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Content

Building phases of the triconch church complex at Bilice with regard to mortar dating

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The paper contains data on the building phases of the early Christian church complex at Bilice near Šibenik. Different chronological phases were already recognised during the first excavations of the complex at the beginning of the 20th century. In the new revision research at the site the existence of earlier and later structures has been confirmed by the position of walls and their connections.

The determination of the phases is provided by radiocarbon mortar dating. In the case of the early Christian complex at Bilice, three mortar samples were radiocarbon dated. The samples originate from different parts of the church complex, two of them from additional structures and one sample from the wall of the triconch church. The paper brings a detailed account of the radiocarbon mortar dating of the Bilice samples, methods used and results in the context of archaeological data on the early Christian church complex in Bilice.

Key words: *Bilice, triconch church complex, mortar dating, building phases, Late Antiquity*

Introduction

The Triconch church complex at Bilice consists of a single-naved church with three apses and annexes at the north, south and west sides of the church. The complex was discovered at the beginning of the 20th century and newly unearthed during the revision archaeological excavations from 2016 to 2019 (Jarak & Jukić Buča 2017: 129-153; Jarak 2019: 37-52).

The triconchal church shape appeared in early Christian architecture and developed through different variations. Dalmatian triconch churches are generally dated to the 6th century, while in other regions there are earlier triconch churches of different typological features, as well as contemporary to the Dalmatian examples. Simple chapels or memories with three conchas, so-called *cellae trichorae*, were very widespread and popular throughout the entire early Christian period (Krautheimer 1986[4]: passim). As a very famous example, *cella trichora* from Sopianae from the end of the 4th century can be mentioned, and the newly discovered sepulchral building of the same type speaks of the popularity of the triconchal memories in the Late Antique Sopianae (Hudák and Nagy 2016: 77-83; Visy 2016: 68-76). Triconch churches differ from *cellae trichorae* with regard to the existence of a nave in front of the triconch termination. The nave is usually long, and besides single-naved churches, three-naved structures are also characteristic in early Christian architecture. With regard to the main topic of this work, namely the triconch church from Bilice, it is interesting to note that all known triconch churches in Dalmatia have been recently dated from the later 5th to the first half of the 6th century (Vežić 2011: 27-66). The dating has been mostly based on the fact that the majority of Dalmatian triconch churches developed in church complexes with annexes during the 6th century. However, there are other opinions in the literature concerning the dating of the triconch churches in Dalmatia, which point to some later building of the churches during the 6th century (Cambi 1984: 45-54; Chevalier 1996: 41-43, 77-79, 91-93, 144-146, 269-271, 394-400). In other parts of the Roman World, triconch churches were built during a broader time span, and as earlier examples of different types of triconch church buildings, the structures from Cimitile-Nola in Italy and Dayr-al-Abiad in Egypt can be mentioned. The Triconch church at Cimitile, dated to the beginning of the 5th century, was attached to an earlier Christian complex dedicated to the martyr Felix. The church has a basilican plan, and its apse formed a trefoil. The architecture in Nola has been well known thanks to the description of Paulinus, who explained the function of the trefoil and its apses. Lateral apses have been determined as a prothesis for the preparation of the Eucharist and chapel for meditation (Krautheimer 1986[4]: 195-196). The architecture at Nola has been constantly researched, and some new details also appeared speaking of several phases during the 5th century (Ebanista 2017: 287-331). At Dayr-al-Abiad (White Monastery), a large basilica has a triconch termination. The church was built in the middle of the 5th century (Krautheimer 1986[4]: 114-117; Ousterhout 2019: 54-56, 132-134). It represents a very monumental early Christian monastic church. Other triconch churches are known from both the eastern and western territories of the early Christian world. The form had further development during the early Middle Ages, e.g. in pre-Romanesque and early Romanesque architecture in Croatia (Vežić 2011: 45-59). It is obvious that early Christian triconch churches in Dalmatia share common features with similar late antique forms, but they also represent a unique group in terms of morphology, function and dating. Archaeological research and analysis of the Bilice triconch church could contribute to better knowledge of this special early Christian church type in Dalmatia.

The triconch churches in Dalmatia are single-naved, modest buildings. With regard to the relation of conches (the majority of churches have connected conches, while some display distanced conches), it is possible to group triconch churches in Dalmatia (Cambi 1984: 45-54). The church from Bilice belongs to the group with interconnected conches decorated with lesenes, together with the churches in Pridraga and Sutivan. It is the most similar to the church from Pridraga. Besides architectural similarities, the churches from Bilice and Pridraga also share very similar stone furniture and certainly were built at the same time.

The task of the analysis of the Bilice triconch church is to check the reliability of its supposed dating according to the general place of triconch churches in Dalmatian early Christian architecture. We have wanted to provide some independent dating and to compare the obtained results with the conventional dating of triconch churches in Dalmatia. A possibility has been found during the new revision of archaeological research in Bilice. Newly unearthed walls have been suitable for mortar analysis that resulted in ^{14}C dating of the early Christian church complex in Bilice.

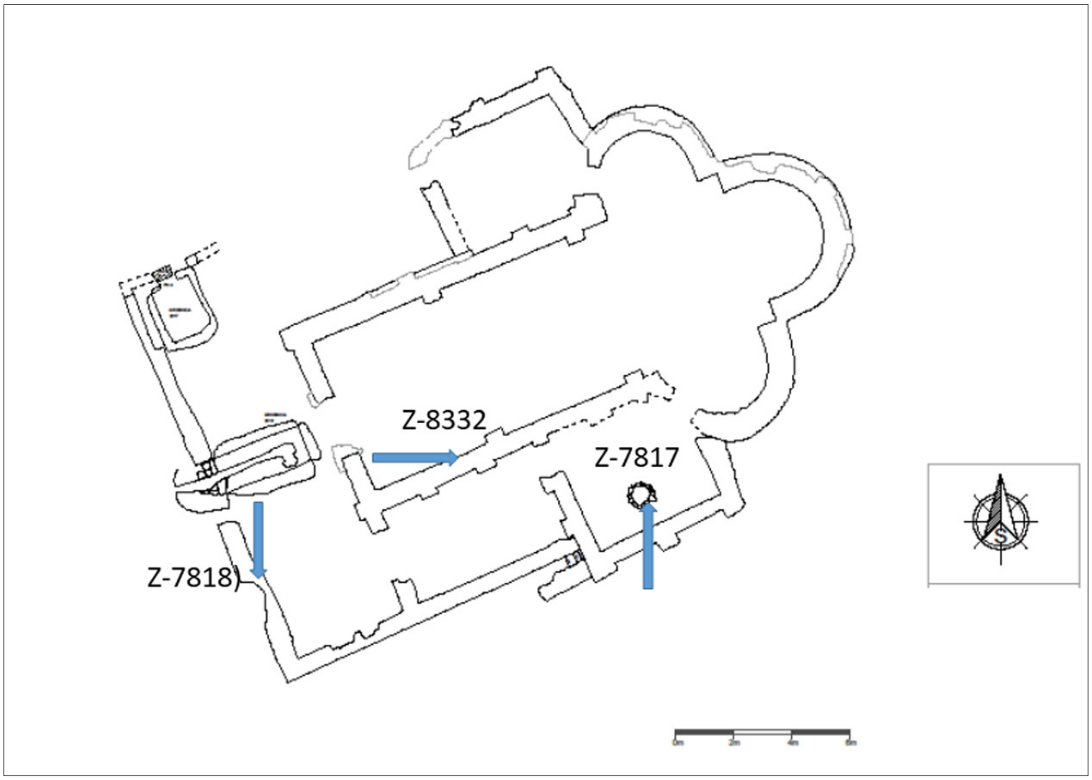


Figure 1. Bilice, ground-plan with locations of mortar samples: Z-7817 – baptistery, Z-7818 - west wall of the narthex, Z-8332 – south wall of the church nave (photo by M. Vuković, modification by M. Jarak).

Mortar can be dated by the radiocarbon dating technique, optically stimulated luminescence (OSL) (Zacharias et al. 2002: 379; Goedicke 2003: 409; 2011: 42; Urbanova et al. 2015: 110; Urbanova 2019: 81) and electron paramagnetic resonance (EPR) (Kabacińska et al. 2012: 825; 2014: 112). Mortar hardens during absorption of atmospheric CO_2, and radiocarbon mortar dating is based on extracting carbonate formed during the mortar hardening process (binder) and determining the amount of remaining natural ^{14}C (Labeyrie & Delibrias 1964: 742). However, mortar is a complex matrix with carbonates originating from aggregate, possible unburned geogenic carbonate, recrystallised carbonate, etc., making it difficult to extract pure binder carbonate that contains information about the date. There is a series of approaches to extract the pure binder or the other representative part (e.g. lime lumps); however, to this day, there is still no consensus on the preferred approach to mortar dating (e.g. Heinemeier et al. 1997: 487; Lindroos & von Konow 1997; Nawrocka et al. 2009: 857; Michalska 2019: 236; Barret et al. 2020; Daugbjerg et al. 2020: 1121). For the mortar samples from the triconch church complex at Bilice, we used the approach of differentiating the binder and geogenic carbonate by sequential dissolution and extrapolation developed in the Zagreb Radiocarbon Laboratory (Sironić et al. 2023: 119; Sironić et al. 2024: 1354). This approach to mortar radiocarbon dating has provided reliable results; however, the method is still being further developed, tested and perfected.

Materials and Methods

Location and sampling

For ^{14}C mortar analysis, three samples were taken from the different parts of the church complex. Two samples were taken from the west wall of the narthex and from the so-called baptistery. The 3rd sample was taken from the south nave wall. So, two samples originate from the annexes, and one from the triconch church (Fig. 1, 2, 3). In all three cases, the mortar was taken from the preserved wall structures that were uncovered during the revision research. The samples were brought to the Ruđer Bošković Institute, Laboratory for low-level radioactivities. The two samples from the annexes were analysed first, and the sample from the nave wall later on.

Figure 2. Bilice, narthex and part of the church nave (photo by M. Vuković).

Figure 3. Bilice, so-called baptistery (photo by M. Vuković).

Description of samples

Three mortar samples (Figs. 4a, b, c) were sampled from the described locations. About 20 g of mortar was sampled. Prior to processing the samples, they were tested with one drop of 0.5 % phenolphthalein for reactivity: if the mortar turned purple at the place of the drop, that meant that it still contained unreacted $Ca(OH)_2$ and the process of mortar hardening was not finished, i.e. that mortar sample contained carbon from all the time after the mortar was applied. All the samples were negative regarding the reaction with phenolphthalein.

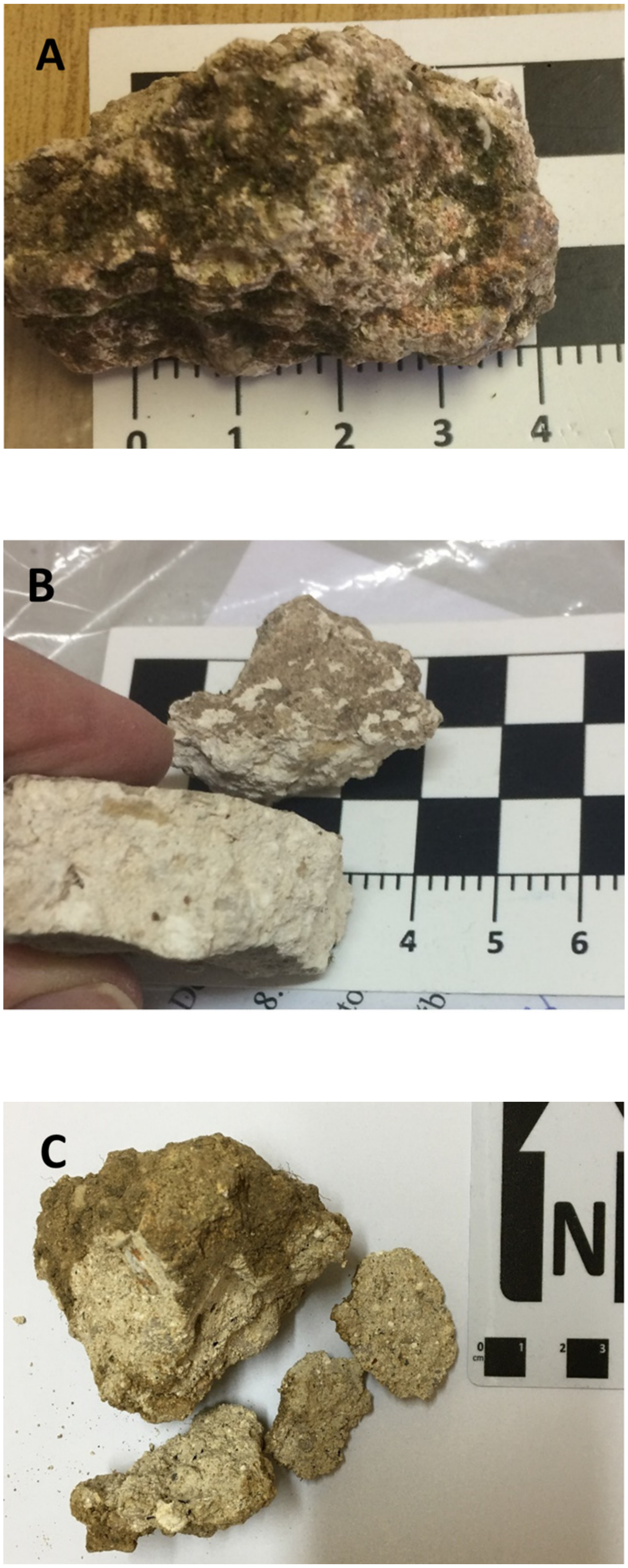
Sample Z-7817, Baptistery (Fig. 4a), was covered with organic fouling such as moss. It was mostly white, implying a large content of carbonate and binder. It contained macroscopic pieces of aggregate and smaller pieces of binder inclusions.

Sample Z-7818, Nartex (Fig. 4b), was mostly homogenous white, while the surface was covered with a darker coating. Some not well-defined inclusions can be spotted, ranging up to 5 mm wide. Some aggregate in the form of white translucent pieces can be observed.

Sample Z-8332, Church nave (Fig. 4c), was darker and more yellowish than the previous samples. Among the smaller observable pieces of aggregate, approximately 0.5 mm wide, smaller pieces of binder inclusion could also be observed (≤ 1 mm), and one piece about 1 cm wide.

Sample preparation for ^{14}C dating

The samples were treated according to the process described in Sironić et al 2023. The samples were cryogenically destabilised, broken with a hammer and inspected for possible charcoal remains, or if the binder inclusions exceeded 1 cm length, in which case the inclusions would be removed. In all the samples, this kind of inclusions were not found. Further on, the samples were gently crushed by a hammer. The powder was dry-sieved to collect particle fraction size 32-63 µm. A kinetic hydrolysis curve was created using 85 % phosphoric acid (H_3PO_4) to select the optimal CO_2 portion collection according to the criteria set in Sironić et al. 2023. Gas CO_2 portions were collected using a kinetic approach (Sironić et al. 2023: 185; 2024: 1354) by 85 % H_3PO_4 and only in the case of sample Z-8332, as a test, using a static approach by 2% HCl (adapted after Daugbjerg et al. 2020: 1121). According to the hydrolysis curve, selected CO_2 portions were collected regarding time frames for the kinetic approach and the HCl equivalent portion to the desired CO_2 amount for the static approach. The collected CO_2 gas was separated for $\delta^{13}C$ analysis and for graphite synthesis needed for ^{14}C analysis (Sironić et al. 2013: 185). The carbon isotope analyses were performed at the Centre for Applied Isotope Studies, Georgia (CAIS) (Cherkinsky



Figures 4a, 4b, 4c. Photographs of mortar samples from the triconch church complex at Bilice: 4a sample Z-7817, 4b sample Z-7818 and 4c sample Z-8332 (photo by A. Sironić).

et al. 2010: 867). ^{14}C values were normalized to $\delta^{13}C$ of -25 ‰ and expressed as $a^{14}C$ and as age before present (BP; Stuiver & Polach 1977: 335; Mook and van der Plicht 1999: 227).

Radiocarbon results for each mortar were extrapolated from the ^{14}C results of the first two CO_2 portions (Sironić et al. 2023: 185; 2024: 1354). Radiocarbon conventional ages were calibrated by OxCal 4.4 software (Bronk Ramsey 2009: 337; Bronk Ramsey 2021) and IntCal20 calibration curves (Reimer et al. 2020: 725).

Results and discussion

The results of the amount of extracted CO_2 portion, $a^{14}C$ and $\delta^{13}C$ for mortar fractions 32-63 µm are summarised in Table 1 and comparative first CO_2 portion dates and extrapolated calibrated dates for each mortar are presented in Fig. 5.

In all the cases, the first CO_2 portion has higher $a^{14}C$ and lower $\delta^{13}C$ values, which is in accordance with the fact that the initial CO_2 portions contain a larger amount of binder carbonate. Therefore, all the samples exhibit typical behaviour for well-preserved non-hydraulic mortars.

For the sample Z-8332 Nave wall, which was prepared twice, using the kinetic and static approach, both extrapolated results are in very good agreement one to another/statistically significantly (*Chi*-square test: df=1 T=0.2, 5% 3.8). Some authors also report the first CO_2 portions as the true ages of mortar, given the series of factors known for the mortars (e.g. Ringbom et al. 2014), and it is also reported here compared to the extrapolated dates. Given that the mortar is a very complex matrix prone to contamination and ^{14}C content alteration, it is important to notice that one of the criteria for checking the trueness of the extrapolated results is that the extrapolated and the first CO_2 portion ^{14}C date should be relatively close. In the case of kinetic approach for Z-8332 when the *Combine* function is applied (Bronk Ramsey 2022) to the first CO_2 portion and the extrapolated results *Chi*-square test fails at 5% probability (df=1 T=15.7, 5% 3.8) meaning that the two results are statically significantly different (there is 95 % chance of the wrong conclusion if it is reported that the results are the same). However, for the static approach, the *Combine* function reports that the *Chi*-square test for the first two CO_2 portion and extrapolated results are statistically significantly the same (1603 ± 24 BP, f=1 T=1.5, 5% 3.8).

Sample ID / name	Z	A	Time frame collection	pCO_2 / %	$a^{14}C$ / pMC ^{14}C date / BP Calibrated dates	$\delta^{13}C$ / ‰
Z-7817 Baptistery	7938	2571	0-3s	0-17	**83.8 ± 0.2** **1420 ± 39** Cal AD 605-652 (68.3%)	-28.7
	7939	2572	3-10 s	17-39	81.8 ± 0.2	-15.8
	Extrapolated				**84.6 ± 0.4** **1343 ± 39** Cal AD 650-684 (44.4 %) Cal AD 744-772 (23.8 %)	-
Z-7818 / Nartex	7828	2529	0-3s	0-7	**83.7 ± 0.2** **1429 ± 38** Cal AD 602-650 (68.3%)	-19.7
	7829	2530	3-10 s	7-28	80.5 ± 0.2	-7.6
	Extrapolated				**84.6 ± 0.4** **1348 ± 39 BP** Cal AD 647-684 (47.7 %) Cal AD 744-772 (20.6 %)	-
	8332	2990	whole fraction	0-100	72.6 ± 0.2	-11.7
Z-8332 / Church nave	8493	3190	0-4 s	0-14	**81.8 ± 0.2** **1713 ± 30** Cal AD 260-277 (14.2%) Cal AD 338-402 (54.1%)	-20.3
	8494	3191	4-10 s	14-37	79.7 ± 0.2	-10.8
	Extrapolated - kinetic				**82.5 ± 0.4** **1542 ± 39** Cal AD 436-463 (14.6 %) Cal AD 476-499 (14.1 %) Cal AD 531-586 (39.5 %)	-
	8365*	3011	1st portion 0.5 ml HCl	0-13	**80.80 ± 0.23** **1624 ± 29** Cal AD 412-439 (25.7%) Cal AD 460-478 (13.6%) Cal AD 496-34 (28.9%)	-12.76
	8367*	3012	+2nd portion 0.5 ml HCl	13-49	75.09 ± 0.22	-11.94
	Extrapolated* - static				**82.3 ± 0.4** **1545 ± 39** Cal AD 436-64 (15.8%) Cal AD 475-500 (14.9%) Cal AD 530-80 (34.9%)	

Table 1. $a^{14}C$ and $\delta^{13}C$ results for CO2 portions of mortar particle fraction size 32-63 μm. Laboratory sample ID number, Z, A – Zagreb laboratory radiocarbon analysis ID number and graphite number, pCO2 – relative amount of hydrolysed CO2 gas, $\delta^{13}C$ is with standard deviation of 0.1 ‰, ^{14}C date and calibrated dates for 68.3 % probability (1σ) are presented only for the extrapolated results (bold). The results are given for the kinetic approach of CO2 portion collection, except for samples marked with *, which are given for the static approach of CO_2 collection.

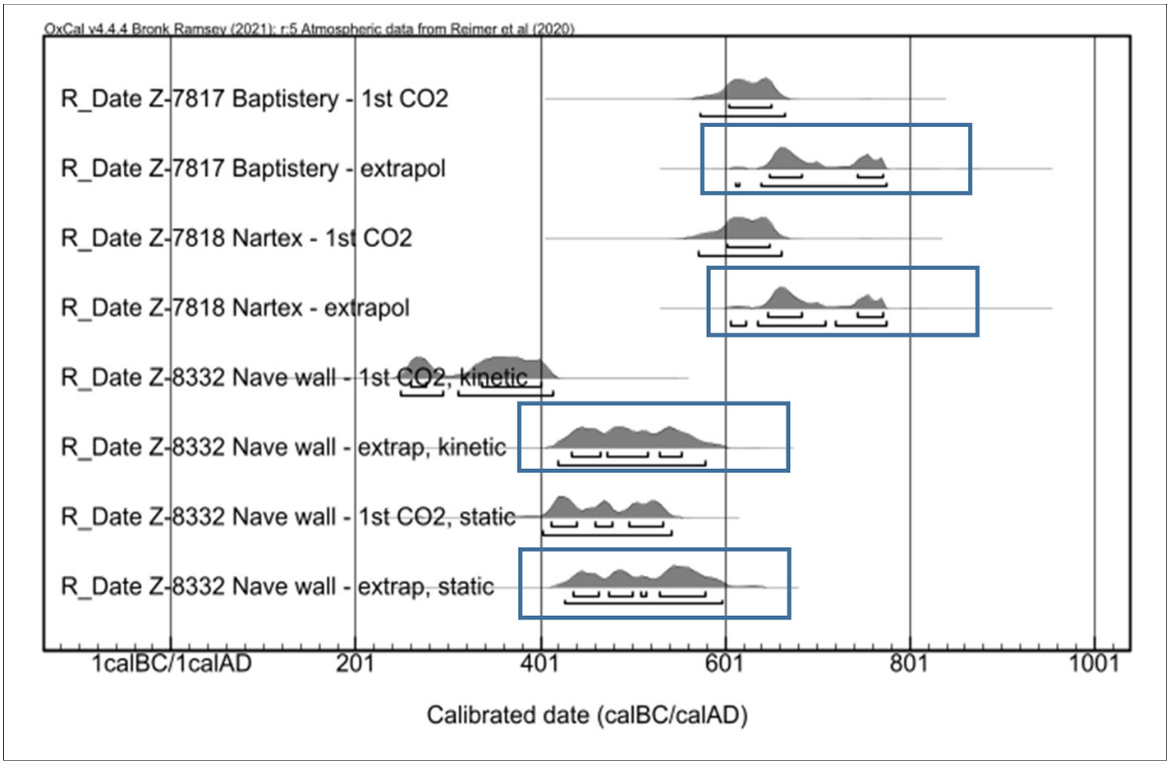


Figure 5. Calibrated results of the first CO2 portions and extrapolated results (in blue squares) for mortar samples from the triconch church complex in Bilice. The first calibrated date spans are marked for 68.3 % probability (1σ), and the second for 95.4% probability (2σ) of 14C radiocarbon dates (Drawing by A. Sironić).

Calibrated combine results for the first CO_2 portion and extrapolated result for static approach for the Nave wall are cal AD 424-440 (14.1%), cal AD 454- 478 AD (20.6%) and cal AD 496-534 (33.6%).

Similarly, when combined the first CO_2 portion and extrapolated result for Z-7817 Baptistery (1400 ± 24 BP, df=1 T=1.9, 5% 3.8), and for Z-7818 Nartex (1393 ± 24 BP, df=1 T=2.8, 5% 3.8), the results are statistically significantly the same at 95 % probability. This means that both the extrapolated and the first CO_2 portion ^{14}C dates can be used in interpretation. When calibrated, the combined results of the calendar ages for Z-7817 Baptistery are cal AD 610-617 (8.5 %) and cal AD 640 – 661 (59.8 %) and for Z-7818 Nartex is cal AD 610-618 (15.4 %) and cal AD 640-658 (52,9 %).

For both extrapolated and the first CO_2 portion ^{14}C results samples from Baptistery (Z-7817) and from Nartex (Z-7818) show the same calibrated dates placing them in the beginning to middle 7th century, while from the nave (Z-8332) shows about 200 years older dates (5th and the beginning of 6th century) which points to the fact that the church complex was built in at least two periods. When observing the morphology of mortar (Fig. 4a, b, c), it is also obvious that the sample Z-8332 differs from the other two.

Another thing that should be pointed out is that it is preferable to take petrographic and X-ray analysis of the mortars to check for recrystallisation, which can incorporate foreign carbon into the sample and for magnesite content, which can cause delayed hardening, which in this case was not performed. Therefore, this ^{14}C analysis should be taken mostly as a landmark for the true results.

The results of mortar dating, in spite of their limitations, can be compared with the archaeological interpretation of the building phases of the Bilice church complex. That interpretation is mostly based on the relations of the walls, which point to different times of building of the church and annexes.

Among earlier opinions concerning building phases, the most important is the notion of Luka Jelić, who analysed the Bilice complex after the first excavations at the beginning of the 20th century (Jelić 1912: 69-80). Jelić described three building phases, mostly based on the structure of the walls of the church and annexes. He saw differences in the structures of the walls of the Bilice church complex. According to Jelić single-naved triconch church was the first object of the complex, and it was built in the 6th century. The second building phase embraces two eastern annexes, northeastern and south-

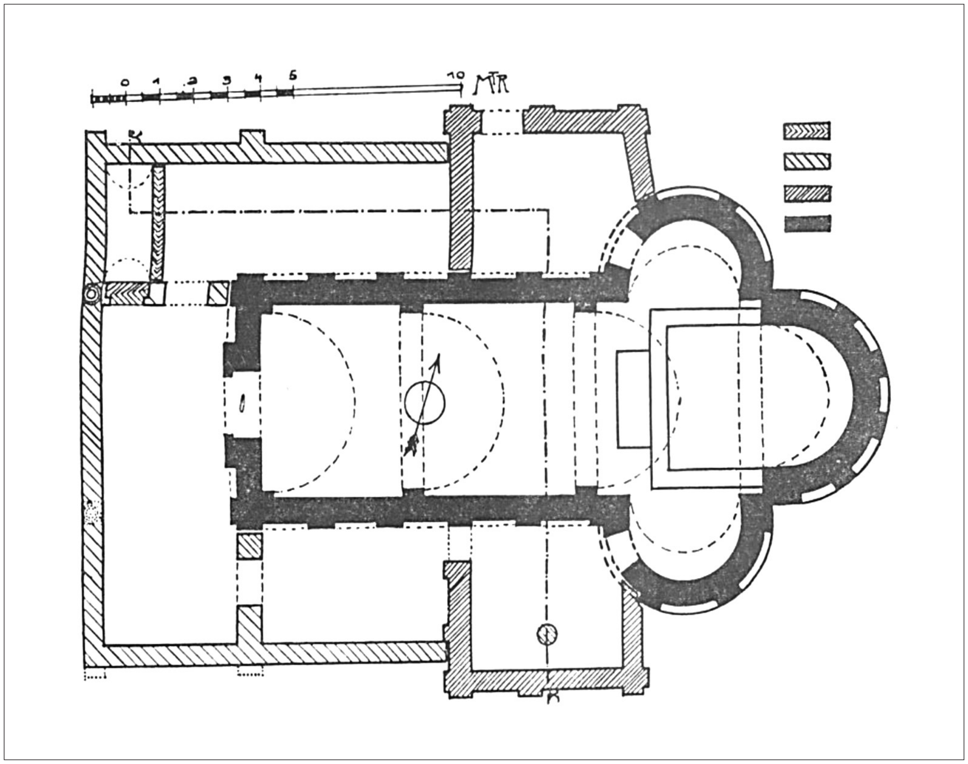


Figure 6. Bilice, ground-plan from the Jelić archives (AMS).

eastern quadrangular rooms that were built close to the walls of the lateral apses. In order to connect the annexes, the builders made openings in the apsidal walls. Jelić dated the 2nd phase to the second half of the 6th century. To his 3rd phase belong the narthex and two western annexes (northwest and southwest). The 3rd phase was dated to the early Middle Ages, from the 9th to the 11th century.

Possible differences in the wall structures, which were underlined by L. Jelić, are insignificantly discernible on the preserved wall remains of the complex, and besides, they could be explained by the different functions of the annexes in relation to the church alone. The church might have been visually separated from the auxiliary rooms by the manner of building of its walls, which were built of somewhat larger and more regular pieces of stone on the outside and internal face, with a filling of smaller rubble between the faces. The walls of the annexes have masonry work of roughly shaped rubble in copious layers of mortar. The manner of building certainly doesn't prove temporal succession, or at least it is not sufficient for such conclusions. Much important for differentiation of the building phases could be lesenes on the walls of the church and its annexes, which point to the temporal succession of the parts of the church complex.

Lesenes are still discernible, and they speak of at least two phases in the building of the church and annexes. Shallow lesenes are depicted on the ground-plan from the Jelić archives, and they were partially preserved on the walls unearthed in the revision excavations (Fig. 6). On some parts of the architecture, e.g. on the badly preserved wall of the south conch, lesenes have completely disappeared. Where they were preserved, like on the south church wall, they exhibit the same features in terms of number and position as on the old ground-plan. So, the correspondence between preserved lesenes and the old ground-plan testifies to the reliability of the latter. That is important with regard to the different phases of the Bilice church complex. Additional rooms, annexes around the single-naved church, have embraced the lesenes on the church walls. Shallow lesenes on the exterior of church walls had primarily a decorative function, and their position inside the annexes is not accessible and testifies to the secondary building of the annexes. The lesenes also have some importance regarding the building history of the annexes. Namely, lesenes on the west wall of the southeastern annex are situated inside the southwestern annex, which perhaps speaks of two different building phases. On the other hand, the north side of the church, the northeastern annex is without illogical lesenes, so the situation at the south side might

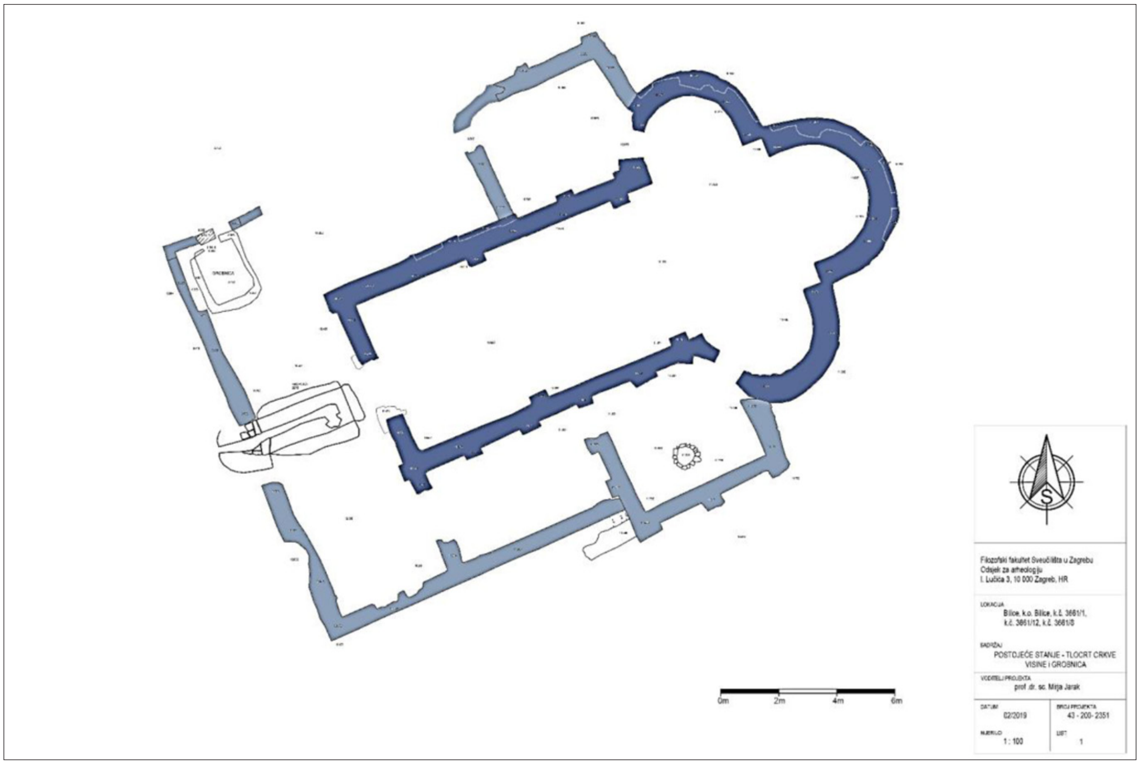


Figure 7. Bilice, new ground-plan with two building phases (Photo by M. Vuković, modification by P. Jeršek after M. Jarak).

be an accidental appearance or a result of the changing of the building plan. It could be concluded that the primary plan included only two eastern annexes. Accordingly, on the west wall of the southeastern annex the lesenes were built. The plan was probably changed during its execution and extended by the narthex and western annexes. All annexes very probably belong to one building phase that could last a longer time. In favour of the late antique building of the narthex speak two vaulted tombs connected with its walls, a typical tomb form for the late Antiquity and well known from many early Christian sites in Dalmatia. Narthex in the Bilice church complex certainly was not built in the early Middle Ages, as suggested by L. Jelić, but in the late antique building phase. Based on the preserved remains as well as the old ground-plan, it seems that the Bilice church complex had two building phases – the 1st belongs single-naved church and the 2nd all annexes. That is in accordance with the mortar dating, which points to different dating of the nave and annexes. Specially important is the same dating of the mortar samples from different annexes (baptistery and narthex), which are clearly younger in relation to the mortar from the single-naved church and support the existence of two building phases of the Bilice early Christian complex (Fig. 7).

Conclusion

Three mortar samples were dated from the early Christian church complex at Bilice near Šibenik using the method of sequential dissolution and extrapolation. The dating reveals at least two different building phases, first during the 5th – 6th century and later in the 7th – 8th century.

The narrower dating of the 1st phase or triconch church alone speaks to its stone furniture. All remains of the stone sculpture have the same stylistic features and have been dated in the literature in the second half of the 6th century (Mišković 2015: 7-20; Jarak 2019: 37-52; Jarak & Maričić 2023: 327-335). Early Christian stone sculpture from Bilice was discovered in the first excavation of the site at the beginning of the 20th century. The most important are the fragments of plutei decorated with a single motif that covers the whole main field of each pluteus. On one pluteus, there is a motif of the shells (squammae), and on the other, the intersected circles. While the shells were very popular during the entire early Christian period, the intersected circles executed by double-branched strips should be dated to the end of Antiquity, to the second half of the 6th or even to the beginning of the 7th century. The flat carving and style belong to the highly developed geometrical phase of the late antique sculpture. Similar sculpture has been known from several localities in Dalmatia and is connected to the Salonitan stonemason workshop from the second half of the 6th century. The best analogies come from Srima and Pridraga, and it is important that the sculpture from Srima has been precisely dated on the basis of the broad context of architecture and sculpture from the locality (Maršić 2005: 73-188; Mišković 2015: 7-20; Josipović 2018).

In the revision of archaeological research in Bilice, a few stone fragments with profiles were found. They have characteristics of church furniture and probably belong to an altar-screen or ambo plutei. Although only small parts of the plutei have been preserved, they can be compared with old findings from the same locality, i.e. with the important plutei with shells and intersected circles which have very prominent upper edges. The newly discovered plutei fragments also have prominent upper edges and could belong to the same time as the earlier discovered church furniture from Bilice. One of the newly found fragments has been petrographically analysed. The stone sample shows similarities with the Seget stone variety, permitting us to assume that the stone used for the Bilice church furniture originates from the Seget quarry. That quarry was very important for the Salonitan stonemason workshops, and the petrographic determination of the analysed sample points to the Salonitan origin of the Bilice church furniture, which has also been established by the stylistic analysis of the sculpture from Bilice and connected localities. On the basis of the stone sculpture, the dating of the single-naved triconch church at Bilice would be from the middle to the end of the 6th century. The dating of the annexes would be during the first half of the 7th century, according to the present interpretation of the historical circumstances during the 7th and 8th centuries.

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