AMS $^{14}$C DATING OF ROMANESQUE ROTUNDA AND STONE BUILDINGS OF A MEDIEVAL MONASTERY IN ŁĘKNO, POLAND

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ABSTRACT. Archaeological excavations performed for many years in Łękno, central Poland, have exposed relicts of wooden fortified settlements, and in its enclosure also basements of stone buildings, consisting of Romanesque rotunda and a Cistercian monastery, including an oratory, church, and abbot’s house. Earlier archaeological, structural, and stratigraphical studies have shown that these buildings were constructed in a sequence and represented several phases of development.

In this paper, we present results of radiocarbon dating of stone buildings of the rotunda and the monastery. For $^{14}$C dating, we used tiny pieces of charcoal retrieved from calcareous and gypsum mortar binding stone elements from the buildings. These pieces were incorporated in mortar during the firing process, where the fuel used for firing was wood. Most of the obtained $^{14}$C dates formed clear groups, confirming that individual buildings were constructed in separate periods. Calibrated $^{14}$C dates of these phases agree well with the constraints provided by historical sources, and enable us to set their ages with accuracy better than previously available. In particular, we have learned that the oldest rotunda was built at the boundary of the 10/11th centuries, and the church and the abbot’s house, before AD 1250. However, some samples gave much too old $^{14}$C ages, clearly reflecting the use of old wood for firing. These problems were revealed only for samples from the rotunda and for the gypsum stone ornamental details.

INTRODUCTION

One basic element of architectural material is mortar. It has been used for binding stone and/or brick pieces of building construction, and also for the preparation of architectural details and ornaments. The main binding agent was gypsum or lime, fired using wood or sometimes with peat as a fuel (e.g. Vitruvius et al. 2002). Thus, inside mortars, fragments of charcoal can sometimes be found as remnants of the firing process. Such charcoals are usually rare, so practically available masses were too low to allow for radiocarbon dating using conventional (radiometric) $^{14}$C techniques. The situation changed after the development of accelerator mass spectrometry (AMS) technique, allowing for much smaller sample sizes to be $^{14}$C dated.

In Poland, attempts to use charcoal fragments for $^{14}$C dating of mortars were initiated and published in 2002 (Wyrwa 2002, 2003), in the framework of research on the early medieval site in Łękno, Poland. Soon, that parallel research appeared that was performed by American and English archaeologists in Khirbet Qana near Nasareth in Israel (Rech et al. 2003). A similar method was used in the studies of Buddhist monuments in Bamiyanie, Afghanistan, destroyed by the Taliban (Petzet 2005), and also an early-medieval multicultural site in Ingelheim, Germany (Haupt 2007). It is clear that similar methodology was introduced independently in several research centers all over the world. In this paper, we present the full series of $^{14}$C dates obtained on mortars from Łękno, and discuss them against the background of other archaeological, architectural, and historical data.

THE ARCHAEOLOGICAL SITE I.3 IN ŁĘKNO

The site I.3, Klasztorek in Łękno, is situated on a small tip on Lake Łęknejskie, in the southwestern part of Pałuki, in northeastern Great Poland (“Wielkopolska” in Figure 1).

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In the course of long-term research (e.g. Wyrwa 2007), many objects have been excavated, i.e. early-medieval fortified settlements (Figure 2) and elements of several stone buildings, including Romanesque rotunda, Cistercian oratory (church of phase A1), a full-scale Cistercian monastery church (in several phases of rebuilding and extension—phases A2 and A2-2), and a cemetery chapel (Figures 3, 4). Archaeological research demonstrated that the rotunda as well as the monastery were built on the site of an earlier existing state fortified settlement.

Extensive studies of elements of settlement walls did show (for details, see Wyrwa 2006b) that the beginning of the oldest phase of the fortified settlement could be dated to the third quarter of the 7th century. At the end of 8th century, the fortification was most probably repaired or some parts of its walls were reconstructed. The fortified settlement existed then with no bigger changes in urbanistic arrangement, and was burnt in the first quarter of 10th century. Afterwards, around the middle of 10th century, it was erected again and adapted as one of several core settlements of the just forming state of the first Piasts. In this paper, we refer to only 2 of >30 14C dates of this object, which are connected with the phase II of the settlement (L3/2/02: 1240 ± 30 14C BP; L3/3/02: 1225 ± 25 14C BP, cf. Figure 5). These dates agree very well with each other, and are also consistent with the dendro-chronological dating of phase II, placing the beginning of phase II at the 8/9th century AD (Figures 5, 6).
Especially important, besides the settlement, were the studies of the stone buildings (e.g. Wyrwa 2004, 2007). As the scarce written documents, disturbed stratigraphy, and unclear spatial-structural properties of excavated fragments of buildings (Figure 3) did not allow to determine the age of particular objects too precisely, independent absolute dating was needed.

The chronology of the architectural details (Figure 7), made of gypsum and found in the extent of rotunda and oratory, was also problematic. Independently of their place of burial, the style and physico-chemical properties of the material (Poksińska et al. 2000) allowed for attribution of the rotunda and the oratory. Therefore, individual details were also forwarded for 14C dating.

**14C AMS DATING OF MORTAR FROM THE ROTUNDA AND MEDIEVAL BUILDINGS OF THE MONASTERY**

In 14C dating for archaeology, the selection of a proper spot for sample collection is crucial, especially when dealing with multicultural sites or multiphase objects. One should try to collect a sample from the place of the clearest context, connected with well-defined objects of the phase.

Second, it is recommended that several 14C samples are collected from the same context, which enables for verification of individual dates and provides better precision of dating. In the case of mortars, this condition is difficult to fulfill. For example, the studied architectural details contained very little charcoal, so to gather a sufficient amount, very big fragments of details had to be searched and destroyed. In most cases, it was impossible due to the items’ great artistic and historical value.

For 14C dating, samples of charcoal were collected from mortars of the rotunda (Figure 3, #1), the Cistercian church of phase A2 (Figure 3, #3), the vestry building (Figure 3, #7) next to the church, the so-called “abbot’s house” situated in southeastern part of the monastery (Figure 3, #10), and from selected architectural details (Figure 7). The results of dating are presented in Table 1. The obtained dates have been calibrated using the OxCal 3.10 program (Bronk Ramsey 1995, 2001), and the results of calibration of independent individual dates are shown in Figure 5.
When interpreting calibrated 14C dates, one must remember that the charcoals in the mortar are always older than the mortar itself, and the difference may be distinct if the analyzed carbon descended from inner parts of the tree trunk used as a fuel for the mortar production, or even larger if the wood came from trees that had been cut much earlier. We noted this effect directly for some samples collected from the rotunda (L3/62/02, L3/62/02 bis, and L3/46/05; Table 1, Figure 5), the 14C dates of which clearly disagreed with the results of other analyses. Evidently, for firing these mortars, old wood has (intentionally or accidentally) been used.

Interdisciplinary (archaeological, architectural, and environmental) studies of site L3 indicated several phases of building construction. Available historical sources put additional constraints on the
timings of construction of both the rotunda and the Cistercian oratory. This additional information has been used in the calibration of related 14C dates, the results of which are presented in Figure 6. A detailed description of the relationships between the dated samples, and the interpretation of the related calibrated dates is given below.

**INTERPRETATION OF RESULTS**

**Rotunda**

14C AMS analysis and relative age determination based on classical archaeological and architectural methods (Wyrwa 2007) indicate that the Romanesque St. Peter’s Rotunda in Lekno was built most probably at the turn of the 10/11th centuries (Table 1; Figures 5, 6). This result agrees with the hypothesis of Semkowicz (1907), according to which the fields between the rivers Welna and Noteć (where the fortified settlement and monastery in Lekno is situated), in AD 955–1003 were “hospitalably” donated to Prince Sobiebor (Sobieslaw) Sławnikowicz, who after escaping from Libice was hosted at the court of Piast Bolesław Chrobry (Semkowicz 1907: 18, 21, 54; Wyrwa 2004:220–1). We can thus suppose that the rotunda was built during Sobiebor’s stay with Boleslaw Chrobry. This hypothesis, however, cannot be checked more precisely. Indeed, using this information as a *terminus post quem*, does not alter the result of calibration of the 14C dates (Figure 6). One has to add that in 2007, in the trade colony next to the settlement (site Ł5), a treasure of silver coins and decorations was found and dated to the turn of 10/11th centuries, in perfect agreement with the dating of the rotunda.
Based on the foundation document of the Cistercian monastery in Łęknó in AD 1153 (KDW 1877; Foundation Document 2003), we can conclude that the object was erected in its main shape between about AD 1150(?) and 1153. At the moment when the foundation document was delivered, the object was surely ready, in a state enabling the monks to perform their liturgical duties (see Foundation Document 2003). The only datable sample of clear context was then collected from the spot at the border between the top of the rotunda’s foundations and the flooring in the area of the Cistercian oratory (Figure 4; Wyrwa 1989:169–72, 2006a). Macroscopically, because of its “pulverization,” this mortar differed distinctly from the light-pinkish mortar of the rotunda. The obtained date (Figures 5, 6) correlates well with the historical dating of the church phase A1.

![Lekno - independent dates](https://doi.org/10.1017/S0033822200055867)
According to the calibrated $^{14}$C dates, the Cistercian church of phase A2 could be dated to the turn of the 12/13th or the beginning of the 13th century (68% probability interval: AD 1170–1225; 95.5% probability interval: AD 1165–1255). As the church of phase A2 was an extension of that of phase A1 (built about AD 1153), one may claim that it was constructed some time after phase A1, most probably in the third part of the 13th century. This supposition perfectly correlates with the obtained $^{14}$C dates.
Table 1  

<table>
<thead>
<tr>
<th>Object</th>
<th>Sample name</th>
<th>Localization</th>
<th>(^{14}\mathrm{C}) age BP</th>
<th>Calibrated date (2-(\sigma) interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotunda</td>
<td>L3/10/02</td>
<td>brickwork floor of rotunda, excavation Vlp</td>
<td>1000 ± 25</td>
<td>AD 980 (77.8%) 1050 AD 1080 (17.6%) 1150 AD 890 (95.4%) 1030</td>
</tr>
<tr>
<td></td>
<td>L3/18-22/02</td>
<td>brickwork floor of rotunda, excavation Vlp</td>
<td>1065 ± 35</td>
<td>AD 890 (95.4%) 1030 AD 980 (17.6%) 1150 AD 1080 (77.8%) 1050</td>
</tr>
<tr>
<td></td>
<td>L3/62/02</td>
<td>north brickwork floor of rotunda, excavation Vlp</td>
<td>2025 ± 35*</td>
<td>160 BC (3.6%) 130 BC 120 BC (91.8%) AD 60 380 BC (95.4%) 200 BC</td>
</tr>
<tr>
<td></td>
<td>L3/62/02 bis</td>
<td>north brickwork floor of rotunda, excavation Vlp</td>
<td>2220 ± 30*</td>
<td>380 BC (95.4%) 200 BC AD 60 (91.8%) 120 BC 160 BC (3.6%) 130 BC</td>
</tr>
<tr>
<td></td>
<td>L3/46 /05</td>
<td>NW part of rotunda</td>
<td>1625 ± 30*</td>
<td>AD 350 (2.7%) 370 AD 380 (92.7%) 540 AD 410 (95.4%) 1200</td>
</tr>
<tr>
<td>Cistercian church phase A1</td>
<td>L3/47/05</td>
<td>C-W foundation floor of rotunda</td>
<td>895 ± 30</td>
<td>AD 1030 (95.4%) 1290 AD 1100 (3.1%) 1080 AD 1180 (95.4%) 1290</td>
</tr>
<tr>
<td>Cistercian church phase A2</td>
<td>L3/2/93A</td>
<td>N brickwork of Cistercian church, phase A2, excavation XXXII</td>
<td>775 ± 40</td>
<td>AD 1180 (95.4%) 1290 AD 1150 (92.3%) 1270 AD 1050 (3.1%) 1080</td>
</tr>
<tr>
<td></td>
<td>L3/5/02</td>
<td>N foundation floor of Cistercian church phase A2, excavation VA</td>
<td>835 ± 35</td>
<td>AD 1050 (6.5%) 1080 AD 1150 (92.3%) 1270 AD 1100 (88.9%) 1260</td>
</tr>
<tr>
<td></td>
<td>L3/6/02</td>
<td>N brickwork of Cistercian church phase A2, excavation VA</td>
<td>860 ± 25</td>
<td>AD 1050 (88.9%) 1260 AD 1100 (92.3%) 1270 AD 1150 (92.3%) 1270</td>
</tr>
<tr>
<td>&quot;Abbot’s house&quot;</td>
<td>L3/50/05b</td>
<td>limestone mortar from “abbot’s house” (excavation XLI, depth 87, 11–86, 63; taken from limestone plate near inner east wall face, on the height of uncovered window)</td>
<td>825 ± 30</td>
<td>AD 1160 (95.4%) 1270 AD 1100 (92.3%) 1270 AD 1050 (6.5%) 1080</td>
</tr>
<tr>
<td>Vestry</td>
<td>L3/8/06</td>
<td>mortar from floor D in vestry (sample A)</td>
<td>845 ± 30</td>
<td>AD 1050 (3.2%) 1080 AD 1100 (92.2%) 1270 AD 800 (95.4%) 1260</td>
</tr>
<tr>
<td>Gypsum architectural details</td>
<td>L3/124/85</td>
<td>architectural detail “block shape”</td>
<td>1000 ± 110*</td>
<td>AD 800 (95.4%) 1260 AD 760 (86.9%) 980 AD 690 (8.5%) 750</td>
</tr>
<tr>
<td>&quot;block shape&quot;</td>
<td>L3/124/85-9</td>
<td>architectural detail “block shape”</td>
<td>1180 ± 50*</td>
<td>AD 690 (8.5%) 750 AD 760 (86.9%) 980 AD 690 (20.5%) 750</td>
</tr>
<tr>
<td>Gypsum architectural details</td>
<td>L3/235/85-5</td>
<td>architectural detail “3-layer”</td>
<td>1220 ± 30*</td>
<td>AD 690 (20.5%) 750 AD 760 (74.9%) 890 AD 760 (90%) 990</td>
</tr>
</tbody>
</table>

**Vestry and “Abbot’s House”**

According to architectural analysis (Wyrwa 2004, 2006a), the sample collected from the vestry was connected with phase A2, which is concordant with the obtained \(^{14}\mathrm{C}\) dates. We thus conclude that the vestry was indeed built at the time of the Cistercian church extension of phase A2. Architectural and archaeological evidence suggest that the “abbot’s house” was built in parallel with the extension of the church phase A2 (Wyrwa 2004). The obtained \(^{14}\mathrm{C}\) date also fits the expected time interval.

**Architectural Details**

Despite the trials performed, the absolute dating of architectural details is still problematic. In the collection of >300 details, 2 basic types have been distinguished: the so-called “3-layer” details (made of 3 layers subsequently laid on one another), and block details (moulded in single pieces) (Figure 7). While the mortars binding the stones of the foundations and walls contained a reasonable admixture of charcoal, the mortars used for the production of details were almost barren of charcoal (presumably because the purity of the mortars produced for that purpose was intentionally controlled). For that reason, an appreciable amount of charcoal could be retrieved from 2 (quite big) blocks only, and the carbon mass in these samples was as small as 0.2 mg.
Macroscopic analysis of mortars from the rotunda and oratory indicated that the “3-layer” details could be a decoration of the rotunda’s interior, while the “block” details could be used outside the rotunda or in the oratory (phase A1, different opinions on that point can be found in Wyrwa 2004: 227–8, 2006a:62). These 2 types of details differ from each other in terms of physico-chemistry and petrography (Poksińska et al. 2000). The obtained 14C dates (Figures 5, 6), however, do not give unequivocal chronological information. Although the calibrated dates are closer to the timing of the rotunda than to phases A1 and A2 of the church, 2 of these dates are significantly older than any of the determined periods of building construction. It seems that for production of these details, old wood was used (accidentally or intentionally). It is intriguing that 14C dates of these samples are concordant with those of the walls of the fortified settlement. Perhaps when making decoration of the monastery, one used some wood from the dismantled walls? This question will probably remain unanswered.

**SUMMARY**

In spite of the difficulties, 14C dating of charcoal fragments may be helpful in the absolute age determination of mortars. This statement is supported by the results obtained on architectural objects at the site L3 in Łękno, Poland. Most of the obtained 14C dates correlated well with the earlier indications of age, based on structural-architectural properties, and archaeological and historical studies, and enabled us to reconstruct a rather precise chronology of the stone buildings in Łękno. The reasonable concordance of calibrated 14C dates with independent data on the history of the site would not be obtained without the careful selection of samples for dating, supported by archaeological and architectural evidence, and physico-chemical and petrographic analyses of the mortar itself.
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