^{14}C DATING OF MORTARS AT TORRE DE PALMA, PORTUGAL

Stephanie J. Maloney[1] – *Åsa Ringbom*[2]

For many reasons dating early Christian buildings can be difficult. Many early excavators removed surviving artifacts without providing what we now consider to be adequate documentation. Even buildings discovered in recent years have rarely yielded conclusive evidence for dating. Consequently, scholars have had to depend primarily on stylistic and typological comparisons to date the buildings they were studying. For well over thirty years scientists and archaeologists have tried to develop a means of dating building mortars. ^{14}C is a prime example of a technique which was tried and, until recently, dismissed as unreliable. As a result of new work by a team of Finnish and Danish scholars[3] ^{14}C now promises to be a viable means of scientifically dating early buildings. These new developments could prove to be especially important for sites, such as many of those in the Iberian Peninsula, from which organic materials (wood, charcoal) suitable for more traditional ^{14}C are not usually available. The new method was developed initially to aid in dating medieval churches on the Åland Islands, Finland. It was later used to date the Newport Tower, Newport, Rhode Island, USA. In order to determine the validity of the approach for earlier sites we began having mortar samples tested in 1996. Although the method is still experimental, results so far obtained at Torre de Palma are both encouraging and exciting.

Building lime is obtained by heating limestone to 1000°C releasing carbon dioxide and leaving calcium oxide or quicklime. When slaked with water, quicklime yields building lime or calcium hydroxide. Mortar is formed by mixing building lime, aggregates such as sand, gravel, or ground pottery or bricks, and water. As the mortar hardens, the calcium hydroxide reacts with the carbon dioxide in the air to form calcium carbonate. In theory, then, the time elapsed since the mortar hardened can be determined by measuring the ^{14}C content of the mortar sample. Calibration procedures based on tree rings can be used to convert ^{14}C age to calendar age.[4] This process has been known for a generation or more. How, then, does the present method differ from those attempted in the past?

Rather than conventional ^{14}C dating this new procedure makes use of accelerator mass spectrometry (AMS).[5] With conventional ^{14}C a very large

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1. Allen R. Hite Art Institute, University of Louisville, Louisville, Kentucky, U.S.A.

2. Department of Art History, Åbo Academy University, Turku, Finland

3. Jan Heinemeier, Institute of Physics and Astronomy, University of Aarhus, Aarhus, Denmark; Hogne Jungner, Dating Laboratory, University of Helsinki, Helsinki, Finland; Alf Lindroos, Department of Geology and Mineralogy, Åbo Academy University, Turku, Finland; Åsa Ringbom, Department of Art History, Åbo Academy University, Turku, Finland; Thorborg von Konow, Department of Inorganic Chemistry, Åbo Academy University, Turku, Finland; Niels Rud, Institute of Physics and Astronomy, University of Aarhus, Aarhus, Denmark.

4. HEINEMEIER, Jan; JUNGER, Högne; LINDROOS, Alf; RINGBOM, Åsa; KONOW, Thorborg von; RUD, Niels, AMS 14C dating of lime mortar, *Beam Interactions with Materials and Atoms*, Proceedings *of the 7th Int. Conf. On Accelerator Mass Spectrometry (AMS-7), Tucson, AZ, USA, May 20-24, 1996,* NIMBEU 123 (1-4), 1997, p. 487-495, and RINGBOM, Åsa, The churches of the Åland Islands and 14C dating of mortar, *Method and Theory in Historical Archaeology (Papers of the 'Medieval Europe Brugge 1997' Conference),* Volume 10, 1997, p. 103-112.

5. For a more complete discussion of the process summarized here see HEINEMEIER, *et al.*, p. 488; RINGBOM, 105-107.

sample of mortar is needed to yield enough carbon for dating, while with AMS only 1 mg of carbon is needed, so samples of mortar can be small (approximately 100 gm).

Two possible sources of error have proved daunting in earlier attempts at ^{14}C dating of mortars. Samples contaminated with old limestone can yield dates older than the construction, while samples taken from inner parts of walls can yield dates that, because of the delayed hardening of the mortar, are deceptively recent. In order to avoid the latter problem samples are gathered near the wall surfaces and are pH tested in the field in order to identify the strongly alkaline mortar that results from delayed hardening. More effort is required to avoid limestone or fossil carbonate contamination.

The goal is to reduce limestone contaminate to less than 1 % and, ideally, no more than about 0,5 %. Samples are very gently crushed in a hand mortar in order to break up the soft mortar carbonate, causing it to break loose of the harder limestone particles. Dry, and then wet, sieving through a mesh of 100 microns or less yields particles from 38-75 micrometers, eliminating most of the limestone. Earlier procedures, in contrast, made use of much larger grains. Thin sections of the original and separated samples are examined with polarizing optical microscopy and with cathodoluminescence to determine the mineral composition of the sample (Limestone generally has a stronger luminescence than mortar). The separated sample is subsequently combined, under vacuum, with 85 % phosphoric acid, yielding carbon dioxide. The softer, more porous mortar carbonate reacts more quickly than does the dense limestone; therefore, the carbon dioxide produced comes from the mortar rather than from any contaminants. The first 30% is collected as a first fraction, and the remainder, which may be influenced by remaining traces of limestone, as a second. ^{14}C ages are determined for each fraction individually. As Heinemeier *et al.* point out, «The age of the first fraction is assumed to be closer to the true date than that of the second fraction. If the two fractions yield similar ages, this is taken as an indication of a successful removal of any fossil carbonate in the mechanical separation process, rendering the date (of both fractions) particularly reliable.»

In order to judge the possible efficacy of this method of AMS ^{14}C dating at Torre de Palma we wanted to begin by testing a sample from an area for which we had other dating evidence. Only in this way could we test the validity of the procedure. Because it is by far the most important building associated with the villa, we also wanted to concentrate our first efforts in the church.

As has been reported earlier,[6] nine coins with reverse types dated from 335 to 357 were found embedded in a white plaster floor in the area just in front of the eastern apse in the basilica of Torre de Palma.[7] Although it is possible those coins were deposited long after they were withdrawn from circulation, the consistency of the group makes that improbable.[8] It was on the basis of these coins, apparently intentionally embedded in the floor, that we postulated a late fourth century date for the eastern double-apsed church. Since this floor is the most securely dated element in the church, it was chosen as an important material for testing. Although the floor no longer exists in the altar area, it is particularly well preserved beneath the west end of the solea wall. A sample was taken there in 1997 (sample 21 in figure 1).

The floor is preserved in patches throughout the eastern basilica, from the north wall to the south and in the south sacristy. A fragmentary surface of apparently similar plaster was found in 1983 in the western apse (Apse 2) of the eastern basilica. There, however, the surface was 0,20 cm higher than that in the nave and aisles. Unfortunately, no sample was taken and the surface was destroyed as excavation in the area continued. One section of the apse remains unexcavated (as of April 1998) and it is possible the same layer can be located and a sample taken. Analysis of that plaster layer could be very helpful in interpreting the original form of the church.

The first fraction (deemed most accurate) from the floor yielded a date of AD 385, or, when the margin of error is considered, a date between 265 and 415. The second yielded AD 400 or 340-420. These readings, with both fractions yielding chronologically similar results, confirm our judgment

6. MALONEY, Stephanie J. The Early Christian Basilican Complex of Torre de Palma (Monforte, Alto Alentejo, Portugal, *IV Reunió d'Arqueologia Cristiana Hispànica, Lisboa, 28-30 de setembre/1-2 d'octubre de 1992* (1995), p. 449-461.

7. These coins were actually found in the matrix of the floor. The conservationist who cleaned the coins complained of the difficulty of removing the plaster.

8. Only a few test results from other parts of the villa are available at this time. Among those, however, are several which indicate a fourth century date for structures previously dated at least in part by the presence of fourth century coins found below floors. Surely one must assume that the vast majority of fourth century coins were deposited during the fourth century when they were most current.

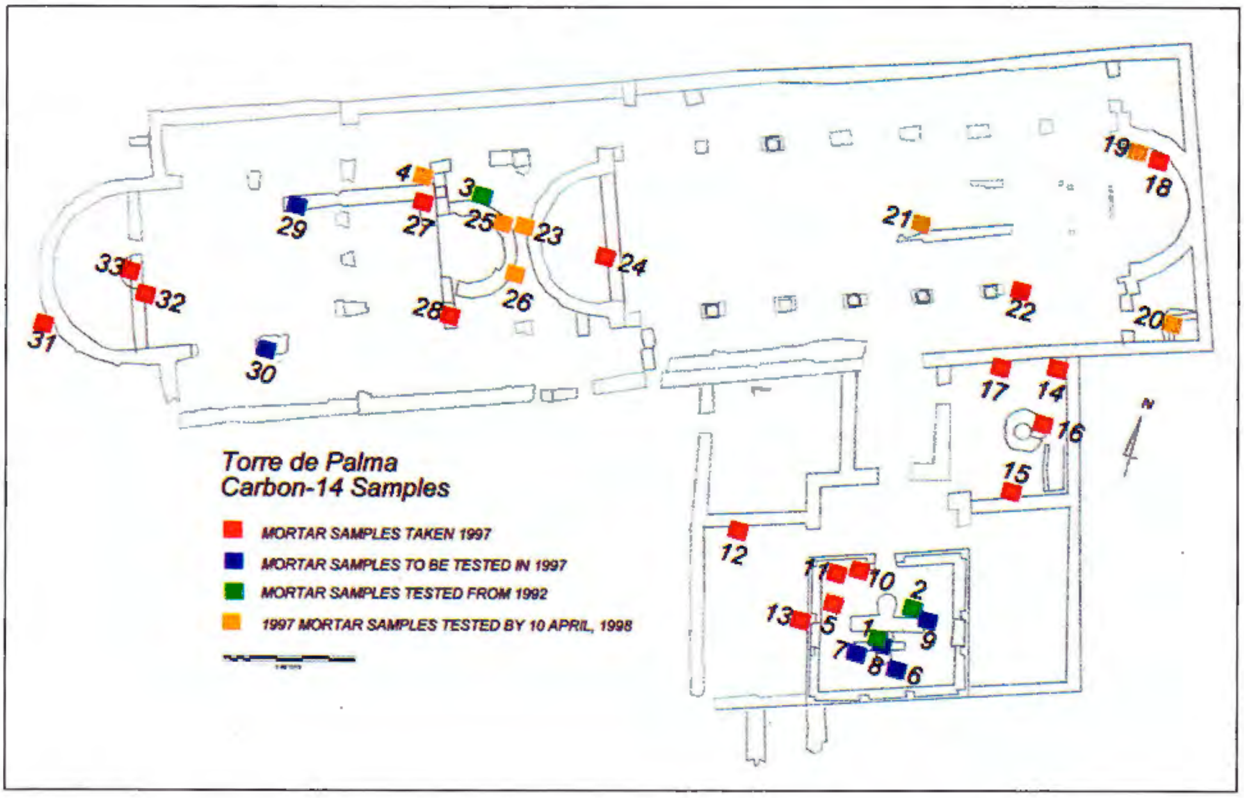

Figure 1: Torre de Palma Carbon-14 Samples

MORTAR SAMPLES FROM THE BASILICA OF TORRE DE PALMA

Sample	^{14}C Age (BP)	Calibrated Age	± 1 stvd.
TP 1.1	1730±55	AD 270-350	AD 250-400
TP 1.2	1745±55	AD 260-330	AD 240-390
TP 2.1	1380±50	AD 660	AD 640-680
TP 2.2	1620±110	AD 430	AD 270-590
TP 3.1	1285±30	AD 715-760	AD 680-780
TP 3.2	1485±40	AD 605	AD 550-635
TP 4.1	1400±30	AD 655	AD 640-665
TP 4.2	1440±35	AD 635	AD 605-665
TP 19.1	1545±40	AD 545	AD 445-595
TP 19.2	1640±35	AD 420	AD 400-435
TP 20.1	900±30	AD 1165	AD 1050-1205
TP 20.2	1135±35	AD 895-950	AD 885-975
TP 21.1	1695±40	AD 385	AD 265-415
TP 21.2	2045±40	AD 400	AD 340-420
TP 23.1	1515±30	AD 560	AD 540-605
TP 23.2	1580±45	AD 460-530	AD 425-545
TP 25.1	1405±35	AD 655	AD 635-665
TP 25.2	1415±35	AD 650	AD 625-660
TP 26.1	1435±40	AD 640	AD 605-655
TP 26.2	1455±30	AD 625	AD 600-645

^{14}C ages are reported in conventional radiocarbon years BP (Before present = 1950) in accordance with international convention (M. Stuiver & H.A. Polach, «Discussion of reporting ^{14}C data,» *Radiocarbon* 19-3 (1977), 355). Thus, all calculated ^{14}C ages have been corrected for fractionation in order to refer the result to be equivalent with the standard δ^{13}C value of-25% (wood).

Calibrated ages in calendar years have been obtained from the calibration tables in *Radiocarbon* 35 (1993) by means of the Seattle calibration program, version 3.03. The intercept of the measured ^{14}C age with the calibration curve is given in the first date (as a time interval if more than one intercept). The intercept method has been used to calculate the calibrated age interval

Figure 2: Mortar Samples from the Basilica of Torre de Palma

that a collection of coins deposited long after they were minted (some have suggested 100 years or more) would be unlikely to be so uniform, and confirm our conviction that this floor was laid in the late fourth century.

A second sample, this time from the southern part of the font in the small baptistery (sample 1 in figure 1), also suggests the existence of a church at Torre de Palma in the fourth century. That sample was actually taken in 1992 for other purposes but was dated in 1996. It provided a range of dates for Fraction 1 of 250-400, and for Fraction 2 of 240-390.

Since the beginning of our work at Torre de Palma in 1983 Apse 3 has been an enigma. Its mortar is stronger and its construction is different in several ways from other visible parts of the church. In 1996 we sent a sample for testing which suggested a date of 715-760. Since no other evidence at Torre de Palma indicates any occupation in the Moorish period, retesting of this apse was a high priority in 1997. Samples 25 and 26, in contrast, both yielded dates in the mid seventh century. Sample 4 from the wall in front of Apse 3 was consistent with such a date. Sample 2, from the northeast corner of the font, also dates to the middle of the seventh century. In fact, these four samples are remarkably consistent: 660 (#2), 655 (#4 and #25), and 640 (#26).

On the other hand, not all of the results have proved equally supportive of our earlier conclusions (figure 2). Sample 19 from Apse 1 and Sample 23 from Apse 2 both yielded dates in the sixth century. Thus, although there clearly was a church and a baptistery at Torre de Palma in the fourth century, it was not the building visible today.

How do these results affect the interpretation of the basilican complex at Torre de Palma? Several of these dates were received only days before this conference. More samples must be tested and more work done at the site before any definitive conclusions may be drawn. Nevertheless, some tentative suggestions can be made. There was a church built, probably by the owners of the nearby villa, in the second half of the fourth century, although its precise form remains to be determined (figure 3). Since fragments of the white floor are preserved against both the north and south walls of the pre-

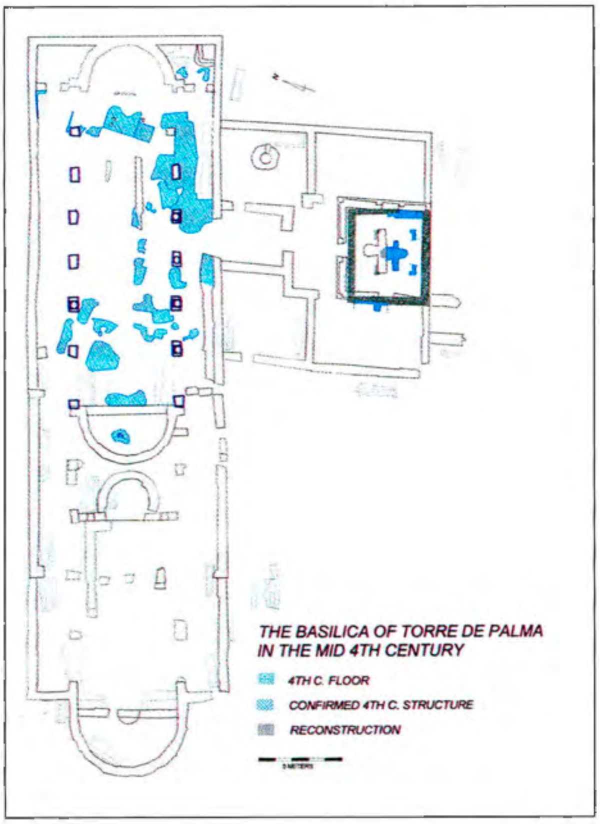

Figure 3: The Basilica of Torre de Palma in the Mid 4th Century

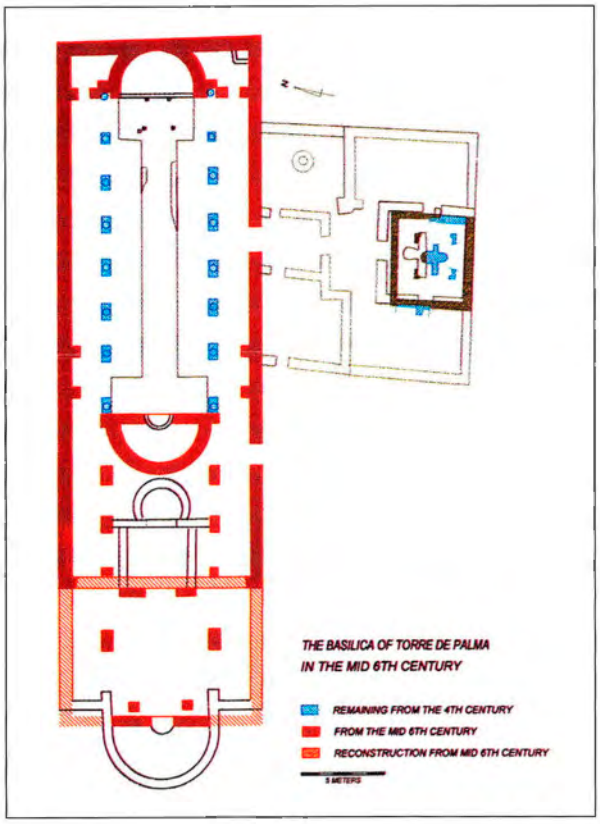

Figure 4: The Basilica of Torre de Palma in the Mid 6th Century

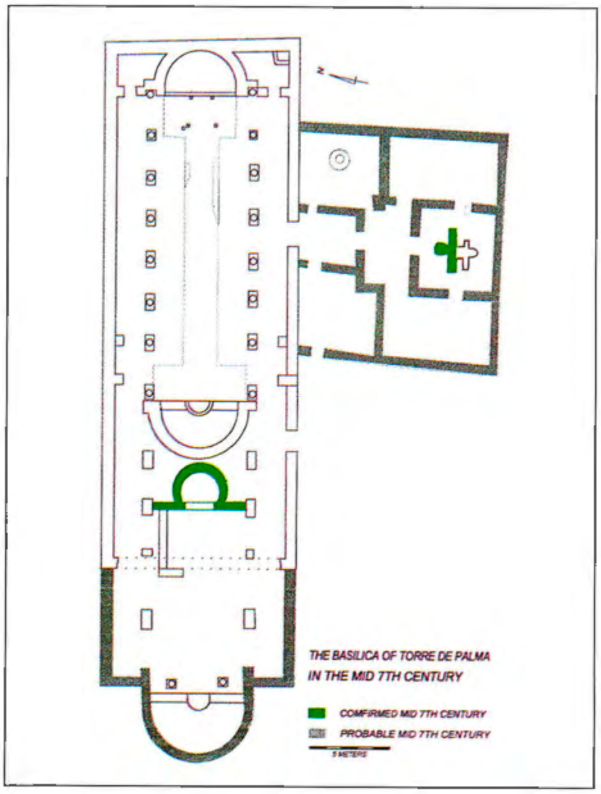

Figure 5: The Basilica of Torre de Palma in the Mid 7[th] Century

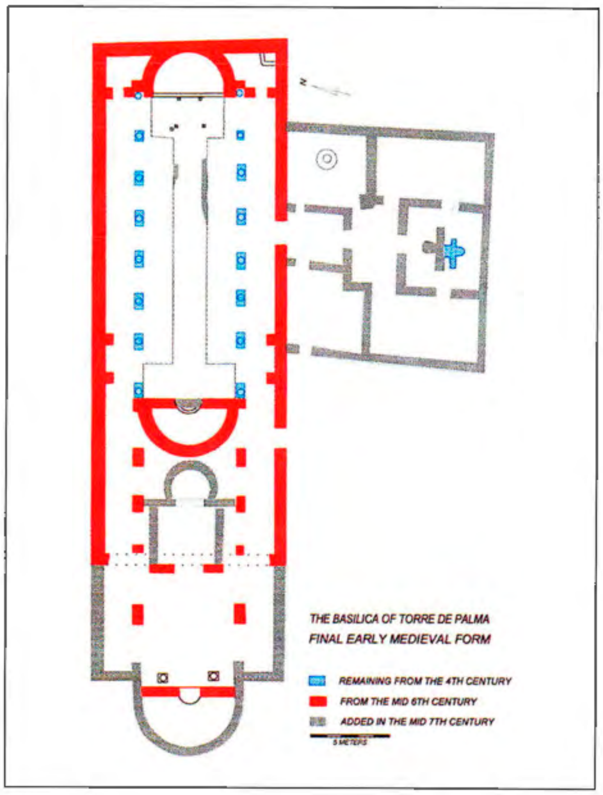

Figure 6: The Basilica of Torre de Palma, Final Early Medieval form

sent church and since the floor was poured against the existing column bases, the first church was probably basilican and only a little, if any, smaller than the present eastern double-apsed church. The arrangement of its apse or apses and its orientation (Was it double-apsed? If not, where was the apse?) cannot, however, be determined without further investigation.[9] On its south side this early church had a separate baptistery building, some of the walls of which were discovered in 1996 and 1997. The font, a small oval with steps on the east and west sides, may have been covered by a baldachin.

The church we originally interpreted as belonging to the fourth century now appears to belong in the sixth (figure 4). In the seventh century Apse 3, the wall on its west side, and perhaps the walls which extend westward from it were added (figure 5). In addition, the baptismal font was expanded, creating the complex, marble-lined font that may be seen today. It was probably at that time the fourth-century baptistery building was replaced with the present complex of rooms. The church functioning at the time of the Moslem invasions was probably the one seen in Figure 6 with four apses and an elaborate baptistery complex to the south.

Only a few of the samples taken at Torre de Palma in 1997 have so far been dated. The process of separation, analysis, and dating is both slow and expensive. The scientists involved are working to further improve the protocols for taking and preparing samples. Nevertheless, AMS ^{14}C dating of mortars already promises to be useful in establishing accurate absolute dates on sites where only relative dates have been discernable, and in dating otherwise undateable buildings. Scientific methods such as this, although they sometimes nullify our previous theories, have the potential to bring us closer than ever to an accurate understanding of the early Christian architecture we have gathered to study.

9. Many of the walls in the villa were made of rammed earth (adobe, *taipa*). It is possible the fourth century basilica was similarly constructed. After more than a century of use that earthen basilica could easily have been in need of major repairs or rebuilding, as a result of a cataclysm such as an earthquake or fire, or as a result of the natural destruction caused by wind and rain. The sixth century church could have been built either following the original plan or with modifications, creating the double-apsed church with a narthex and perhaps a small atrium.