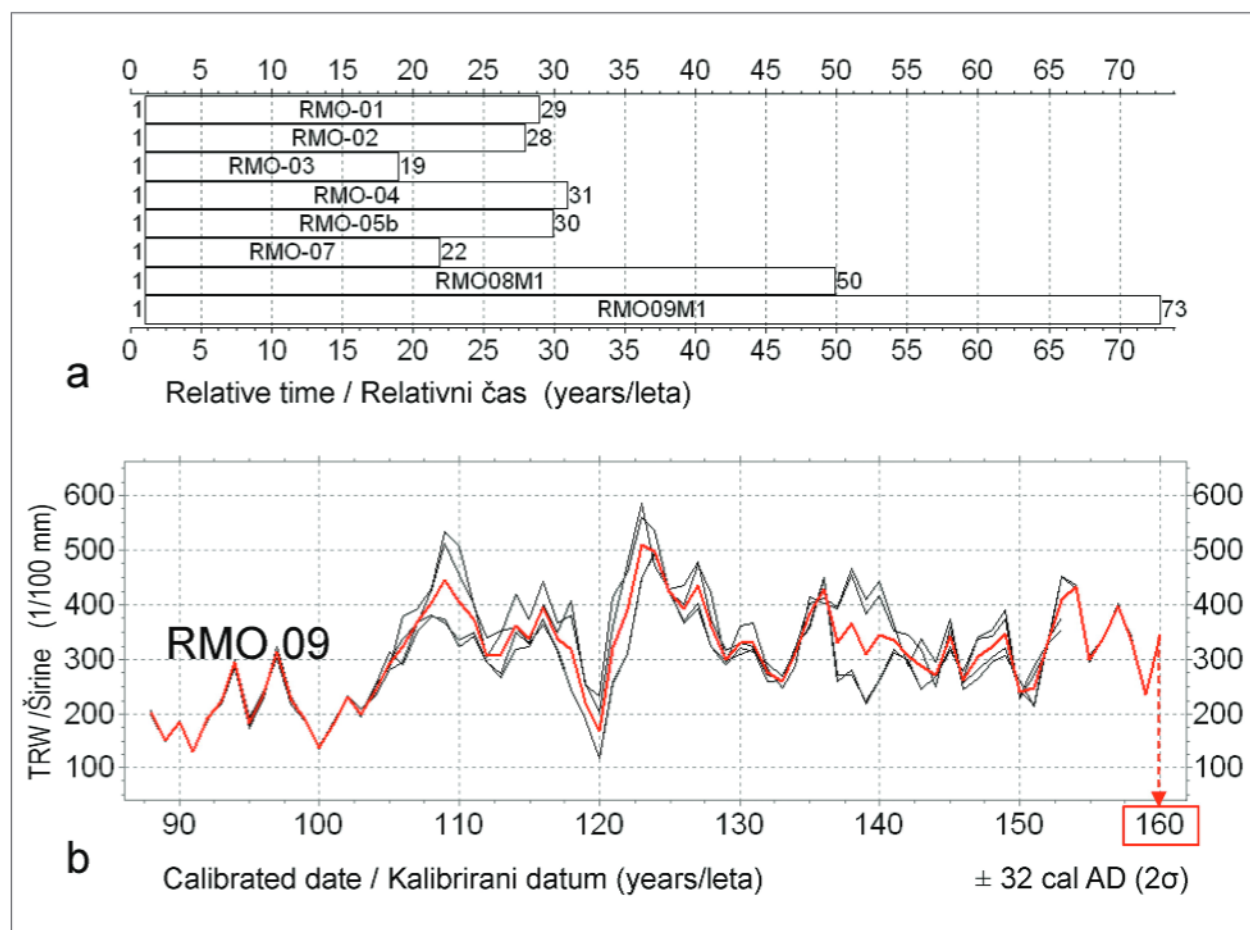


Figure 9. Graphical representation of (a) number of tree rings in piles in relative time and (b) tree-ring series of RMO-09 measured along multiple radii (black) and average of all (red) with the date of the last ring obtained by wiggle-matching.

Slika 9. Grafični prikaz (a) števila branik merjenih pilotov v relativnem času in (b) zaporedij širin branik vzorca RMO-09, merjenih vzdolž različnih radijev (črno), povprečje vseh meritev (rdeče) ter datum zadnje branike, ugotovljen z metodo wiggle-matching.

and to repeat the analyses if the first attempts have not produced tangible results. We have analysed the wood from all 8 piles of the same construction curated by the museum. The number of piles is small compared to a famous Roman bridge over the Rhine in Cologne, where over 100 piles have been excavated and dendrochronologically dated. Investigations began in the 1960s and were completed with the publication of Frank and Hanel (Frank &

Hanel, 2019). This study allowed the dating of the oldest group with an end date of 378 AD, and three phases of reconstruction with dendrochronological end dates of 1175, 1546 and 1795 AD (Frank & Hanel, 2019).

When examining piles, it is important to note that they can often remain *in situ* for millennia, as illustrated by the case of the 4th millennium BC pile-dwelling settlement of Resnikov prekop,

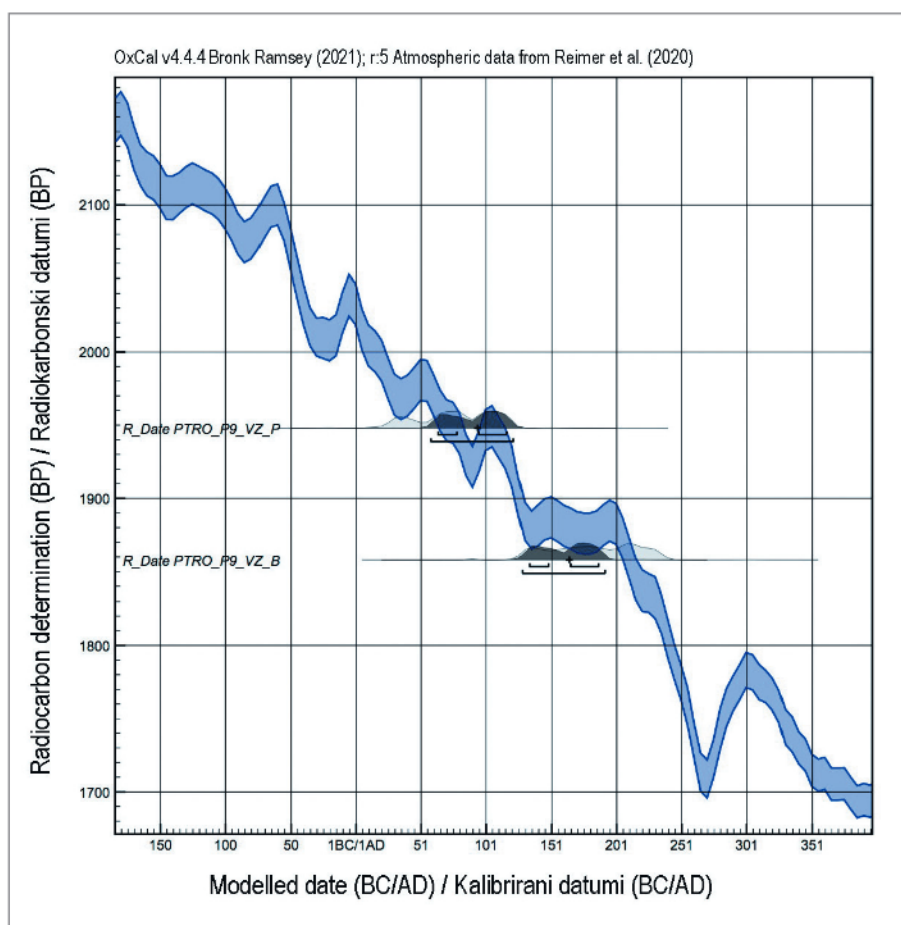


Figure 11. Calibration of the radiocarbon determination (BP) of the older sample PTRO_P9_VZ_P and the younger sample PTRO_P9_VZ_B vs. modelled calibrated dates (BC) on the time axis using OxCal v4.4.4 software (Ramsey, 2021) and IntCal 20 atmospheric curves (Reimer et al., 2020). The actual age difference between the two samples is 70 years. The dating of the younger sample is 161 ± 27 cal AD (1σ) or 160 ± 32 cal AD (2σ).

Slika 11. Kalibracija radiokarbonskega datuma (BP) starejšega vzorca PTRO_P9_VZ_P in mlajšega vzorca PTRO_P9_VZ_B ter prikaz kalibriranih datumov (BC/AD) na časovni osi, pridobljenih s programom OxCal v4.4.4 (Ramsey, 2021), in atmosferske krivulje IntCal 20 (Reimer et al., 2020). Dejanska razlika v starosti vzorcev je 70 let, datacija mlajšega vzorca je 161 ± 27 kal. n. št. (1σ) ali 160 ± 32 kal. n. št. (2σ).

where dated piles at the original site in the ground helped in the dating and interpretation of other archaeological artefacts that could be 'displaced' due to erosion or sedimentation (Čufar & Tolar, 2006).

It is important to note that in the present study all 8 piles from the Drava River were re-analysed, although most of them showed only a small number of tree rings. However, the selection of pile RMO09 for detailed analyses, the application of the AMS (Accelerated Mass Spectrometry) method, which allows radiocarbon dating of small amounts of wood (in our case one or two tree rings), and the use of wiggle-matching have helped us to confirm that the pile and the stone elements belong to a Roman bridge over the Drava.

5 CONCLUSIONS

5 ZAKLJUČKI

Dendrochronology, radiocarbon dating, and wiggle-matching calibration determined the date of the last (outer) tree ring of the RMO-09 pile, 161 ± 27 cal AD (1σ) or 160 ± 32 cal AD (2σ). The estimated date of tree felling for the pile that did not contain sapwood is approximately 15 years after the determined dates. The dating thus provisionally agrees with the presumed dating based on the building inscription, which attributes the commission to build or rebuild the bridge to Emperor Hadrian in the last years of his reign, and places the intervention in the context of the reconstruction of the road network in the wider area of the Poetovio colony (Horvat et al., 2003; Šašel Kos & Belak, 2013). According to the calibration curve and wiggle-matching dates, however, it cannot be excluded that the construction or renovation took place under one of Hadrian's successors. In this way, more than 100 years after the recovery, wood research has contributed to solving the mystery and confirmed that the remains of the wooden piles and adjacent stones found in the Drava River belong to a Roman bridge.

6 SUMMARY

6 POVZETEK

Pokrajinski muzej Ptuj - Ormož v svojih zbirkah hrani skupino 8 lesenih pilotov, ki po muzejski dokumentaciji pripadajo ostankom rimskega mostu čez Dravo in so bili pridobljeni med posegi pod nadzorom kustosa Viktorja Skrabarja v letih 1912 in 1913 (Skrabar, 1913, 1914). Epigrafijsko Hadrijanovega gradbenega napisa ter drugo arhitekturno opremo domnevne mostne glave ter zgodovinsko-urbanistične vidike povezave med mostom in središčem kolonije na levem dravskem bregu je pred časom celovito obdelal Zsolt Mráv, katerega študija prinaša pregled dokumentiranih rimskih mostov v Panoniji (Mráv, 2002). Spoznanja in domneve o gradbeno-tehničnih značilnostih in topografiji mostu na Ptujso so sintetično predstavljena v članku soavtorja pričujočega dela (Gaspari, 2001), pomemben prispevek k zgodovini raziskav pa je dal Andrej Preložnik z zaznamkom k prvim opažanjem zgradb na desnem dravskem bregu na začetku 19. stoletja (Preložnik, 2020). Ob odsotnosti novih terenskih odkritij je bilo v okviru priprave članka iz leta 2001 izvršeno vzorčenje hrastovih pilotov iz muzejskega depoja. Pregled z vzorčenjem za preiskave lesa in dendrokronološko analizo, ki ga je izvedel Tom Levanič, takrat zaposlen na Katedri za tehnologijo lesa Oddelka za lesarstvo Biotehniške fakultete v Ljubljani, v spremstvu Andreja Gasparija in kustosa Ivana Žižka, je pokazal, da gre v vseh primerih za pilote iz lesa hrasta. Dendrokronološko datiranje vzorcev, ki so bili odvzeti z motorno žago iz najširšega dela pilotov, v letu 1999 ni bilo mogoče, izostala pa je tudi radiokarbonska analiza (Gaspari, 2001).

Potencial ostankov pilotov je bil predmet ponovne preverbe v začetku leta 2019. V sodelovanju z muzejsko kustosinjo Aleksandro Nestorovič je bil 20. februarja 2019 opravljen ponoven pregled ostankov vseh osmih pilotov. Pregled se je osredotočil na njihovo primernost za dendrokronološko analizo oz. število branik, vidnih v prerezi ostankov pilotov, vzorčenih leta 1999. Za podrobnejšo preiskavo sta bila zaradi ustreznega števila branik izbrana dva pilota, PMO-08 in PMO-09, od katerih je bil ob mestu vzorčenja iz leta 1999 odrezan po en odrezek debeline 3 cm.

Na Oddelku za lesarstvo Biotehniške fakultete, Univerze v Ljubljani smo izvedli pripravo površin vzorcev za pregled pod stereo lupo. Ponovna

identifikacija lesa je potrdila, da je vseh 8 pregledanih pilotov iz lesa hrasta, doba (*Quercus robur*) ali gradna (*Quercus petraea*), ki ju po lesu ne moremo razlikovati (Merela & Čufar, 2013).

Merjenje širin branik smo opravili z merilno mizico RINTECH LinTab TM5 in programsko opremo TsapWin 4.81. Šest vzorcev (številke 1, 2, 3, 4, 5, 7) je imelo 19–31 branik, kar je premalo za uspešno datiranje, vzorca RMO-08 in RMO-09 pa sta imela 50 in 73 branik.

Zaporedij širin branik različnih pilotov nismo mogli medsebojno sinhronizirati. Tako nismo mogli potrditi, ali piloti pripadajo isti gradbeni fazi in ali so bili uporabljeni za gradnjo istočasno. Zaporedja širin branik pilotov RMO-08 in RMO-09 smo skušali datirati z različnimi referenčnimi kronologijami Od-delka za lesarstvo (Čufar et al., 2019), vendar datiranje ni bilo uspešno.

Iz vzorca RMO-09, ki je imel največ branik, smo nato odvzeli še dva vzorca za radiokarbonsko datacijo in kalibriranje po metodi wiggle-matching (Čufar et al., 2010). Vzorec RMO-09-P je vseboval prvi dve braniki ob strženu, vzorec RMO-09-B pa zadnjo zunanjo (najmlajšo) braniko.

Rezultate radiokarbonskih datacij dveh vzorcev smo kalibrirali s pomočjo metode wiggle-matching ob uporabi programa OxCal v4.4.4 (Ramsey, 2021) in atmosferske krivulje IntCal 20 (Reimer et al., 2020). Ugotovljeni datum zadnje branike na vzorcu PTRO_P9_VZ_B, branika 73 je bil 161 ± 27 kal. n. št. (1σ) ali 160 ± 32 kal. n. št. (2σ) (sl. 10).

Pri oceni starosti pilota moramo ugotovljene-mu datumu zadnje branike prišteti še vsaj 15 let za manjkajočo beljavo. Datacija bi tako lahko okvirno sovpadala s časovno opredelitvijo rekonstruiranega gradbenega napisa, ki naročilo obnove oz. novogradnje mostu pripisuje cesarju Hadrijanu v zadnjih letih njegove vladavine in poseg umešča v okvir prenove cestnega omrežja na širšem območju kolonije Poetovio (glej Horvat et al., 2003; Šašel Kos & Belak, 2013). Glede na obliko kalibracijske krivulje za datiranje z metodo wiggle-matching ni izključeno, da je bila postavitve mostu ali njegova obnova izvršena pod katerim od Hadrijanovih naslednikov.

Predstavljeni rezultati potrjujejo, da je smiselno analizirati les iz rimskih konstrukcij ter da je treba analizirati ves razpoložljivi material in ponoviti analize, če prvi poskusi ne prinesejo oprijemljivih

rezultatov. Število pilotov s Ptuja je majhno v primerjavi z znamenitim rimskim mostom čez Ren v Kölnu, kjer je bilo proučenih in dendrokronološko datiranih več kot 100 pilotov. Tudi tam so se raziskave začele v šestdesetih letih 20. stoletja in so se zaključile z objavo, ki sta jo pripravila Frank in Hanel (Frank & Hanel, 2019). Ta študija je omogočila datiranje najstarejše skupine pilotov s končnim datumom 378 n. št. in treh faz rekonstrukcije z dendrokronološkimi datumi 1175, 1546 in 1795 n. št. (Frank & Hanel, 2019).

Pomembno je poudariti, da je bil izbor pilota RMO09 za podrobne ponovne analize lesa smiselni, saj sta razvoj metode AMS (Accelerated Mass Spectrometry), ki omogoča radiokarbonsko datiranje majhnih količin lesa (v našem primeru ene ali dveh branik) in kalibriranje wiggle-matching, pomagala potrditi, da pilot in ob njem najdeni kamniti elementi zares pripadajo rimskemu mostu čez reko Dravo, ki je bil najverjetneje zgrajen ob koncu vladavine cesarja Hadrijana.

ACKNOWLEDGEMENTS

ZAHVALA

This study was supported by the Slovenian Research Agency (programmes P4-0015 and P6-0247). We would like to thank Aleksandra Nestorović, the museum curator, for her help and support with sampling in the museum depot, Luka Krže for sample collection and preparation, Blaž Kumer for help with graphic design and Primož Stergar and Branko Mušič for permission to use the results of the latest geophysical survey and test excavations (2021).

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