

Radiocarbon dating of paper and parchment

Ines Krajcar Bronić, Nada Horvatinčić,
Jadranka Barešić, Andreja Sironić, Damir Borković
Ruđer Bošković Institute, Zagreb

krajcar@irb.hr

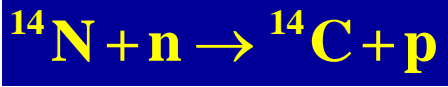
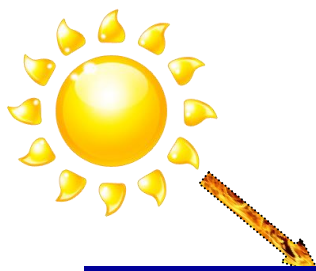
Dating – determination of the age of an object

Absolute dating of object of cultural heritage and art is one of the most important issues in art history studies and in archaeology.

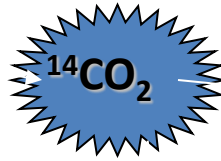
Accurate dating in art history is essential for valuation of original objects of arts, for differentiation between the original works and later imitations and/or frauds and for recognition of reparation and restoration works.

Radiocarbon (^{14}C) dating

- one of the most well-known radiometric methods of absolute dating
- it can be applied for dating materials of biogenic origin, such as wood, charcoal, bones, grains, paper, parchment, textile, etc.
- the range of ^{14}C age determination spans from 19th century up to ~60,000 years in the past
- the anthropogenic influence on the natural ^{14}C distribution during 20th century can be used for recognition of frauds



O_2

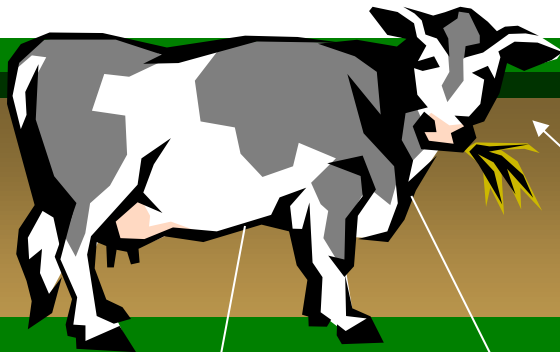


Carbon on Earth

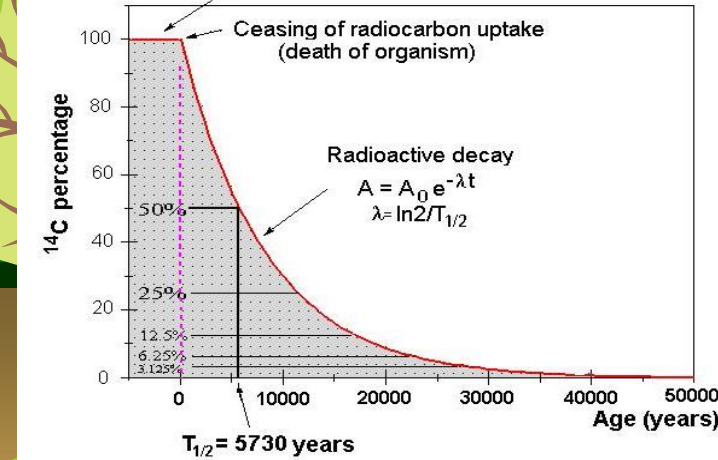
^{12}C : 98.89 %

^{13}C : 1.1 %

^{14}C : 1.18×10^{-10} %



Decayed ^{14}C balanced by its constant uptake



Techniques

Due to very low natural ^{14}C concentration the radiocarbon dating method requires special techniques for chemical preparation of samples and measurement of ^{14}C .

Particular care has to be taken for sample collection and/or storage as well as during sample pretreatment and chemical preparation.

- Extract all carbon from a sample (fractionation)
- All carbon only from the sample (contamination)

Measurement technique - AMS

Accelerator Mass Spectrometry (AMS)

number of ^{14}C atoms is counted, together with the number of ^{12}C and ^{13}C

Required mass: <2 mg C, <1 g sample

The AMS measurement technique enables precise analysis of very small amount of samples, e.g. micro-sized samples containing a few milligrams of carbon, or less, and is therefore applicable to various objects of cultural heritage.

^{14}C sample preparation for AMS

ABA pretreatment

Collagen extraction

Combustion to CO_2

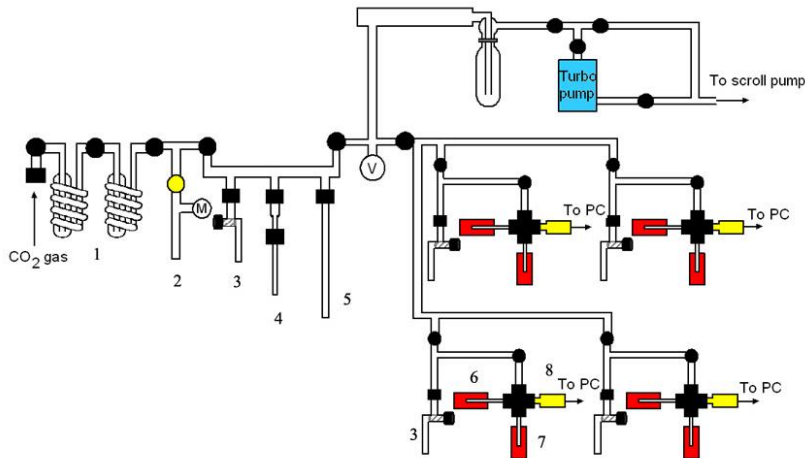
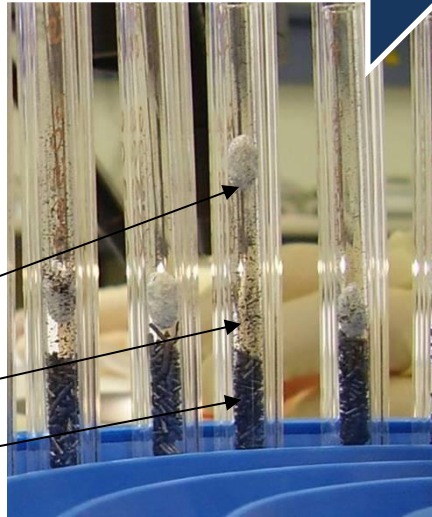
Reduction to C

Preparation of targets

AMS measurement

For $\delta^{13}\text{C}$ IRMS

Organic carbon



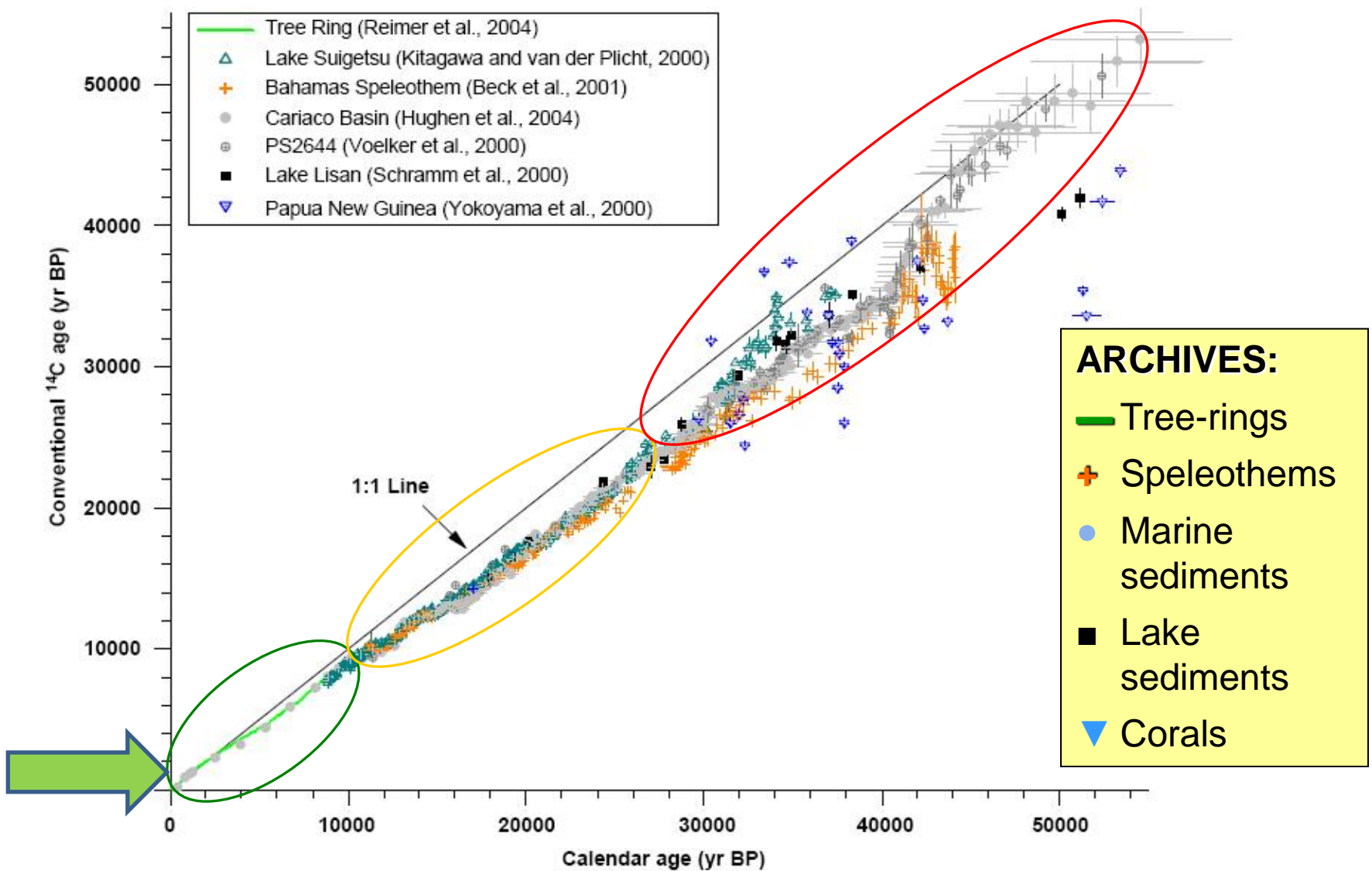
Graphitization line

What is the results of the measurement?

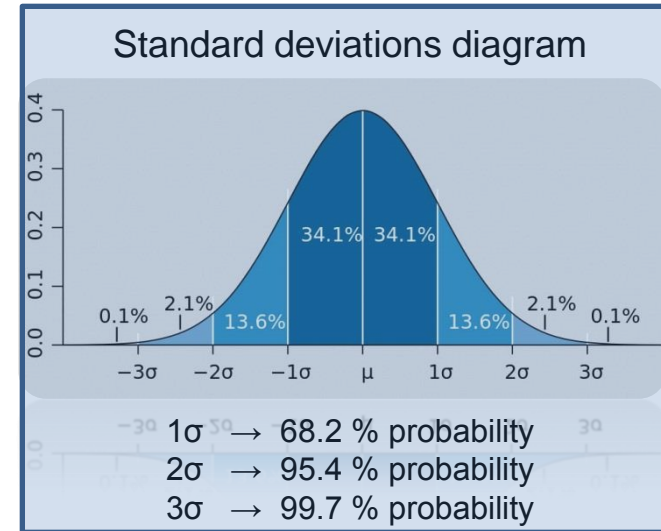
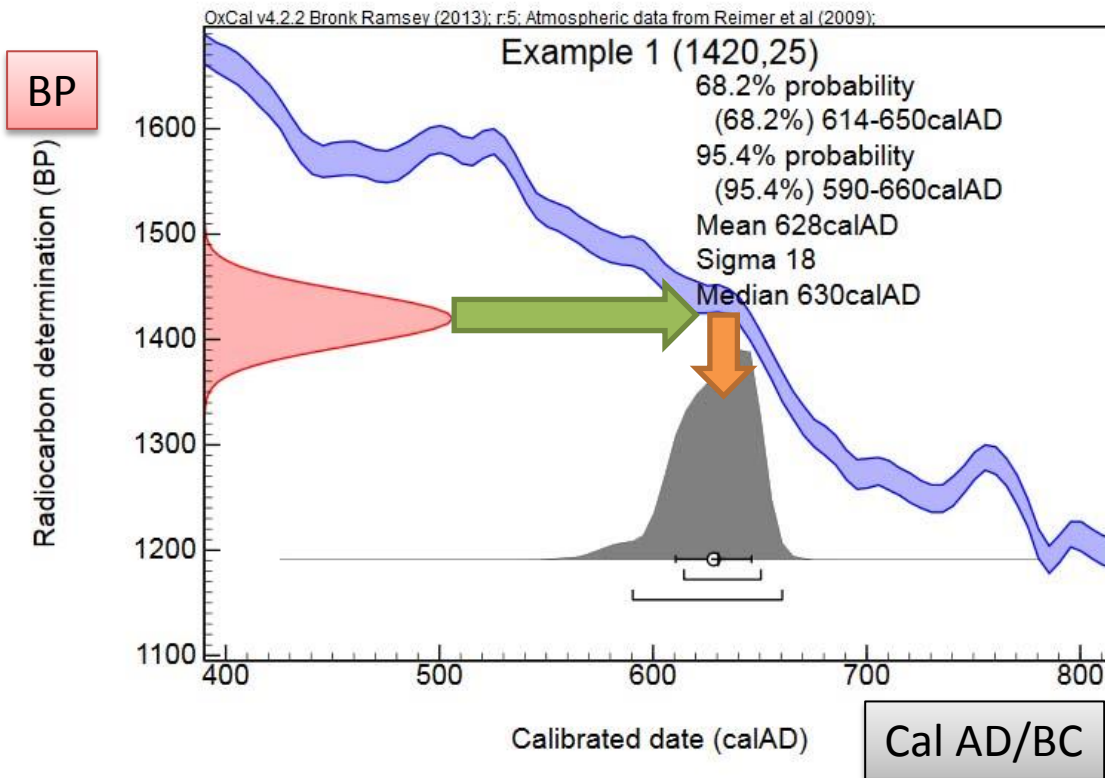
- **conventional radiocarbon age of the sample**, expressed in years Before Present (BP), where **0 BP = 1950 AD**
- conventional ^{14}C years do not directly equate to calendar years because atmospheric ^{14}C concentration varies through time due to changes in the production rate
- a **calibration is required** to convert the conventional radiocarbon age to the calendar age
- accurate and precise **calibration curves** should be based on absolutely dated record that has carbon incorporated directly from the atmosphere at the time of formation

Radiocarbon calibration curves

R.G. Fairbanks et al. / *Quaternary Science Reviews* 24 (2005) 1781–1796



Presentation of calibrated data



Example of a single calibrated date

Conventional radiocarbon ages (ordinate) in years BP are represented as the Gaussian curve with mean and standard deviation (uncertainty) being 1420 ± 25 . Calibrated values, in calendar years, are obtained by transferring the values on ordinate over calibration curve to the abscissa. Results can be presented by 1σ , 2σ or 3σ probabilities and by mean or median values.

Several cases of ^{14}C dating of objects (paper, parchment) of arts will be presented here.

How to interpret radiocarbon dates and calibrated ages?

One has to keep in mind that radiocarbon dating gives the **age of material** (e.g., wood) and not the time of the creation of the art work, and that the creation of the art work cannot precede the formation of the material.

Case 1. Ahd-Namah

Fojnica is a town and municipality in central Bosnia and Herzegovina, located west of the capital Sarajevo. The most important cultural site in Fojnica is the Holy Spirit Franciscan Monastery which houses an important part of the nation's cultural heritage, maintained by the Franciscan Province of Bosna Srebrena.

The Franciscan monastery in Fojnica has a large library of philosophical and theological works printed from the 16th to the 19th centuries, with some dating back to 1481.

The monastery's museum collections hold the Ahd-Namah (the Order) of Sultan Mehmed II the Conqueror (**1463 AD**) guaranteeing security and freedom to the Franciscans. This document allowed the Franciscans of the day to preach freely among the Catholics in BiH, which in turn enabled the preservation of Bosnian Catholicism through the centuries.

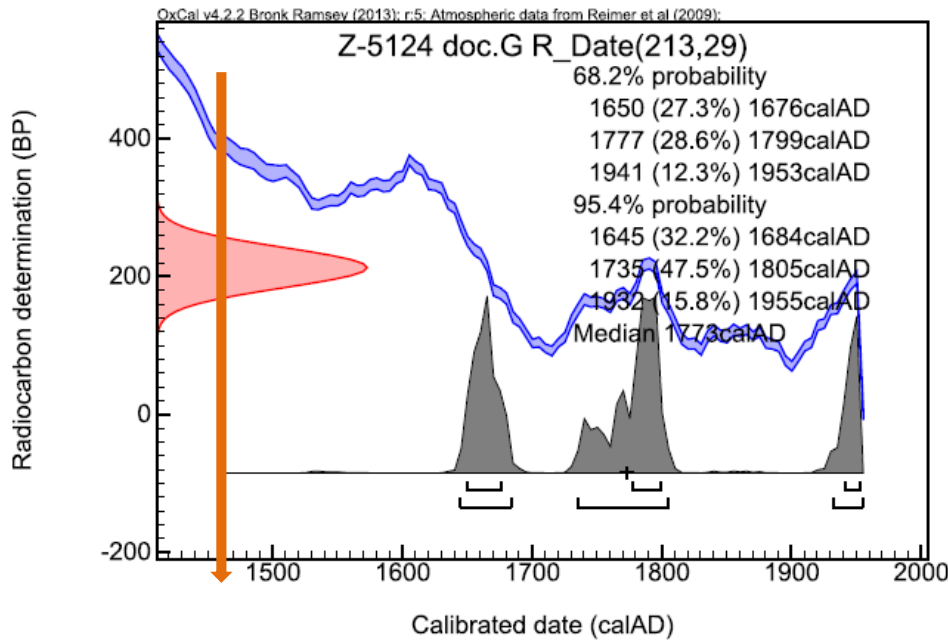
In 2013 celebration of the 550th anniversary of Ad-Namah

Ahd-Namah and mantel from the museum collection in Fojnica Monastery
(Ottoman Empire, Sultan Mehmed II, 1463 AD)



¹⁴C age of Ahd-Namah

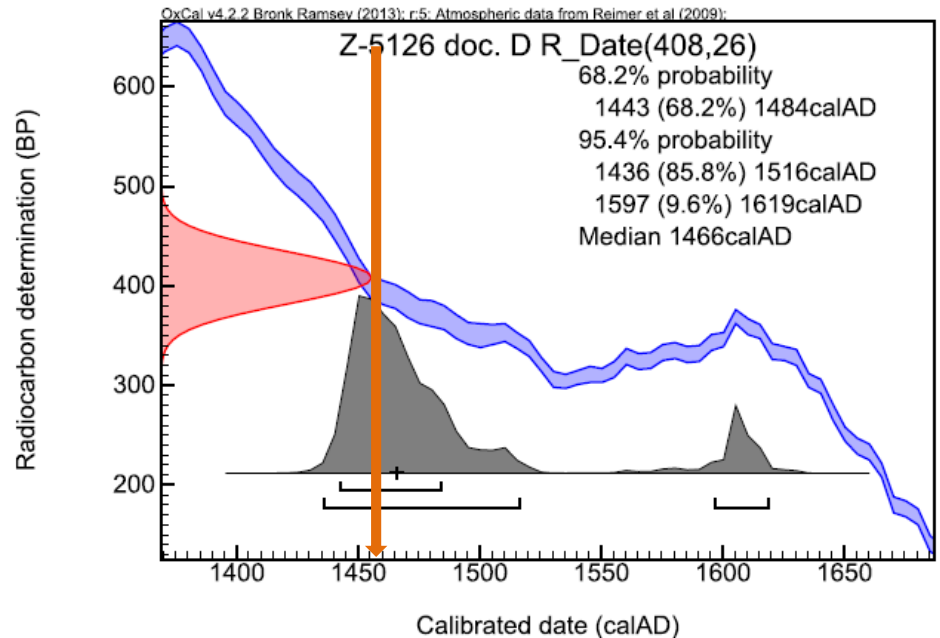
Upper part (#1) Z-5124 A628



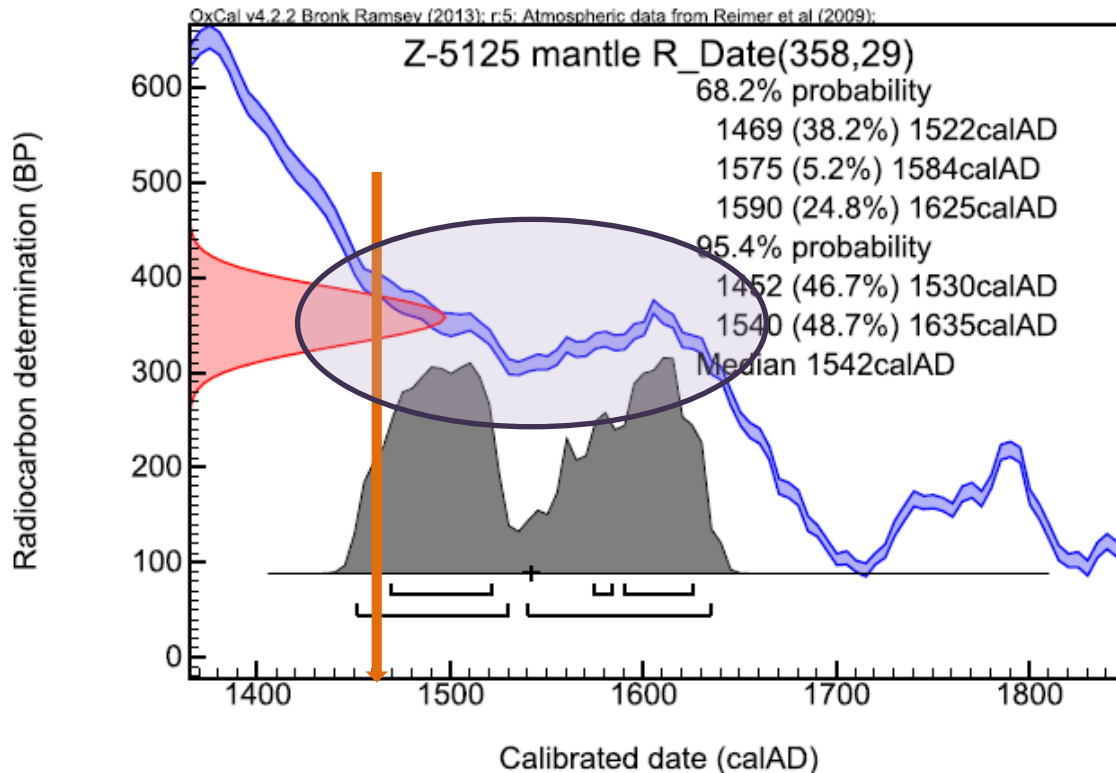
¹⁴ C conventional age (BP)	215 ± 30
Calibrated age (cal AD)	1650 – 1799 (55.9%)
Median cal AD	1773

Lower part (#2) Z-5126 A630

¹⁴ C conventional age (yr BP)	410 ± 25
Calibrated age (cal AD)	1443 – 1484 (68.2%)
Median cal AD	1466



^{14}C age of linen of mantel



Note the flatness of the calibration curve!

^{14}C conventional age (yr BP) <i>Z-5125 A629</i>	360 ± 30
Calibrated age (cal AD)	1469 – 1625 (68.2%)
Median cal AD	1542

Case 2. Fojnica Armorial

Fojnički grbovnik *Fojnica Armorial*
an early modern roll of arms including heraldry of
South Slavic history.

The manuscript is an important source of the
classical heraldry of the Balkans peninsula.
The manuscript contains a total of 139 coats of
arms.

Various estimates of its ages (from 1340 AD to
18th cent.)

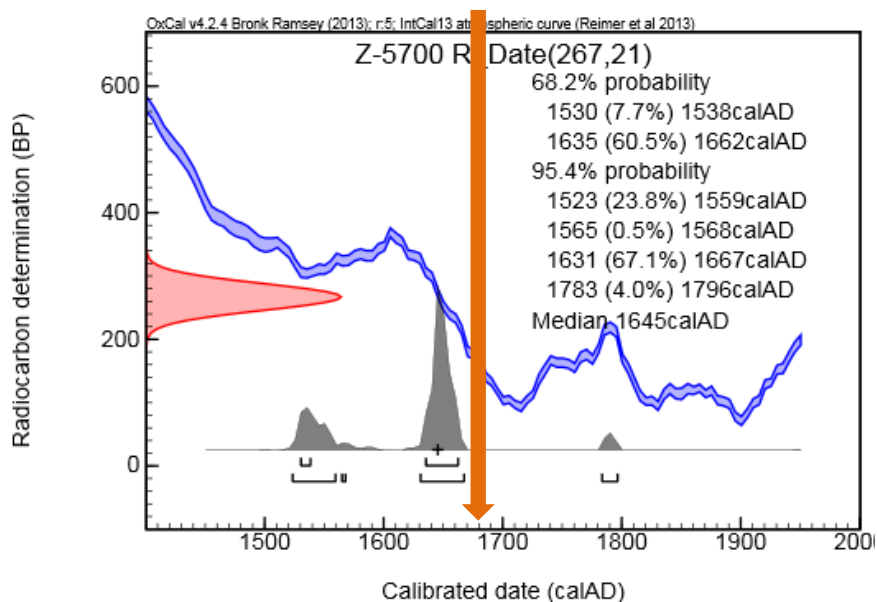
Most probably dated to in between **1675 and
1688**, i.e. in the context of the revolts against
Ottoman rule during the Great Turkish War.

<1 cm² of original sample
13 mg – after pretreatment

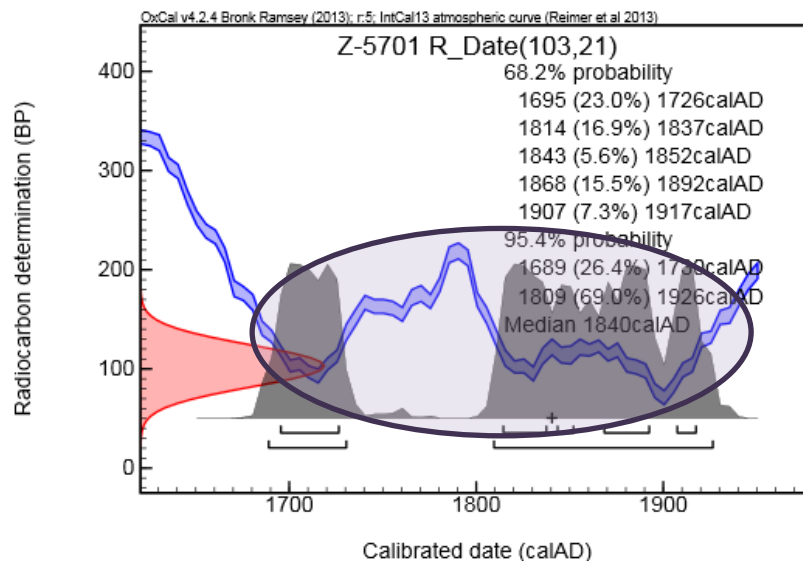


^{14}C dating – 2 samples, paper, AMS

ID	Sample name	Conventional ^{14}C age (BP)	$\delta^{13}\text{C}$ (‰)	Calibrated age (cal AD)	median cal AD
Z-5700 A1079	Paper (thick), #1	270 ± 20	-25.6	1635 – 1662 (60,5%)	1645
Z-5701 A1080	Paper (thin), #2	105 ± 20	-24.9	1695 – 1917 (68,2%)	1840



Confirmed hypothesis for the time of origin (17th century)

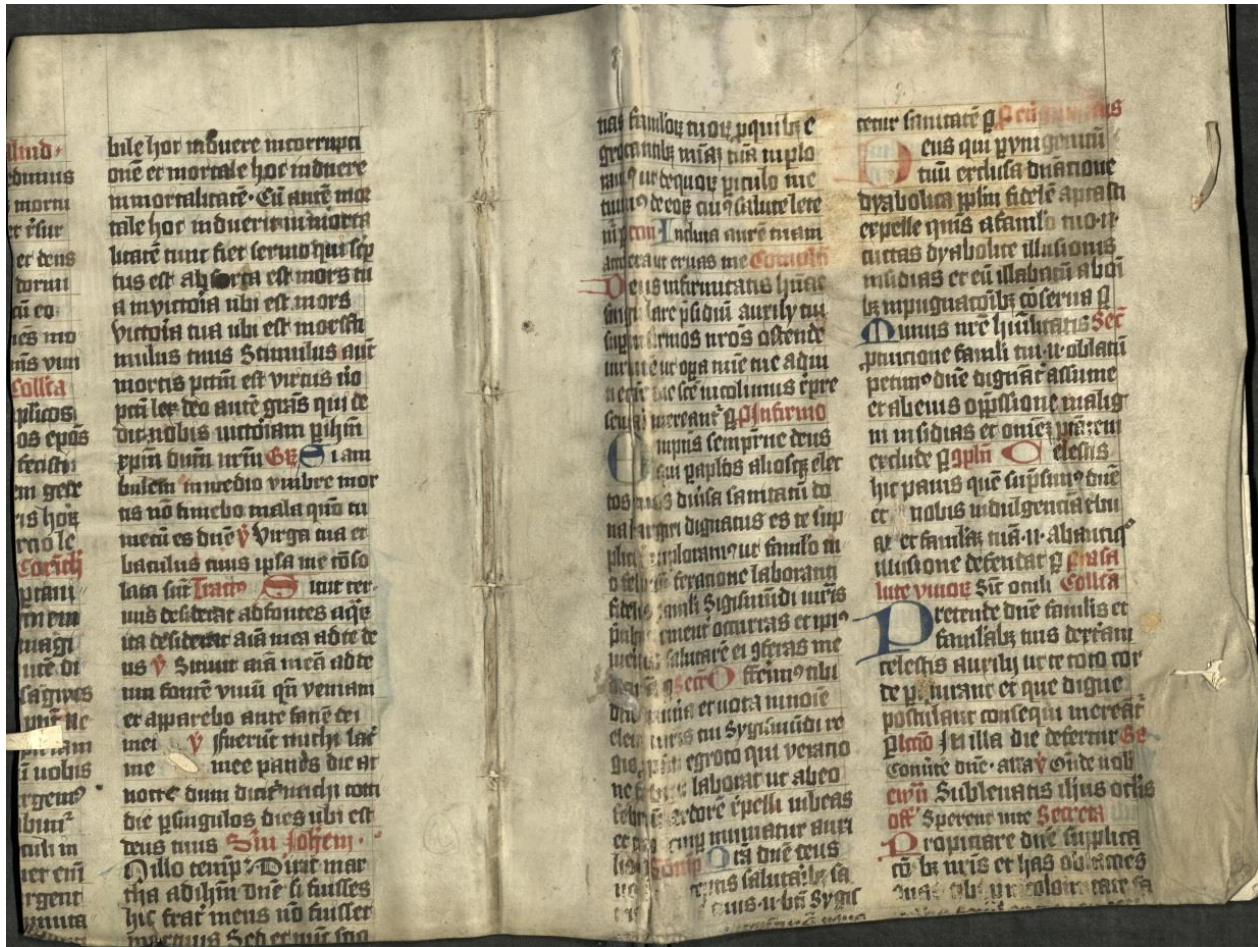


Most probably restauration/reparation

Case 3. manuscripts on parchment

manuscripts K3 and K4 with liturgical texts in Latin
from the Archives of Vojvodina, Novi Sad

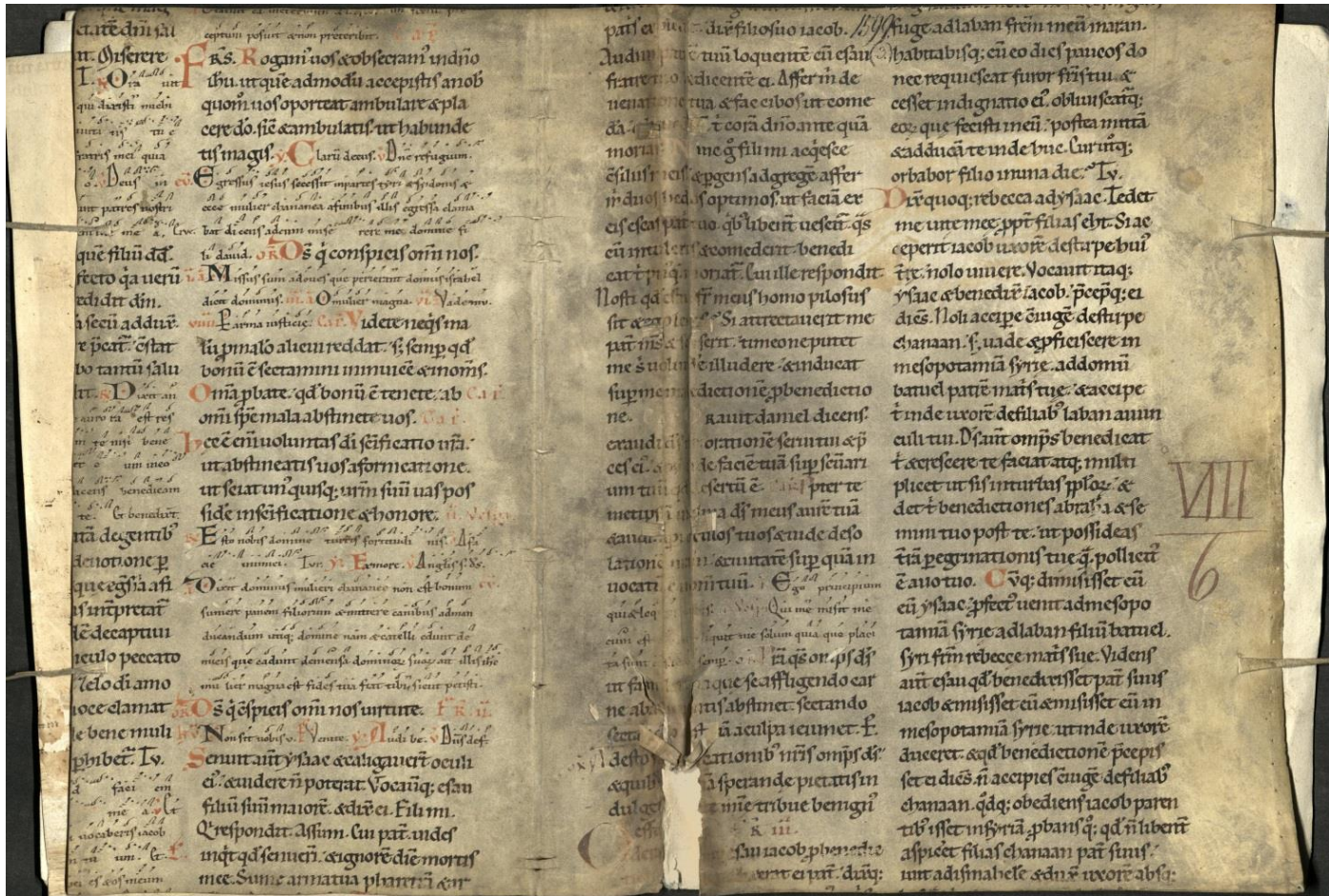
Used as binders for the notebooks from the end of 16th cent (1569-70 AD, 1590 AD)



K3

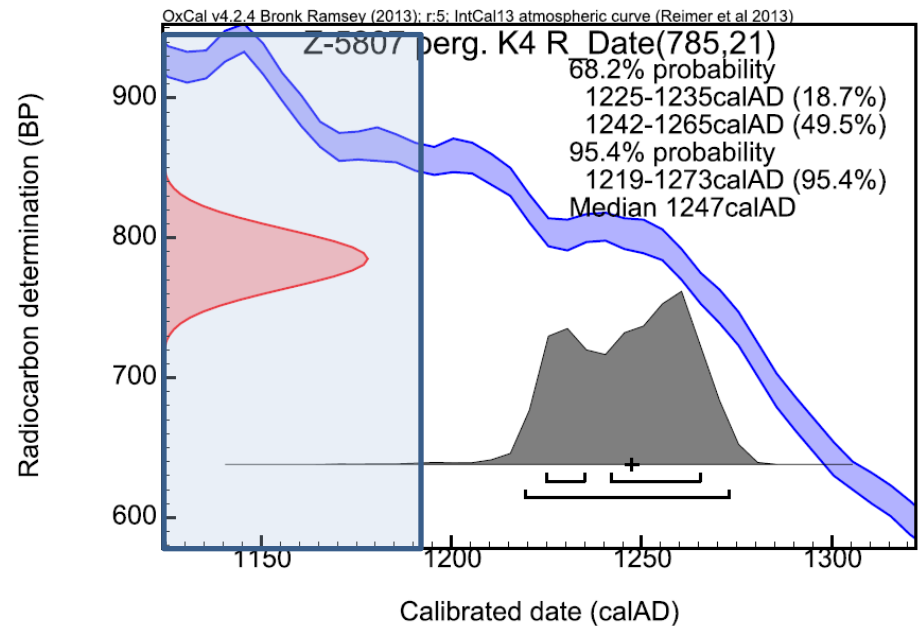
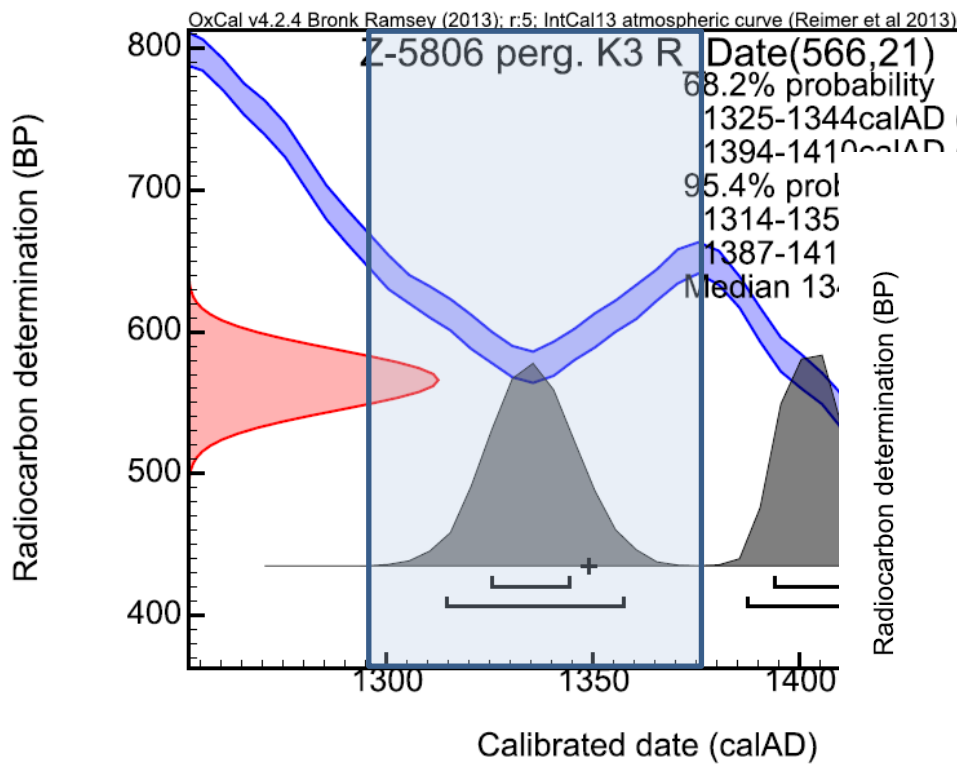
Case 3. manuscripts on parchment

manuscripts with liturgical texts in Latin from the Archives of Vojvodina, Novi Sad
Used as binders for the notebooks from the end of 16th cent (1569-70 AD, 1590 AD)



K4

Lab. no	Sample name	Conventional ^{14}C age (BP)	$\delta^{13}\text{C}$ (‰)	Calibrated age span (cal AD)	median cal AD	Expected period
Z-5806 A1140	Parchment K3	565 ± 20	-21.0	1325 – 1410 (68.2%)	1349	14th c.
Z-5807 A1141	Parchment K4	785 ± 20	-21.4	1225 – 1265 (68.2%)	1247	12th c.



CONCLUSIONS

- ❖ Radiocarbon dating gives **the age of material** (e.g., wood, canvas, paper, parchment... - the material of biogenic origin) and not the time of the creation of the art work – however, the creation of the art work cannot precede the formation of the material
- ❖ Radiocarbon dating cannot give a single year – **a range of years** is obtained with a certain probability, the width of the range depends on the measurement uncertainty and on the shape of the calibration curve
- ❖ Interpretation of results should be performed in **close collaboration** of art historian and radiocarbon specialists