

DATING OF THE OLD BRIDGE IN MOSTAR, BOSNIA AND HERZEGOVINA

Bogomil Obelić[1,2] • Ines Krajcar Bronić[1] • Jadranka Barešić[1] • Željko Peković[3] • Ante Milošević[4]

ABSTRACT. The famous single-arch stone bridge over the Neretva River in Mostar, Bosnia and Herzegovina, was built in 1557–1566 by the order of Ottoman Sultan Süleyman the Magnificent. During the reconstruction of the Old Bridge, which was destroyed during the war in 1993, remnants of 2 older wooden bridges were found at the same location. Six wood and 2 charcoal samples were dated using the radiocarbon method. Wood samples with visible tree rings were taken for dendrochronological dating. The results point to several periods of construction and repairs to the bridge and the towers at each end, spanning from the 12th to 18th century. Calibrated ^{14}C and dendrochronological ages were in good agreement.

INTRODUCTION AND HISTORICAL BACKGROUND

The Neretva River runs through the town of Mostar, which is the administrative and cultural center of the historical region of Herzegovina, the SE part of Bosnia and Herzegovina (Figure 1). Mostar owes its fame to its magnificent Old Bridge, which was added to UNESCO's World Heritage List in July 2005. (The name Mostar comes from the word "most," which means "bridge.")

Figure 1 Mostar in Bosnia and Herzegovina

[1]Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia.
[2]Corresponding author. Email: Bogomil.Obelic@irb.hr.
[3]Omega Engineering, Dubrovnik, Croatia.
[4]Museum of Croatian Archaeological Monuments, Split, Croatia.

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Despite its very favorable strategic location, the uncrossable river was the main reason why this area was scarcely populated until the late Middle Ages. Milošević and Peković (2006) give an overview of the historical records of the town and the bridges over the Neretva River. Fifteenth century records from the historical archives of the Republic of Dubrovnik (Ragusa) refer to 2 fortified settlements clustered around 2 towers, 1 on each bank. The settlement on the right bank was first mentioned in a 1443 document issued by Stjepan Vukčić Kosača, the governor (*herzeg*) of the area. Kosača refers to the area as the town of Cim in the county of Večerić, probably after *Civitas Pontis* ("a town on a bridge"), with a tower at the place of today's Helebija Tower (Peković et al. 2002–2003). The town on the left bank, Nebojša, with a tower at the place of today's Tara Tower, was first mentioned in 1444 in a certificate of possessions of *herzeg* Kosača issued by Alfonso V, king of Aragón and Naples. Dubrovnik records of 1452 ("*do castelli al ponte de Neretua*") and the second certificate of possessions by Alfonso V of 1454 ("*civitate Pontis cum castris et pertinentiis suis*") suggest that close to where the present Old Bridge stands there was a bridge in the Middle Ages with 2 towers on each side. This was later confirmed by Turkish traveler Evliya Çelebi, who wrote in 1664–1665: "... in ancient times, there was a bridge in town [Mostar] that hung across the Neretva River on a strong iron chain, as thick as a human thigh, and hence the town's name." In 1466, Dubrovnik, according to its records, sent Paskoje Miličević, one of the architects who built the town walls, with timber and tools to build a wooden bridge over the Neretva River. It is likely that he widened and fortified the existing suspension bridge in order to carry across the troops of the Croato-Hungarian king Matthias Corvinus in an attempt to stop the Ottoman invasion (Anđelić 1999).

However, 2 yr later, the whole of Herzegovina was conquered by the Ottomans. During Ottoman rule, a trading and manufacturing center was developed next to the bridge fortifications, which made the core of today's town of Mostar. The medieval bridge ran across the Neretva River until the mid-16th century. According to Ottoman records from 1565 and 1566, the stone bridge was preceded by a wooden bridge that was built during the reign of the Sultan Mehmed II El Fatih (1432–1483), the conqueror of Constantinople. However, it is more likely that this information relates to a reconstruction of the wooden bridge in the last decade of the reign of this sultan.

In 1557, by the order of the Sultan Süleyman the Magnificent, the imperial head architect Kodja Mimar Sinan designed a stone bridge with a span of 28.60 m. Construction problems were many and hard to solve, and would be even using today's technologies, which is exactly what makes the Old Bridge one of the greatest architectural structures in the world. At the time, it was the longest single-arch stone bridge in the world. Records of Evliya Çelebi have it that Mimar Hayruddin, Sinan's disciple, completed the construction in the year 974 after Hijra (AD 1566). This year is also found on the inscription at the left support of the bridge along with the dates of repairs that followed. Figure 2 shows the bridge and the Tower Helebija at the end of the 19th century.

The bridge was destroyed on 9 November 1993 during the war in Bosnia and Herzegovina. The reconstruction of the Old Bridge started in 2000 under the supervision of UNESCO, with funds managed by the World Bank but donated by different countries. The bridge was inaugurated on 23 July 2004. Reconstruction was supervised by the Croatian company OMEGA Engineering from Dubrovnik, which was also in charge of the reconstruction of both towers and of archaeological investigations. These investigations revealed the remains of 2 bridges from pre-Ottoman times, referred to in the Dubrovnik archives, but the exact positions of which were not known.

The aim of this study was to determine the ages of the wooden bridges and to compare these ages with Ottoman and Dubrovnik records. Additionally, it was not clear whether the whole complex, including the towers at both sides, had been constructed over several centuries at the location where the stone bridge now stands.

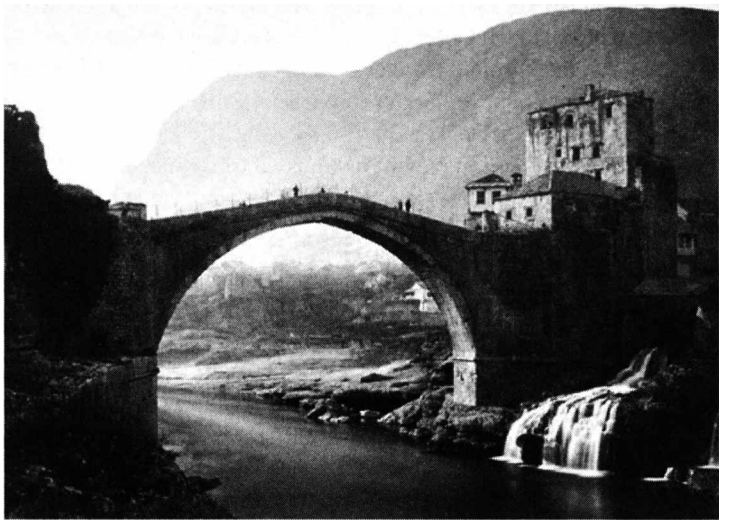

Figure 2 The Old Bridge in 1890 with the Tower Helebija to the right

SAMPLING AND MEASUREMENTS

Archaeological explorations at the location of the Old Bridge in 2002–2004 revealed dozens of objects, mainly from pre-Ottoman times, including parts of 22 wooden beams (18 pine and 4 oak) from various stratigraphic levels of the older wooden bridges and towers of Tara and Helebija. Six wood and 2 charcoal samples (Figure 3) from different periods of construction of the bridge were dated using the radiocarbon method, and 16 wood samples with visible tree rings were sent to Cornell University for dendrochronological analyses (Kuniholm et al. 2004). Only dendrochronological data associated with the ^{14}C-dated samples are discussed below.

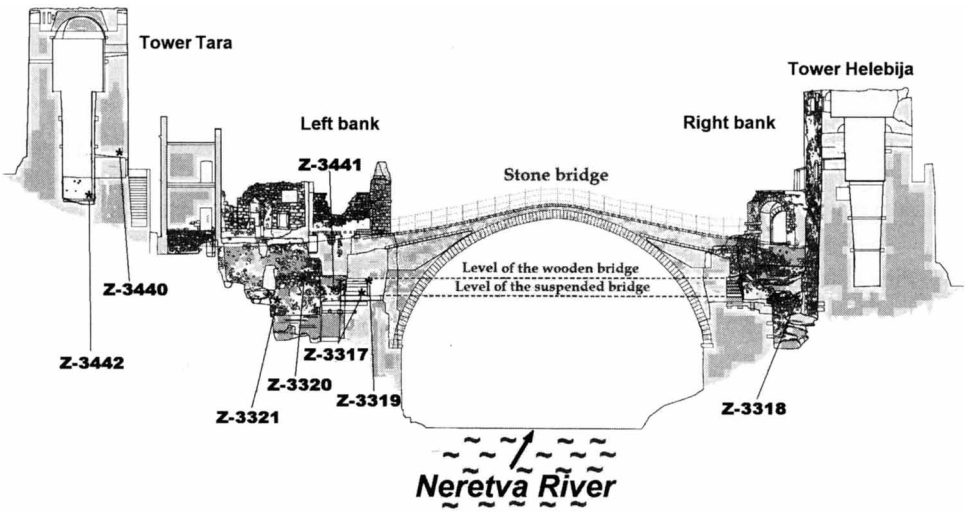

Figure 3 Drawing of the Old Bridge from upstream with positions of samples submitted for ^{14}C and dendrochronological analyses.

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^{14}C measurements were performed by gas proportional counting (GPC) and liquid scintillation counting (LSC) (Obelić et al. 2002; Horvatinčić et al. 2004). We used oxalic acid I and II as modern standards and anthracite as a background standard. Outer tree rings were taken for ^{14}C dating. Age calculation followed the conventional protocol (Stuiver and Polach 1977; Mook and van der Plicht 1999) based on the Libby half-life of 5570 ± 30 yr and using AD 1950 as the reference year. Ages and standard deviations (1 σ error) of samples were adjusted for stable isotope fractionation to a normalized concentration ratio ($\delta^{13}C = -25‰$) using the default $\delta^{13}C$ values. Calibrated ages were calculated using OxCal v 3.10 (Bronk Ramsey 1995, 2001) with 1-σ error (confidence level of 68.2%) and using the IntCal04 calibration curve (Reimer et al. 2004).

RESULTS

Table 1 shows the results of ^{14}C and dendrochronological dating. Conventional ^{14}C ages are rounded (Stuiver and Polach 1977), while calibrated age ranges, together with corresponding probabilities, are calculated from non-rounded data. Figure 4 shows calibration curves for non-rounded ^{14}C values and the last years of the tree-ring growth, obtained by dendrochronology.

Table 1 Conventional ^{14}C ages (BP, years before 1950) and dendrochronologically calibrated ranges (cal AD) of the outer tree rings of wood samples, and the year of the last tree ring determined by dendrochronology. Conventional ^{14}C data are rounded, while calibrated age ranges are calculated from non-rounded ^{14}C data.

Lab code Z-	Description	^{14}C age BP	Calibrated age range cal AD (% probability)	Year AD of last tree ring (dendrochronology)
3321	Pine beam #5 — suspension bridge, left bank	980 ± 65	990–1060 (27.8%) 1070–1160 (40.5%)	1001, 1009, 1050, 1052, 1082
3441	Charcoal #16 — anchorage of the suspension bridge, left bank	805 ± 65	1170–1275 (68.2%)	
3317	Pine beam #15 — wooden bridge, left bank	585 ± 65	1300–1370 (46.6%) 1380–1420 (21.6%)	1385
3442	Charred beam #17 — basement of the Tara Tower	580 ± 65	1300–1370 (45.3%) 1380–1420 (24.4%)	
3440	Pine beam #10 — first level of the Tara Tower	575 ± 70	1300–1370 (43.8%) 1380–1420 (24.4%)	1316
3318	Oak beam #2 — wooden bridge, right bank	415 ± 65	1420–1520 (54.9%) 1590–1620 (13.3%)	1480
3319	Pine beam #3 — wooden bridge, left bank	395 ± 65	1440–1530 (45.1%) 1570–1630 (23.1%)	1367, 1388
3320	Oak beam #4 — repairs of the stone bridge	220 ± 60	1630–1700 (22.5%) 1720–1820 (32.1%)	1737–1738

Two samples, pine beam #5 and charcoal #16, belong to the lowest stratigraphic level of the wooden bridge at the left bank of the Neretva River. The oldest is sample Z-3321 (#5), a part of a pine beam found together with 2 iron wedges (nails). The calibrated age range obtained (at 68.2%) is AD 990–1160. This is confirmed by dendrochronological measurements of 5 samples separated from this beam, giving ages of AD 1001, 1009, 1050, 1052, and 1082 for the outer tree rings. Another sample from the same level (Z-3441, #16), belonging to a beam walled into mortar used for the construction

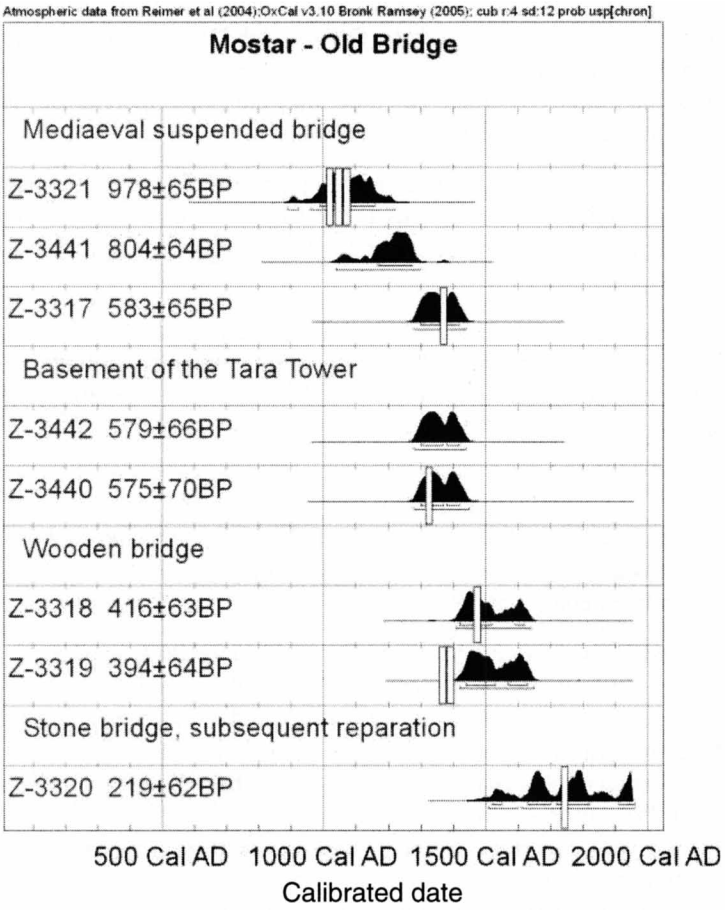

Figure 4 Calibration ^{14}C curves (OxCal v 3.10; Bronk Ramsey 1995, 2001) for samples from Table 1. The last year of the tree-ring growth, obtained by dendrochronology, is marked by vertical lines.

of the suspension bridge, is dated to cal AD 1170–1275. Both samples confirm the existence of the oldest suspension bridge and a 2-floor tower at the base of the present-day Tara Tower. A small golden ampulla made by a goldsmith between the 12th and the 13th century under Venetian influence was found in the tower walls (Milošević and Peković 2006).

Two samples were taken from the Tara Tower at the left bank of the river. Z-3442 (#17), a charred beam from the foundations of the tower, gives an age of cal AD 1300–1420. A pine beam from the first level of the tower (Z-3440, #10) is also dated to cal AD 1300–1420 and the dendrochronological result of the last tree ring is AD 1316. Although both samples give termini post quem for the construction of the Tara Tower, it can be concluded that the tower existed before the Ottoman times. To the same period belongs the beam covered with materials used in later construction of the Ottoman bridge, close to the stronghold (abutment) of the suspension bridge at its left side (Z-3317, #15), dated to cal AD 1300–1420 by ^{14}C and to AD 1385 by dendrochronology. At the base of the Tara Tower, a barbuta type of helmet was discovered, which was commonly used in Dalmatia from the 1330s to the 15th century (Milošević and Peković 2006).

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Pine beam #3 (Z-3319), found in a wall with iron wedges, dates to cal AD 1440–1630. Dendrochronological analysis of this sample gives ages of AD 1367 and 1388. This is the only instance of disagreement between the 2 methods. Since both samples Z-3317 and Z-3319 were found inside the foundations of the stone bridge constructed in 1566, they are contemporaneous and older than this bridge, which is confirmed by dendrochronological analysis.

Only 1 fragment of an oak beam, Z-3318 (#2), was found in the earth dyke on the right bank of the Neretva River. It stratigraphically corresponds to the sample Z-3317 from the left bank, but was dated by both ^{14}C and the dendrochronological method to the 15th century (cal AD 1420–1620) and AD 1480, respectively.

Sample Z-3320 (#4) was taken from one of the 2 beams found on the left river bank on the stratigraphic level of the wooden bridge. According to the results obtained by both ^{14}C (cal AD 1630–1820) and the dendrochronological method (AD 1737–1738), it is more likely linked with repair works on the stone bridge of the 18th century.

CONCLUSION

During the reconstruction of the old Ottoman bridge in Mostar, and thanks to thorough archaeological investigations, we were able to build a chronology of bridge construction over the Neretva River and resolve some historical controversies.

The evidence obtained shows that there were at least 2 wooden bridges over the river before the Ottoman stone bridge. The lower was a suspension bridge built on wooden A-shaped pylons and the upper bridge had a rigid frame. The oldest samples confirmed the existence of a bridge even before the building of the 2 towers at each side. The fact that the remnants of the wooden bridge were found at almost the exact location of the stone bridge dismisses the hypothesis that the wooden bridge was located downstream. Prior to this, of course, its existence was only known through 5-century-old documents, so this is a very important finding. We cannot exclude the possibility that in this initial period loads were transported from one bank to another by a cable-car system. The suspension bridge was reconstructed in the mid-14th century. This is when the 2-floor tower at the basis of the present-day Tara Tower on the left bank was also built. The dating receives support from the discovery of the Venetian golden ampulla dated to the 12th or 13th century.

The suspension bridge was replaced by a rigid-frame wooden bridge at either the end of the 14th century or the beginning of the 15th century. At the same time, a free-standing 2-floor tower (present-day Helebija) was constructed. This was confirmed by the discovery of the barbuta helmet used in Dalmatia until the 15th century.

The wooden bridge was completely reconstructed after the Ottoman conquest in the second half of the 15th century and was finally replaced by the single-arch stone bridge, completed in 1566. ^{14}C and dendrochronological datings of the remaining wooden elements give clear answers regarding the chronology of the construction of the pre-Ottoman bridges. Results presented in this paper prove that the wooden bridges were considerably older than historical references suggest and that the whole complex was under continuous construction over several centuries. Ages obtained by both dating methods are in good agreement, compatible also with stratigraphical investigations at the location, analyses of archaeological findings, and visible differences in construction of the structures revealed by the conservation-restoration studies made on all objects in the fortification.

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