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

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ABSTRACT. Archaeological excavations performed for many years in Łekno, 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 Łekno, 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 Łekno, and discuss them against the background of other archaeological, architectural, and historical data.

THE ARCHAEOLOGICAL SITE Ł3 IN ŁEKNO

The site Ł3, *Klasztorek* in Łekno, is situated on a small tip on Lake Łekneńskie, in the southwestern part of Pałuki, in northeastern Great Poland ("Wielkopolska" in Figure 1).

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Figure 1 Location of Łekno in the region of Wielkopolska (Great Poland) and Pałuki in Poland

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 ^{14}C dates of this object, which are connected with the phase II of the settlement (Ł3/2/02: 1240 ± 30 ^{14}C BP; Ł3/3/02: 1225 ± 25 ^{14}C BP, cf. Figure 5). These dates agree very well with each other, and are also consistent with the dendrochronological dating of phase II, placing the beginning of phase II at the 8/9th century AD (Figures 5, 6).

Figure 2 Remnants of burnt wooden construction of the settlement wall (1) near the gate where the samples for ^{14}C dating were collected; 2—dispersed traces of burnt wooden wall; 3—stone coating of the settlement wall. Photo courtesy P Namiota.

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 ^{14}C dating.

^{14}C AMS DATING OF MORTAR FROM THE ROTUNDA AND MEDIEVAL BUILDINGS OF THE MONASTERY

In ^{14}C 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 ^{14}C 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 ^{14}C 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.

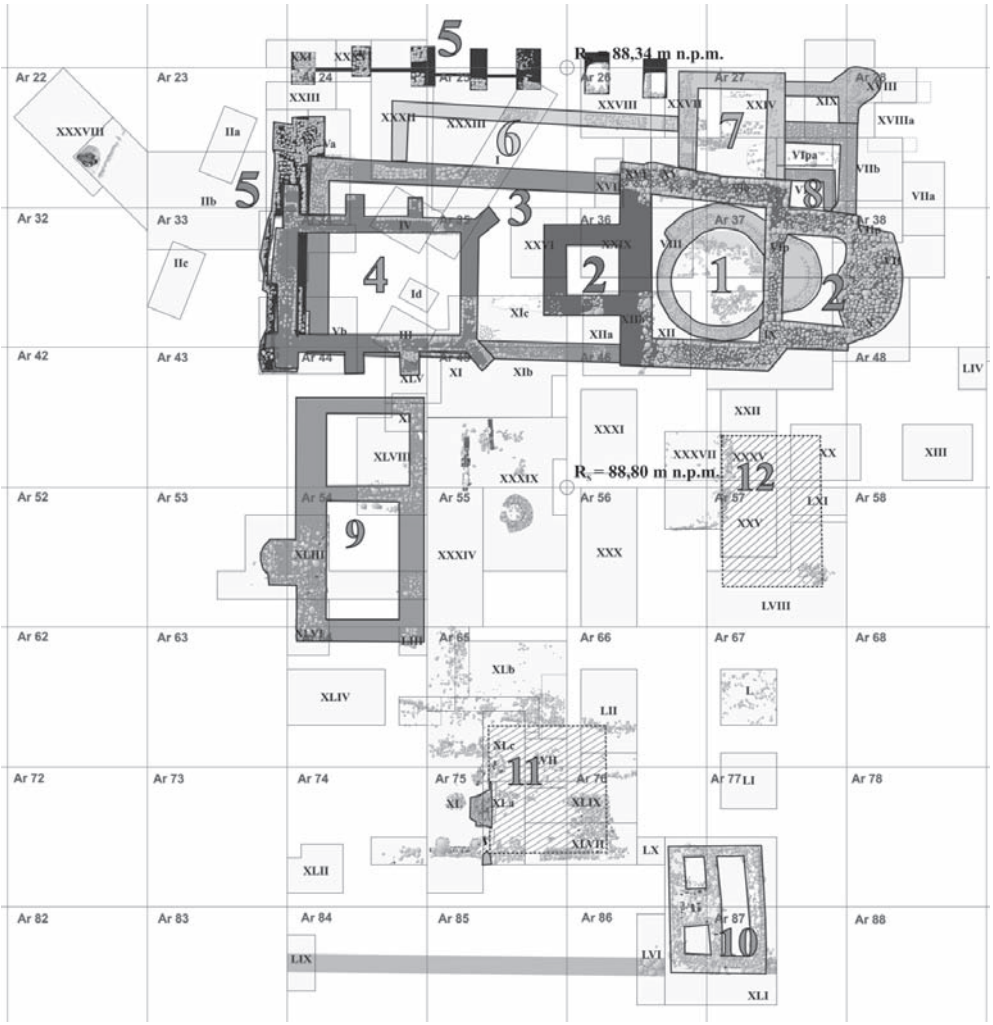

Figure 3 Plan of basement of architectural objects in Łekno site Ł3. The remnants of settlement walls have not been taken into account (the settlement is situated below the objects 1–9, 12, and partly 11): 1 – rotunda; 2 – Cistercian church, phase A1 (oratory); 3 – Cistercian church, phase A2 (full-scale church, connected with phase A1); 4 – cemetery chapel, middle 15th cent.; 5 – Phase A2-2 of Cistercian church; 6 – chapels of phase A2; 7 – vestry, phase A2; 8 – vestry, phase A1; 9 – dormitorium; 10 – so-called "abbot's house"; 11 – kitchen and refectory; 12 – remnants of chapter house.

When interpreting calibrated ^{14}C 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 (Ł3/62/02, Ł3/62/02 bis, and Ł3/46/05; Table 1, Figure 5), the ^{14}C 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 Ł3 indicated several phases of building construction. Available historical sources put additional constraints on the

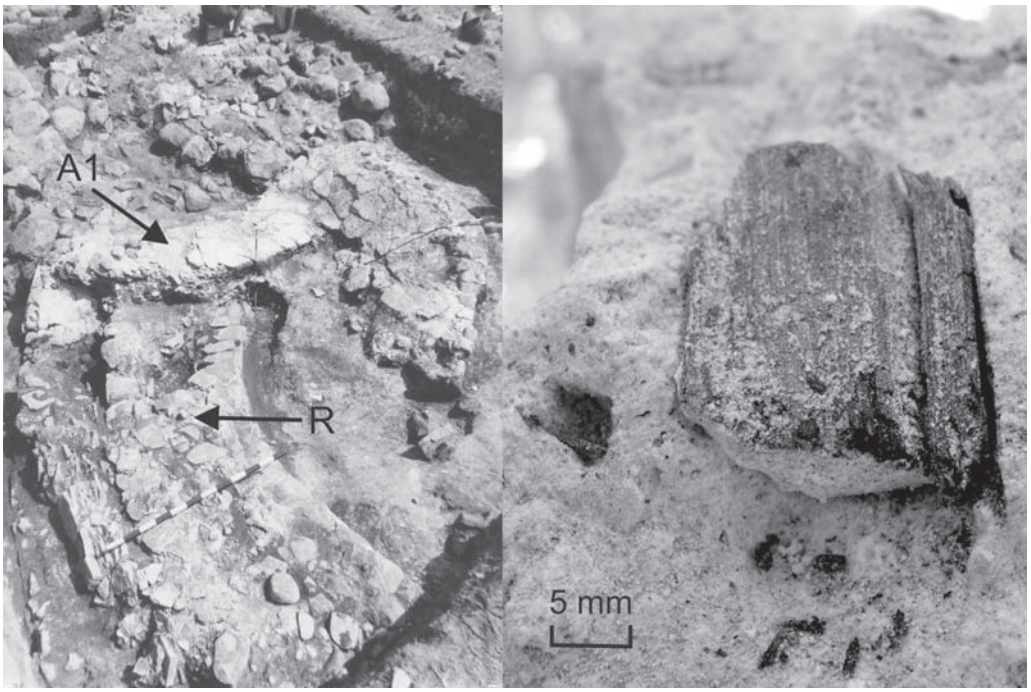

Figure 4 Left: top fragments of the rotunda's foundations "R" and fragment of flooring in the area of Cistercian oratory (phase A1). Right: pieces of charcoal embedded inside the calcareous mortar from Łekno. The large piece (~15 mm long) is absolutely exceptional; all other charcoals in the mortar from Łekno were no bigger than 2 mm, like those visible below the large piece.

timing of construction of both the rotunda and the Cistercian oratory. This additional information has been used in the calibration of related ^{14}C 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

^{14}C AMS analysis and relative age determination based on classical archaeological and architectural methods (Wyrwa 2007) indicate that the Romanesque St. Peter's Rotunda in Łekno 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 Wełna and Noteć (where the fortified settlement and monastery in Łekno is situated), in AD 955–1003 were "hospitably" donated to Prince Sobiebor (Sobiesław) 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 Bolesław 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 ^{14}C 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.

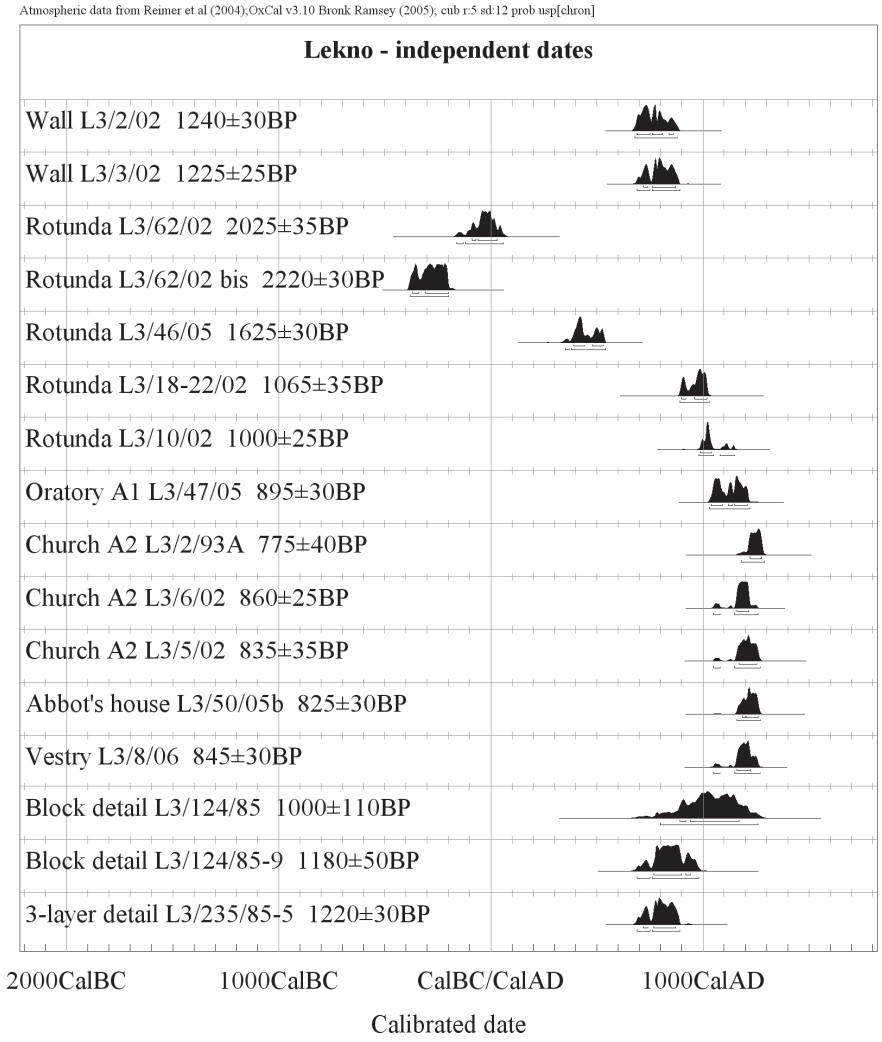

Figure 5 Calibrated ^{14}C dates of the walls of the fortified settlement (phase II) and mortars from the rotunda and stone buildings of the monastery in Łekno. Individual dates were treated as independent of one another.

Church, Phase A1

Based on the foundation document of the Cistercian monastery in Łekno 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.

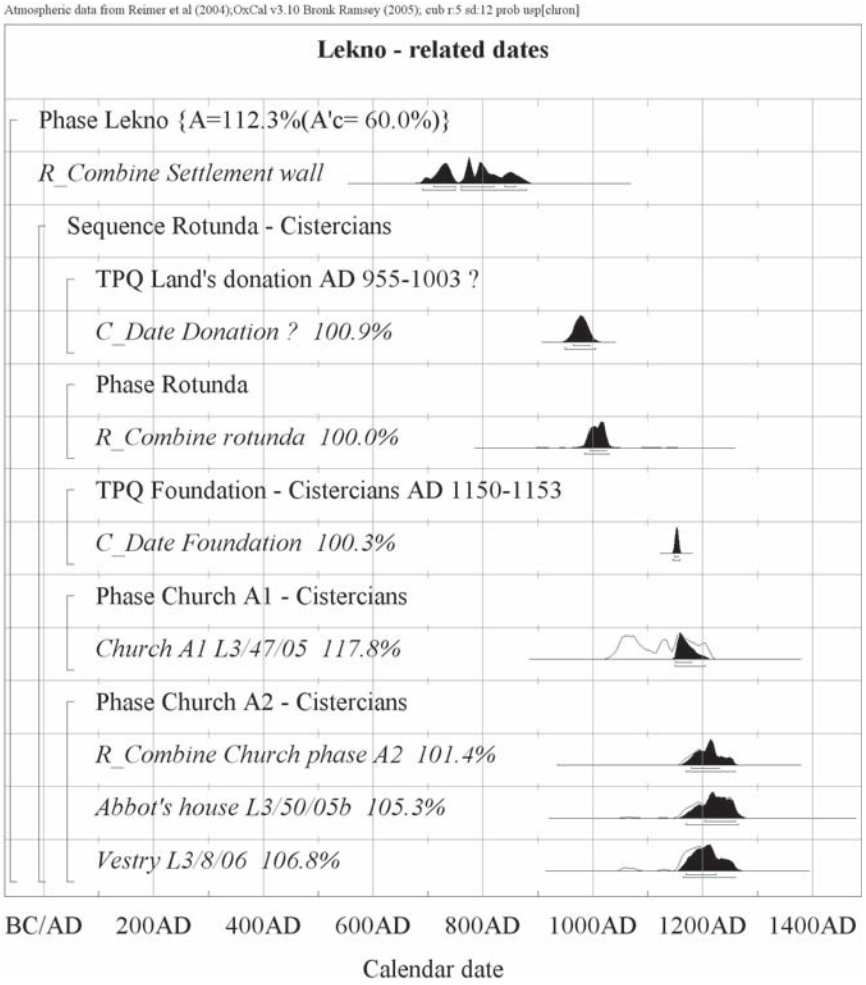

Figure 6 Calibrated ^{14}C dates of the walls of the fortified settlement and mortars from the rotunda and stone buildings of the monastery in Łekno. In calibration, chronological relationships between samples were taken into account (as described in the text). The dates from the rotunda, which were evidently too old, have been ignored. Black silhouettes represent calibration results obtained with the assumption of a relationship between dates. For comparison, white silhouettes show the results of the calibration of independent dates.

Church, Phase A2

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 is 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 ^{14}C dates of mortars from the architectural objects on the site Ł3 in Łekno. The dates marked with asterisks have been ignored in the calibration of related dates.

Object	Sample name	Localization	^{14}C age BP	Calibrated date (2-σ interval)
Rotunda	Ł3/10/02	brickwork floor of rotunda, excavation VIp	1000 ± 25	AD 980 (77.8%) 1050 AD 1080 (17.6%) 1150
	Ł3/18-22/02	brickwork floor of rotunda, excavation VIp	1065 ± 35	AD 890 (95.4%) 1030
	Ł3/62/02	north brickwork floor of rotunda, excavation VIp	2025 ± 35*	160 BC (3.6%) 130 BC 120 BC (91.8%) AD 60
	L3/62/02 bis	north brickwork floor of rotunda, excavation VIp	2220 ± 30*	380 BC (95.4%) 200 BC
	Ł3/46 /05	NW part of rotunda	1625 ± 30*	AD 350 (2.7%) 370 AD 380 (92.7%) 540
Cistercian church phase A1	Ł3/47/05	C-W foundation floor of rotunda	895 ± 30	AD 1030 (95.4%) 1220
Cistercian church phase A2	Ł3/2/93A	N brickwork of Cistercian church, phase A2, excavation XXXII	775 ± 40	AD 1180 (95.4%) 1290
	Ł3/5/02	N foundation floor of Cistercian church phase A2, excavation VA	835 ± 35	AD 1050 (3.1%) 1080 AD 1150 (92.3%) 1270
	Ł3/6/02	N brickwork of Cistercian church phase A2, excavation VA	860 ± 25	AD 1050 (6.5%) 1080 AD 1150 (88.9%) 1260
"Abbot's house"	Ł3/50/05b	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)	825 ± 30	AD 1160 (95.4%) 1270
Vestry	Ł3/8/06	mortar from floor D in vestry (sample A)	845 ± 30	AD 1050 (3.2%) 1080 AD 1150 (92.2%) 1270
Gypsum architectural details "block shape"	Ł3/124/85	architectural detail "block shape"	1000 ± 110*	AD 800 (95.4%) 1260
	Ł3/124/85-9	architectural detail "block shape"	1180 ± 50*	AD 690 (8.5%) 750 AD 760 (86.9%) 980
Gypsum architectural details "3-layer"	Ł3/235/85-5	architectural detail "3-layer"	1220 ± 30*	AD 690 (20.5%) 750 AD 760 (74.9%) 890

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}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}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.

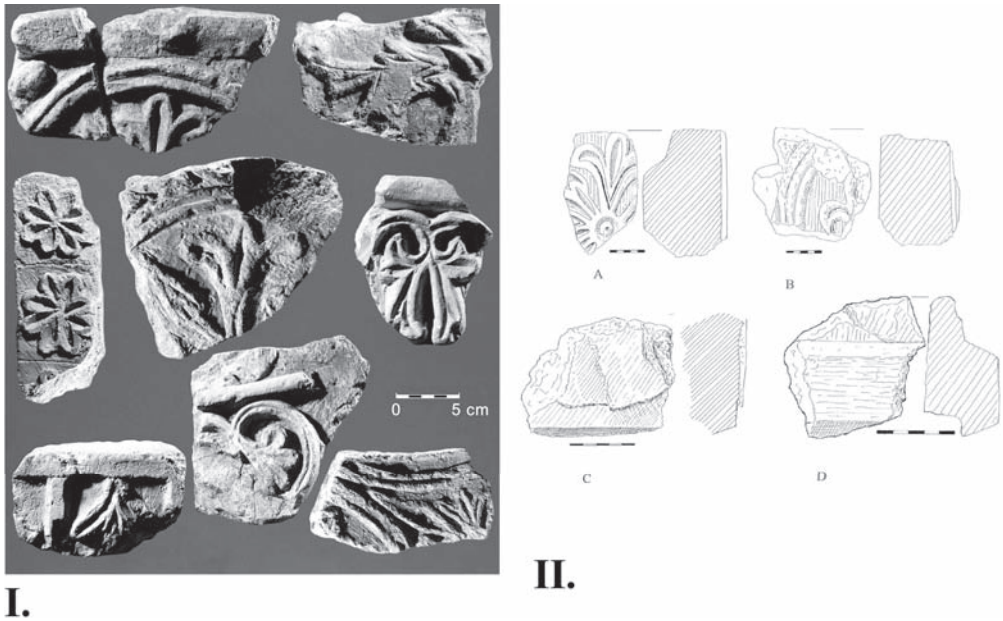

Figure 7 Selected architectural details made from gypsum found in site Ł3 in Łekno (I), and details forwarded for ^{14}C dating (II). Details: A—"block detail"—Ł3/124/85-9; B—"block detail" Ł3/124/85-2; C—"3-layer" Ł3/118/86; D—"3-layer" Ł3/235/85-5.

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 ^{14}C 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 ^{14}C 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, ^{14}C 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 Ł3 in Łekno, Poland. Most of the obtained ^{14}C 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 Łekno. The reasonable concordance of calibrated ^{14}C 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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