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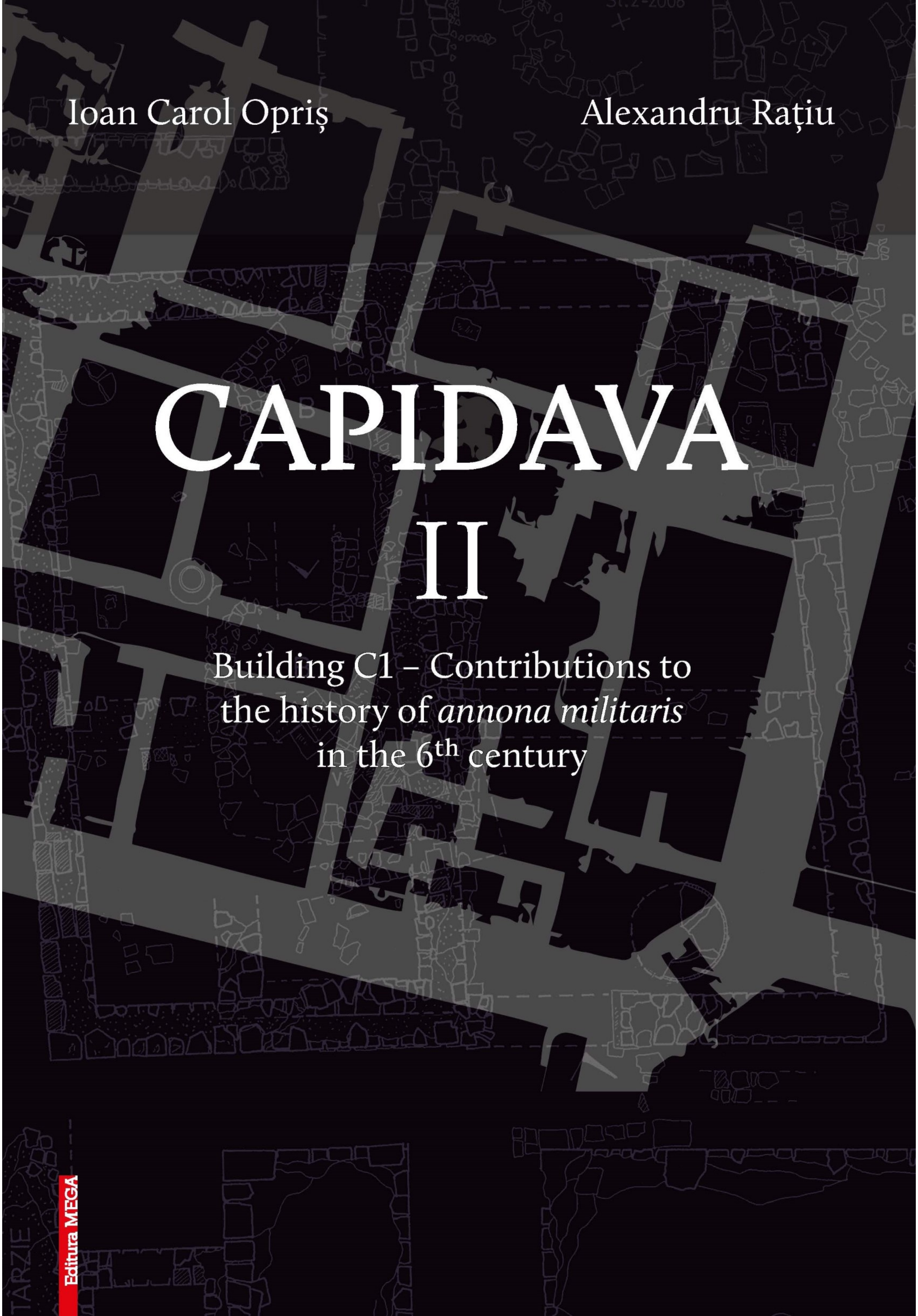

CAPIDAVA
II

Building C1 – Contributions to the history of *annona militaris* in the 6th century

Editura MEGA

Ioan Carol Opriș Alexandru Rațiu

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With contributions by:
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ANNEX II.

DENDROCHRONOLOGY OF THE EARLY BYZANTINE FORT AT *CAPIDAVA*

***Tomasz Ważny*[*, **]*, Peter I. Kuniholm*[*]*, and Charlotte L. Pearson*[*]**

Capidava, strategically located on the right bank of the Lower Danube, just where the river turns north and east, reaching the Black Sea about 280 km further downstream, was first occupied prior to the Roman conquest[1]. In the early 2nd c. AD it became an important military and civil Roman centre, after an auxiliary fort was built in order to defend the ford of the Danube[2]. The ruins from which we collected eight sets of charcoal samples are believed by the excavators to date to a building phase (phase IV) at the end of the 5th c. – early 7th c. AD[3]. The general chronology of the site goes from the early 2nd to the 11th c., when the Pechenegs destroyed the fortress for the last time (ca. 1046)[4].

All the samples were taken from an early Byzantine building constructed next to the main gate of the fort. This quadrangular building (labeled C 1) 10 by 11 m, located in the southeastern sector of the fort, was excavated in 1993–2014. A detailed description of the archaeological context, stratigraphy, and finds was published by I. C. Opriş and Al. Raţiu[5]. The building remained in use until the last decades of the 6th c. AD. The bronze coin-hoard found on the doorsteps of Rooms I and III and especially two coins from Emperor Tiberius II Constantine provide more precise dates – these coins were issued between December 578 and December 580, "although their dating could be extended to 582.[6] It should, however, be noted that the building was built after leveling the dismantled walls of an older imposing structure, so hypothetically some older materials may have been reused in construction.

Samples for dendrochronological examination were taken from the profile along wall Z 6 inside Room III of the building (Fig. 1). They represent the burnt structural timbers of a collapsed roof. A few beams were preserved in larger fragments, and, despite the high temperature of the burning and the lapse of nearly 1500 years, we also recovered one complete joist composed of two beams joined firmly by an iron nail (Fig. 2)[7]. We also collected select loose pieces of charcoal from rooms I and III which showed potential for dendrochronology in order to provide ourselves with better reference material for the development of tree-ring chronologies for early Byzantine *Capidava*. All

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1 FLORESCU, FLORESCU, DIACONU 1958, 12, 14, 16.
2 OPRIȘ 2003, 17–26; OPRIȘ 2006.
3 OPRIȘ 2003, 23–24; OPRIȘ, RAȚIU 2016a.
4 See the *Introduction* chapter *supra*, 18 and n. 35 (1046 *vs*. 1064).
5 OPRIȘ, RAȚIU 2016a.
6 OPRIȘ, RAȚIU 2016a; GÂNDILĂ in Annex I of this volume.
7 See KUNIHOLM, STRIKER 1977, Abb. 31 and Taf. 1–4 for similar woodwork – albeit more sophisticated – from Hg. Eirene in Constantinople.

the samples collected were from whole sections of slow-grown oak (*Quercus* sp.) ca. 80–120 years old at the time of felling. Since these fragments of structural timbers were no longer in place, there is not much we can say about the original shape of the elements, the woodworking techniques, or their precise architectural placement.

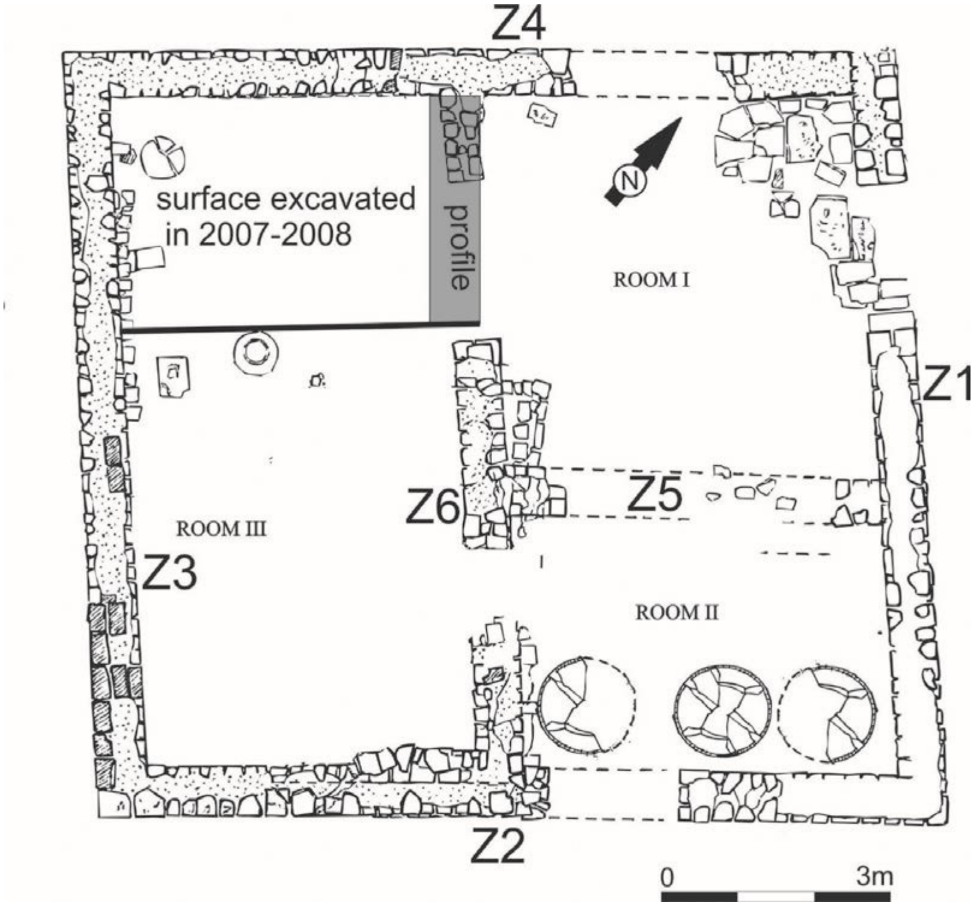

Fig. 1. Plan of building C1 with location of samples (orange/light brown strip).

Dendrochronology (or tree-ring dating) provides precise dates for wooden elements and constructions and has become one of the most important analytical methods applied to the study of historical objects for dating, provenance, and studies of forest management and wood technology. Dendrochronology is based on wood biology and therefore is completely independent from other historical proxies. Dating accuracy depends on the preservation of the youngest rings – those from the outer part of the tree. Annual precision can be achieved only when the youngest (outermost) ring – the last ring created by the tree before it was cut down – is present. The *Capidava* material was in the form of fragmented charcoal pieces, as noted above, which required our piecing together the various sections to enable us to combine these short tree-ring series into something that approximated the original intact beam. Statistical characteristics of the reconstructed tree-ring series are presented in Table 1. Sample 2/2009 was discarded because of insufficient tree-rings (fewer than 30). Despite the burning process and the fragile nature of the resulting samples, the wood-anatomical structure was very well preserved and ring boundaries were clearly visible (Fig. 3). Unfortunately, however, the *Capidava* samples did not have the outermost part of the tree preserved and we can only estimate the number of missing rings before the actual felling date for the sample.

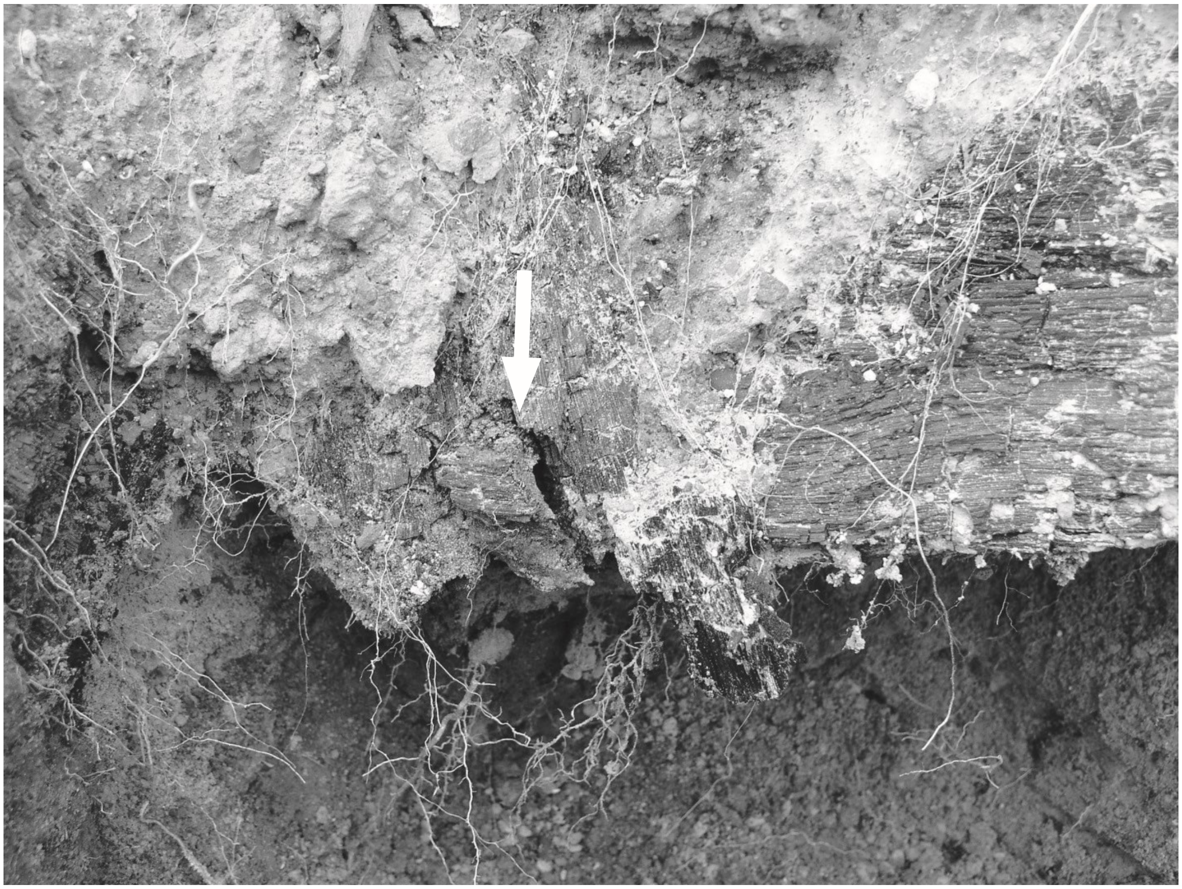

Fig. 2. Beams 2/2008 and 3/2008 joined perpendicularly by an iron nail (see arrow).

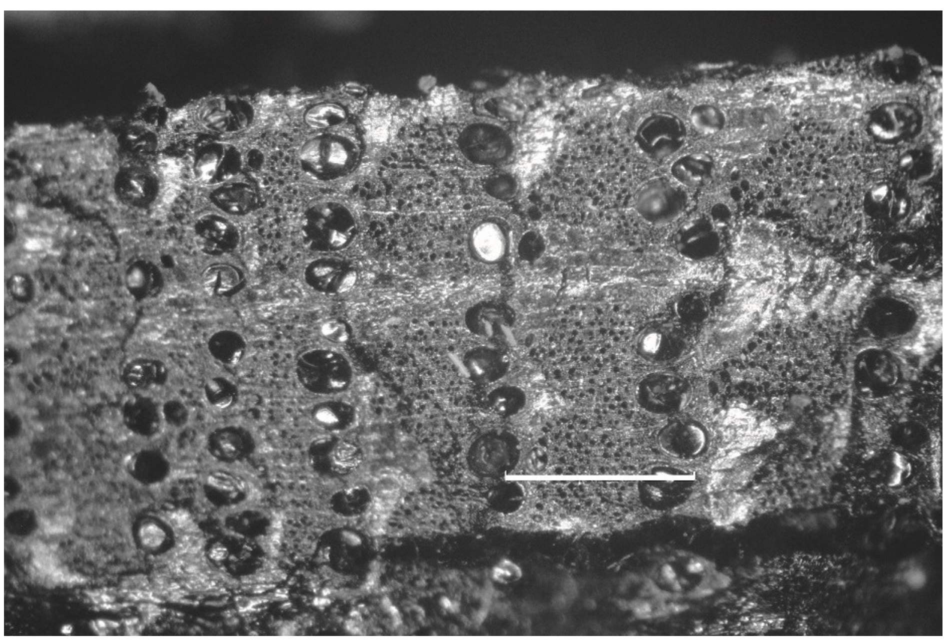

Fig. 3. Cross-section of sample 2/2008. White bar shows 1 mm. The large circles are the spring or earlywood vessels for each year.

Table. 1. Characteristics of samples and tree-ring series. "Min" "Mean" and "Max" mean minimum, mean, and maximum tree-ring width. "STDV" means standard deviation. "MS" is the mean sensitivity of each tree-ring series.

Sample No	Length [years]	Min [mm]	Mean [mm]	Max [mm]	STDV	MS [%]
1/2008	50	0.58	1.48	3.11	65.7	24
2/2008	101	0.31	0.75	1.60	27.4	21
3/2008	108	0.29	0.78	2.22	37.3	22
4/2008	77	0.24	0.63	1.13	18.9	24
5/2008	46	0.35	0.68	1.11	19.4	23
6/2008	74	0.33	0.82	2.28	41.8	28
1/2009	37	0.33	0.58	0.87	14.0	25

First, the measured ring-series from individual samples were cross-dated with others from the same structure using visual comparison of the tree-ring graphs and selected statistical parameters such as the Student's "*t*-value"[8], coefficient of agreement "GL"[9] and cross-dating index "CDI"[10] to indicate possible relative placements (Table 2). The series with the highest visual agreements were selected for the chronology.

TABLE 2. Results of Student's *t*-values displaying correlation between relatively dated tree-ring series. The calculation in this table was based on Hollstein's[11] algorithm.

Sample number	2/2008	3/2008	4/2008	5/2008	6/2008	1/2009
2/2008	-	7.6	7.4	5.0	5.4	5.0
3/2008	7.6	-	7.0	9.5	2.6	4.9
4/2008	7.4	7.0	-	*	3.3	4.2
5/2008	5.0	9.5	*	-	3.0	*
6/2008	5.4	2.6	3.3	3.0	-	3.8
1/2009	5.0	4.9	4.2	*	3.8	-

Next, we put together a 109-year-long sequence based on five selected pieces numbered from 2/2008 to 6/2008. This sequence, representing the total available sum for this construction, was compared with all existing oak chronologies for the 1st millennium AD: the Czech oak chronology[12], unpublished German chronologies developed by Becker for subfossil oaks from the German section of the Danube, the Rhine, and the Main; floating oak chronologies from Bosnia and Croatia[13] and the recently developed Marmaray chronology based on timbers from the Byzantine harbor of Yenikapı excavated during construction of the station for the new metro system in Istanbul[14]. In other words, we were looking for dendrochronological standards to the North, West, and South in the hope that long-distance correlation could be found, because the nearest absolutely-dated oak chronologies to *Capidava* were from distant regions of c. 400–1000 km from the site. This was especially challenging as most of the cited tree-ring sequences represent different climatic zones. However, we finally succeeded in crossdating the *Capidava* oaks with the Yenikapı harbor chronology with unexpectedly high statistical parameters: T_H-value 6.6, trend coefficient GL 74% and

8 BAILLIE, PILCHER 1973.
9 ECKSTEIN, BAUCH 1969.
10 RINN 2011.
11 HOLLSTEIN 1980.
12 KOLÁŘ, KYNCL, RYBNÍČK 2012.
13 PEARSON, WAŻNY, KUNIHOLM, BOTIĆ, DURMAN, SEUFER 2014.
14 PEARSON, GRIGGS, KUNIHOLM, BREWER, WAŻNY, CANADY 2012; KUNIHOLM, PEARSON, WAŻNY, GRIGGS 2015. *Capidava* is site #67 in this chronology. Note that three years have been added to the end-date for *Capidava* due to the addition of several more dated samples from the site.

Cross Dating Index CDI=51. The 109-year long *Capidava* tree-ring chronology spans the years AD 458–566. Dating results of individual samples are presented in Table 3.

TABLE 3. Dating results of samples from *Capidava*, building C1. The number in brackets in column "Data length" means an existing but unmeasurable outer ring was present; "A" in the "Bark" column means that the bark or waney-edge were not present.

AZ Sample number	Excavator number	Data length	Sap-wood	Bark	Dating of tree-ring series	Final dating result
RCP0001	1/2008	50	0	A	undated	
RCP0002	2/2008	101	0	A	AD 463–563	$578^{+X}/_{-6}$
RCP0003	3/2008	108 (+1)	0	A	AD 458–565	$581^{+X}/_{-6}$
RCP0004	4/2008	77	0	A	AD 472–548	$563^{+X}/_{-6}$
RCP0005	5/2008	46	0	A	AD 521–566	$581^{+X}/_{-6}$
RCP0006	6/2008	74	0	A	AD 490–563	$578^{+X}/_{-6}$
RCP0007	1/2009	37	0	A	AD 506–542	$557^{+X}/_{-6}$

Linking these dating results to an exact felling date was not possible because the outer parts of the beams were heavily deteriorated with all the outermost sapwood rings absent. As a result, the number of years missing after the outermost dated rings for the samples shown in Table 3 is unknown. However, we think that the compact hardwood survived almost completely whereas the softer sapwood was lost. This idea is supported by the close distribution of the end dates for each series (Fig. 4) and visual inspection of the timbers.

The youngest ring dates to AD 576 (samples 3/2008 and 5/2008). If we assume that the heartwood is largely intact and only the sapwood is missing we can then offer an informed estimate of the years missing in order to close in on a precise felling date. This estimate is based on data from studies involving a larger sample of trees of the same species where sapwood and cutting dates were clearly preserved. In this case dating results published, e.g. Botár and his team[15] for Transylvania, the study of Romanian oaks by Nechita[16] and the results of our research in the region[17], can be used to indicate that sapwood for oaks in the region can range from a minimum of 9 sapwood rings to a median of 15 sapwood rings. Adding this estimate to the end date for the sequences derived from samples 3/2008 and 5/2008 brings us to the date AD 577 as the earliest possible 'date after which' (*terminus post quem*) the sample was cut, with AD 581 the most probable cutting year for the trees. Usually the cutting year is equal with utilization year in this region and time period, unless trees were felled in the winter, in which case construction in the following year (AD 582) is likely. This date fits in very well with the evidence from the coins noted in the Annex I at the end of this volume[18].

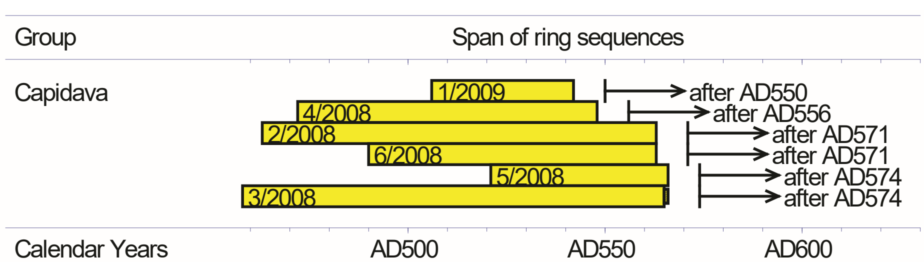

Fig. 4. Time span of the dated tree-ring series representing samples with interpretation of results.

[15] BOTÁR, GRYNAEUS, TÓTH 2015.

[16] NECHITA 2013.

[17] WAŻNY, LORENTZEN, KÖSE, AKKEMIK, BOLTRYK, GÜNER, KYNCL, KYNCL, NECHITA, SAGAYDAK, VASILIEVA 2014.

[18] See also GÂNDILĂ 2009.

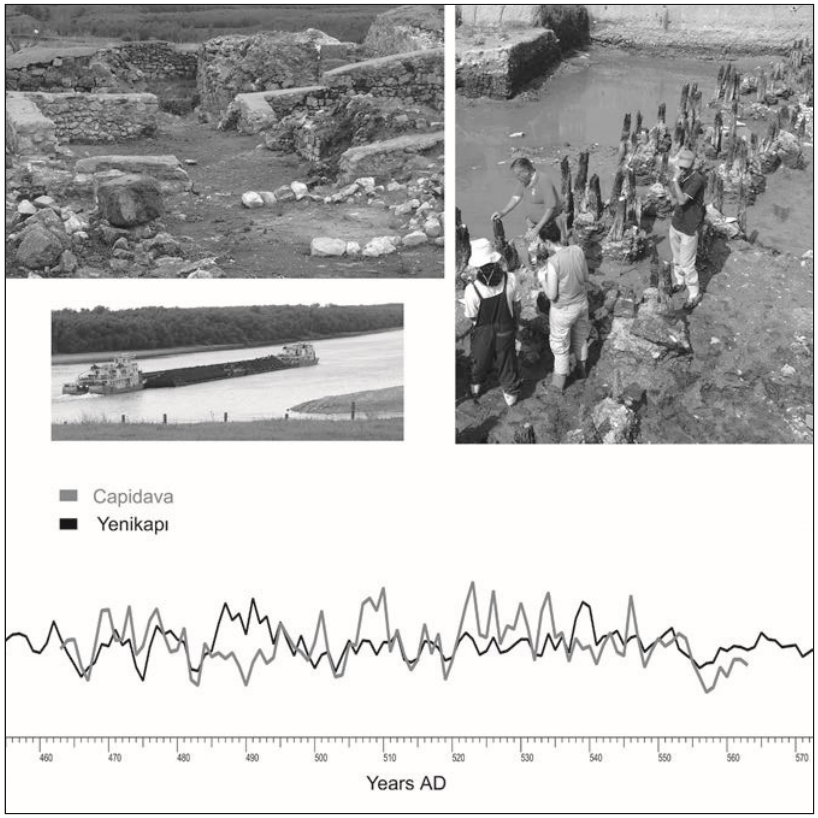

Fig. 5. *Capidava* (photograph top left), and general view of the Danube from the site (bottom left) and an early Byzantine dock at Yenikapı in Istanbul (photograph right). The graph at the bottom shows the quality of the fit between tree-ring series representing both objects.

The location of the *Capidava* fortress on the bank of the second-longest European river immediately raises the question of trade and the origin of various materials used in the construction of the site. Sadly, it is not yet possible to answer this question fully for the building timbers because of a lack of reference chronologies going back to the 1st millennium AD for the surrounding regions. The source of timbers used in *Capidava* could be from anywhere along the Danube or its various tributaries and we should not exclude local resources, for example the Danube Delta. The high statistical parameters of comparison between the *Capidava* and Yenikapı chronologies are, however, excellent evidence for timber exports from the NW coast of the Black Sea and probably the reach of trade along the Danube River to destinations as far away as Constantinople. The rapid expansion of the Constantinopolitan trade networks and general infrastructure in the first millennium AD[19] required large-scale construction, not least in the Yenikapı harbor where our research shows multiple phases of dock construction and harbor expansion over this period. Local timber resources were unable to meet the growing demand for building material, necessitating long-distance transportation across the sea as in the later Ottoman period, and following some 4000 years of established timber trade in the wider Mediterranean region[20]. In Istanbul's Yenikapı harbor we have already identified wood from the southern coast of the Black Sea, from the Aegean (northern Greece) and from inland Asiatic regions[21]. This link, showing common source materials with the Danube region at the northern edge of the Eastern Empire (Fig. 5), may indicate a

[19] MANGO 2004; MAGDALINO 2000; MÜLLER-WIENER 1994.
[20] KUNIHOLM, GRIGGS, NEWTON 2007.
[21] KUNIHOLM, GRIGGS, NEWTON 2007; PEARSON, WAŻNY, KUNIHOLM, BOTIĆ, DURMAN, SEUFER 2014; KUNIHOLM, PEARSON, WAŻNY, GRIGGS 2015.