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^{14}C DATING OF THE 'TITULUS CRUCIS'

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ABSTRACT. The authors study the radiocarbon dating of a relic believed to be the tablet that was placed on the cross of Jesus Christ at the time of his crucifixion.

INTRODUCTION

The scope of the present work was the dating of a religious relic preserved in the Basilica of "Santa Croce in Gerusalemme" in Rome, Italy. This relic is believed to be the tablet that was placed on the cross of Jesus Christ. Dating was performed in a new radiocarbon (^{14}C) laboratory ("E. Amaldi" Physics Department of "Roma Tre" University) using 2 highly sensitive liquid scintillation spectrometers. Control measurements were performed on samples of known historical dates. A comparison between the ^{14}C dates and the historical dates of the control samples indicates the good operation of the analytical system and validates the calculated age of the "Titulus Crucis".

SAMPLE DESCRIPTION

The sample studied is a religious relic preserved in the Basilica of "Santa Croce in Gerusalemme" in Rome (Italy). This relic is believed to be the tablet that was placed on the cross of Jesus Christ, following the practice of the Roman penal code for every condemned prisoner. Inscribed on the tablet (Rigato 1999, 2001) is the phrase "Jesus of Nazareth, King of the Jews", written in Latin, Greek, and Hebrew.

The irregularly shaped tablet is approximately 26 × 14 × 4 cm in size, weighs about 687 g, and consists of a single piece of walnut wood (species *Juglans Regia* L) (E Corona, personal communication 2001). A sample for ^{14}C dating was collected from the lower central part of the back of the "Titulus Crucis", an area characterized by surface alteration of about 4 mm that covers wood that is completely intact, very compact, and perfectly preserved. Six samples were collected from different locations in and around a knot in the wood.

SHIELDING AND ELECTRONIC REGISTRATION

Dating was performed in the new ^{14}C laboratory located in the E Amaldi Physics Department of Roma Tre University. The laboratory has 2 independent, highly sensitive liquid scintillation spectrometers (A and B) as well as the capability to synthesize benzene. The characteristics of this laboratory are very similar to those of the ^{14}C laboratory at La Sapienza University of Rome, of which dates are prefixed by the letter *R* (*Radiocarbon* 1964 and successive years) and both laboratories were designed and constructed by the same researcher (Bella et al. 1960; Alessio et al. 1970; Alessio et al. 1973). Each spectrometer consists of the following:

1. A system for shielding the soft component of cosmic rays, consisting of iron, borate paraffin and lead;
2. Two photomultipliers which, in coincidence, monitor the benzene-filled sample vial;
3. A vial holder. The watch-shaped vial is constructed of low-sodium glass and has a volume of 2 cm^3, an external diameter of 3 cm and a depth of 0.6 cm. A small tube is fused onto the outer

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surface of the vial and closed with a flame using a technique adopted by the laboratory (Alessio et al. 1978);

4. A system for shielding the penetrating component of cosmic rays, consisting of a plastic scintillator with 8 photomultipliers that surround the coincident detector and which, through a Fan-in/Fan-out, create a classic anti-coincident system.

The new registration system is different from its predecessor at La Sapienza University because:

1. Highly stable electronic components, which allow for resolved real times within 6 ns, have been used;
2. For more control, it allows calculating ^{14}C dates directly from the coincidence between the two photomultipliers monitoring the sample, in addition to that from the anticoincidence.

CHEMICAL PREPARATION OF THE SAMPLES

Sample preparation was conducted very carefully, as the quality of the dating depends greatly on the mechanical and chemical pretreatment. The preparation of benzene was performed following the well-tested suggestions of Prof H A Polach (Polach et al. 1967). The small amounts of non-coeval contamination were eliminated first by unaided visual examination and then by using a stereoscopic microscope. The fragmented samples were then subjected to chemical treatment, including hot 5% HCl to eliminate carbonate contamination and 2% NaOH to remove secondary humic acids. A final 5% HCl treatment completes the cleaning procedure. After each acid treatment, the samples were neutralized with successive washing and boiling in distilled water and then desiccated in an oven at 70 °C.

The production of benzene is relatively complex, and is based on the 4 fundamental steps that are summarized below.

1. Combustion of the sample in a flux of O_2, followed by purification and storage of the produced CO_2;
2. Fluxing of the CO_2 in a titanium catalytic reactor containing metallic Li at 700 °C to obtain Li_2C_2. The exothermic reaction is completed at 900 °C in 1 hr, after which the sample is cooled to room temperature and distilled H_2O is injected in the vessel to convert the Li_2C_2 into C_2H_2;
3. The acetylene is transformed into benzene in the presence of an aluminum silicate catalyst activated with potassium-bichromate. Benzene is produced when the acetylene adsorbed on this material is heated to 150 °C and then collected in a small cryogenic oxygen trap.
4. Finally, a stoichiometric amount of PBD scintillator (Fluka) is added to the obtained benzene.

There was little problem in preparing the benzene for this study because the 4 samples were well-preserved. Notably, the weight of the wood treated from the "Titulus Crucis", sample 43, was 5.8 g before chemical and mechanical treatment and 5.1 g before combustion.

DATING

The activity of our "modern standard", consisting of wood that grew near Rome between 1949 and 1953, was checked repeatedly with 95% of the counting rate of NBS oxalic acid and was found to be within 1 σ. All dates are reported in conventional ^{14}C yr, using the Libby half-life of 5568 ± 30 yr, with AD 1950 as the standard yr of reference. The dating of the studied samples was performed under different background conditions by varying the discriminator thresholds and the voltage of the photomultipliers. Besides the accurate count checks, each series included ^{14}C age measurements of the following samples:

Sample 43. **"**Titulus Crucis" (see Tables 1–3)

Sample 29. A piece of a wooden lintel from a small storeroom in the attic of the Basilica of "S. Croce in Gerusalemme" where the "Titulus Crucis" may have been kept (Rigato 1999)

Radiocarbon age[2] **t = 960 ± 260 BP**

Sample 31. Part of the wooden plank, on which the body of Giovanni de Alessandro de Medici was laid when he was buried around AD 1360, taken from the center of the nave in the Florence Duomo (Azzi et al. 1973, 1974).

Radiocarbon age **t = 650 ± 73 BP**

Sample 40. Wood from Roman ships housed in the "Museo delle Navi Romane" in Nemi (Italy). This sample was 1 of 3 distributed among many ^{14}C researchers in order to perform the first inter-laboratory cross-check. The average value calculated using all of the values was 1990 ± 85 BP (Alessio et al. 1964). Historically, construction of the ships occurred during the reign of Caligula, from AD 37 to 41.

Radiocarbon age **t = 1943 ± 40 BP**

The following 3 tables give the results of the datings performed.

Table 1 Dating of wood samples from the Nemi ships and the "Titulus Crucis" using spectrometers A and B under different conditions by varying the discriminator thresholds and the voltage of the photomultipliers. Measurements were collected directly by coincidence of the 2 photomultipliers that monitor the vial. The errors of the single age are calculated as experimental errors.

	Age measurements using only coincidence		
Counter	Background C/min	Nemi wood (BP) sample 40	"Titulus Crucis" wood (BP) sample 43
A	21.6 ± 0.1	2063 ± 163	973 ± 115
	22.5 ± 0.2	1676 ± 199	1084 ± 157
	21.1 ± 0.2	1907 ± 90	1051 ± 123
B	3.77 ± 0.07	2340 ± 240	986 ± 135
	4.7 ± 0.1	1919 ± 152	1073 ± 210
	4.37 ± 0.03	1985 ± 307	999 ± 208
	4.80 ± 0.03	1937 ± 133	970 ± 96
	Weighted mean:	1941 ± 56	1006 ± 50

[2]This sample is subject to a large error due to the uncertainty of the volume of benzene used for the radioactivity counting and by the imperfect closure of the vial.

Table 2 Dating of wood samples from the Nemi ships and the "Titulus Crucis" using spectrometers A and B under different conditions. The measurements were acquired by the anticoincidence between the coincidence of the 2 photomultipliers monitoring the benzene-filled vial and the fan-in/fan-out system. The errors of the single age are calculated as experimental errors.

	Age measurements using anticoincidence		
Counter	Background C/min	Nemi wood (BP) sample 40	"Titulus Crucis" wood (BP) sample 43
A	2.47 ± 0.03	2030 ± 155	951 ± 90
	2.20 ± 0.03	1898 ± 232	1052 ± 214
	2.43 ± 0.03	2012 ± 152	1162 ± 110
	2.43 ± 0.03	1959 ± 87	1026 ± 51
B	0.97 ± 0.03	1893 ± 173	991 ± 103
	1.13 ± 0.03	1611 ± 269	1063 ± 219
	1.10 ± 0.03	1859 ± 163	1025 ± 154
	1.30 ± 0.03	1948 ± 122	915 ± 193
	Weighted mean:	1945 ± 51	1023 ± 36

Table 3 Comparison between the historical and ^{14}C dates of the reference samples, with the latter being calculated with a half-life of τ = 5568 yr, the value agreed upon at the 5th Conference on Radiocarbon Dating (Cambridge 1962)

Sample nr	Sample description	Historical dates (BP)	Radiocarbon dates (BP)
29	Attic lintel	~1000	960 ± 260
31	Burial plank	~600	650 ± 73
40	Roman ship wood	~1990	1943 ± 40
43	Wood from the "Titulus Crucis"	–	1020 ± 30

CONCLUSION

The experimental confirmation of the known historical dates of the control samples indicates a good operation of the analytical system and validates the calculated age of the "Titulus Crucis":

Radiocarbon age of the "Titulus Crucis" = 1020 ± 30 BP

Calendar age of the "Titulus Crucis" = AD 996–1023 (1 σ)
AD 980–1146 (2 σ)

The calendar age has been calculated using the INTCAL98 program (Stuiver et al. 1998). This dating permits one to consider alternative hypotheses regarding the origin of the tablet, such as the possibility that it is a copy of the original, as discussed by Rigato (2002).

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