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# ISSUE OF ACTUAL CHRONOLOGY OF A ROMANESQUE CHAPEL AT THE WLEŃ CASTLE (LOWER SILESIA, POLAND) IN THE LIGHT OF MORTAR RADIOCARBON DATING

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**Abstract:** The presented work discusses results of radiocarbon dating of lime mortars sampled from walls of a Romanesque chapel at the Wleń castle. Considering a homogeneous structure of the mortars, an attempt to determine the chronology was made. Radiocarbon dating was carried out both on carbonate binders and laboratory-selected charcoals from the mortars. According to obtained data, charcoal ages are older than the age of the binders. Assuming the 12$^{th}$ century chronology of the chapel's erection to be correct, it was found that the applied method did not provide the result which is consistent with archaeological estimations.

**Keywords:** radiocarbon dating, Castle Wleń, lime mortars, charcoal

## INTRODUCTION

The paper presents results of the research on the radiocarbon age of lime mortars sampled from a ducal chapel's walls at the Wleń castle (**Fig. 1**). The research is a continuation of previous studies on spatial development of the castle from the Middle Ages to the Renaissance, which were based on chemical analysis of lime mortar samples and on determination of petrographic composition of aggregate (Michniewicz, 1997). The results obtained then indicated an entire distinction between Romanesque mortars of the ducal chapel's walls, ramparts and remaining buildings of the castle.

A problem with application of the radiocarbon method for precise dating of carbonate binders, their relative overestimation – connected with presence of so called "dead carbon" – and then radiocarbon rejuvenation – resulted from their secondary recrystallization, has not been totally solved (Folk and Valastro, 1979; Zouridakis *et al.,* 1987; Heinemeier *et al.,* 1997; Sonninen and Jungner 2001; Nawrocka *et al.,* 2005). Two determinants are essential in providing radiocarbon ages of binders: dead-burned lime materials and completed slaking process. In the past, these requirements usually were not realized and, consequently, obtained radiocarbon dating of mortars was older or younger than the actual age (Nawrocka *et al*., 2005). The homogeneous structure of the mortars the castle chapel's walls found by petrographic analysis and low aggregate content indicated, that these mortars might be a perfect material for the $^{14}$C method.

According to archaeological investigations, the castle chapel, together with the rampart, a residential building and a hexagonal keep are the oldest structures of the castle (Buśko, 1998). It is difficult to reconstruct precisely the castle history, however, historians and archaeologists connect the first masonry structures with Boleslaw I the Tall (Boleslaw Wysoki: 1127-1201), a grandson of Boleslaw III Wrymouth (Boleslaw Krzywousty).

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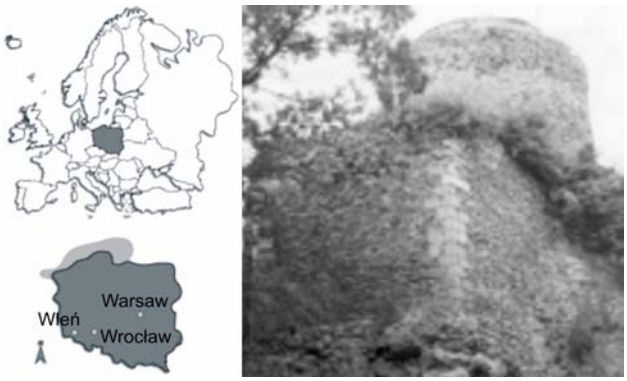


**Fig. 1.** *Location: Wleń Town, Lower Silesia province (SW Poland); front elevation of Wleń castle*

## SUBJECT OF THE ANALYSIS AND APPLIED METHOD

The analyses were carried out on mortar samples taken from the chapel's walls:

- K160/4 – the base of the rood-arch, a structure of yellow sandstone ashlars;
- K157/1, K1/93 – the northern wall of the church, a structure of broken greenstone ashlars.

Two samples of carbonate binder were analyzed and two samples of laboratory-selected charcoals were analyzed as well (cf. **Table 1**). The conventional ages of the binder were obtained with the use of gas proportional counters (the GPC) in the Gliwice Radiocarbon Laboratory ("S" samples, Gd-15369 and Gd-17105; Pazdur *et al.,* 2000, 2004). Dating of the charcoals was carried out with the use of accelerator technique (AMS) in the Radiocarbon Laboratory in Poznań ("W" samples, Poz-5091 and Poz-5092; Goslar *et al.,* 2004).

## THE RESULTS

The obtained conventional radiocarbon data and the intervals of calendar years, together with probability for 68 and 95% confidence intervals are presented in **Table 1**. The distribution of the probability density function of the calendar age for individual samples were obtained with the use of the OxCal v.3.10 calibration software (Bronk Ramsey 2005). The distributions are presented in **Fig. 2**, and also in numerical form in **Table 1**.

## DISCUSSION ON THE RESULTS

In the obtained conventional data one may observe a relatively high uncertainty of binder chronology indicated by the GPC technique (dates Gd-15369 i Gd-17105) and high precision of charcoals age obtained by the AMS technique (dates Poz-5091 and Poz-5092, cf. **Table 1**). This fact exerts an influence on the form of the probability function (cf. **Fig. 2**) and width of most probable intervals of calendar age both at the 68 and 95% confidence levels.

Moreover, those intervals are widened owing to unambiguous value of the calibration curve observed in the discussed time span. It is particularly clear in AMS precise date Poz-5092, 1185±35 BP, where the width of the most probable interval of calendar age at the 68 and 95% confidence levels equals, respectively, 110 and 140 years.

While considering the results of data calibration at the 95% confidence level, calendar age intervals indicate a certain shift of the charcoal ages in comparison with the binder ages, towards higher values. The significance of differences of binder and charcoal ages may be questionable due to a high measurement uncertainty of radiocarbon dates of binders samples. The estimated calendar age intervals of charcoal fragments taken from mortar and determined precisely with the AMS technique do not cover the 12$^{th}$ century (cf. **Table 1**), i.e. the chronology of the chapel established on the basis of the historical and archaeological survey. **Fig. 2** also shows that the ages of charcoals are older in comparison with binder ages, what may indicate using old wood in burning process. Therefore we continue the interpretation of radiocarbon results on binder samples only. In the case of the studied castle we know from the reliable historical sources (*after* Buśko, 1998), that the Wleń church existed from 1177AD to 1239 AD. These events define a *terminus ante quem* (TAQ) – none dated sample can be older than 1230AD, and *terminus poste quem* (TPQ) – none dated sample can be younger than 1177AD. We combined radiocarbon dates and the above-mentioned information using option

**Table 1.** *Measurement results of conventional radiocarbon age of mortar binder samples ("S" samples) and charcoals from mortars ("W" samples) and intervals of calendar years for 68 and 95% confidence intervals together with their probability, determined with the use of the OxCal v.3.10 (Bronk Ramsey, 2005). Approximate age established by archaeological research for Romanesque church mortars: 12$^{th}$ Century.*

| Sample Name | M | Lab. No | $^{14}$C Age (BP) | $\delta^{13}$C (‰) | Cal. Age (68.2% conf. intervals) (AD) | Cal. Age (95.4% conf. intervals) (AD) |
|---|---|---|---|---|---|---|
| K1/93/W | S | Gd-15369 | 1030 ± 80 | -12.5 | 890-1050 (54.1%)<br>1080-1150 (14.1%) | 810-1210 (95.4%) |
| K160/4/W | S | Gd-17105 | 940 ± 130 | -13.2 | 980-1230 (68.2%) | 750-1300 (95.4%) |
| K/160/4 | W | Poz-5092 | 1185 ± 35 | -26 | 780-890 (68.2%) | 710-750 (3.3%)<br>760-900 (82.8%)<br>910-970 (9.3%) |
| K/157/1 | W | Poz-5091 | 1035 ± 30 | -21.9 | 985-1025 (68.2%) | 890-920 (5.6%)<br>940-1040 (89.8%) |

*M=dated material, S=mortar binder, W=charcoals.*

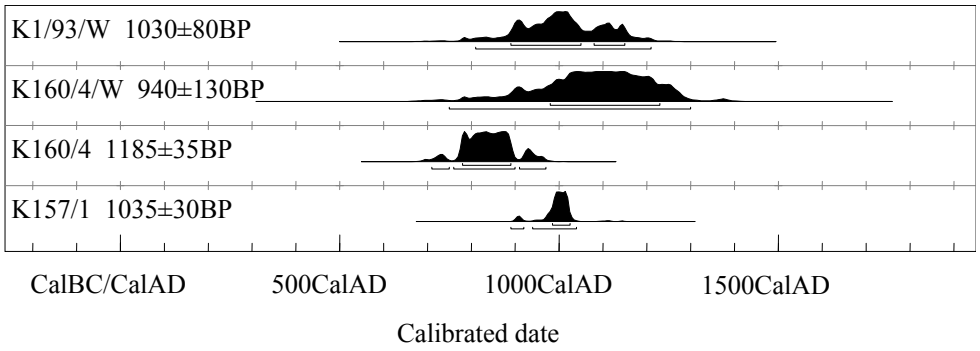


**Fig. 2.** *The distribution of the probability density function of the calendar age for binder and charcoal samples obtained with the use of the OxCal v.3.10 calibration software.*

TAQ and TPQ in OxCal programme. The results of the calibration of mortar binders seem to be congenial to historical data. The age of binders is compatible with the archaeological and historical estimations, but it is not absolute confirmation of these premises, for the sake of a large width of confidence intervals.

It should be added, that the binder calendar age obtained on the basis of calibration of the conventional radiocarbon date should determine the chapel chronology more precisely than the charcoal age. On the basis of petrographic observations, the whole radiocarbon contained in the binder seems to originate from atmospheric carbon dioxide during the setting of the lime mortar. The charcoal age indicates probably the age of wood used in lime burning. It depends both on wood provenance and its burnt fragments. Thus, the charcoals age – older then the binder – is not surprising.

## CONCLUSIONS

The obtained calendar age intervals indicate a certain displacement of the charcoals age, in comparison with the binders age, towards its higher value. The significance of the differences is not too high due to relative high measurement uncertainties of binder dating obtained with the GPC technique, resulting from a small quantity of accessible material to dating with the conventional method and ambiguity of the calibration curve. The charcoal ages are older than binders, possibly indicating that the old wood fragments were use in burning process.

The castle chapel, according to archaeological historical evidence, belongs to the oldest masonry structures of the castle, ascribed to Boleslaw I the Tall. Assuming that the 12$^{th}$ century is the actual date of the chapel erection, one should conclude, that charcoal radiocarbon dating fails to confirm the historical premises. The calendar age interval of the binder seems to be more congenial to archaeological historical expectations and premises referring to the chronology of the chapel's erection, but because of a high measurement uncertainty (a large width of confidence intervals) they cannot absolutely confirm the historical data.

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