DATING: RADIOCARBON METHOD

Chronology holds a central place in archaeology. Chronology can be based on both relative dating (e.g. stratigraphy, typology) and absolute dating. The latter is increasingly applied in archaeology because it does not require large sample quantities and allows for more precise dating of past events.

Since the dated event and the archaeological event may not always coincide, **it is necessary to ask oneself before dating a past event through an archaeological object/item the following questions:**

Principle of the Method

Dating objects using the radiocarbon method is based on the half-life of radioactive carbon (5568±30 years). Carbon-14 (^{14}C) present in atmospheric carbon dioxide molecules enters the biological carbon cycle during the life of organisms – it is absorbed from the air by green plants and transferred to animals and humans through the food chain. The dating range is 50 to 55,000 years. For dating biological materials, the accelerator mass spectrometry (AMS) method is predominantly used

- What archaeological event am I dating?
- What is the best context for dating the event under study? Why?
- Which material best dates the event under study? Why?
- What are the advantages and disadvantages of one material over another for dating a specific archaeological event?
- Which method should be chosen for dating? What are the advantages and disadvantages of the chosen method?

In addition to measuring radioactive carbon (^{14}C), the $\delta^{13}C$ ($^{12}C/^{13}C$) value is also measured. Why?

- This ensures the reliability of the dating through 'isotope fractionation correction'.
- It is important to know whether $\delta^{13}C$ is measured with AMS or IRMS (isotope-ratio mass spectrometry). If the $\delta^{13}C$ value is measured with AMS, it cannot be used in dietary studies.

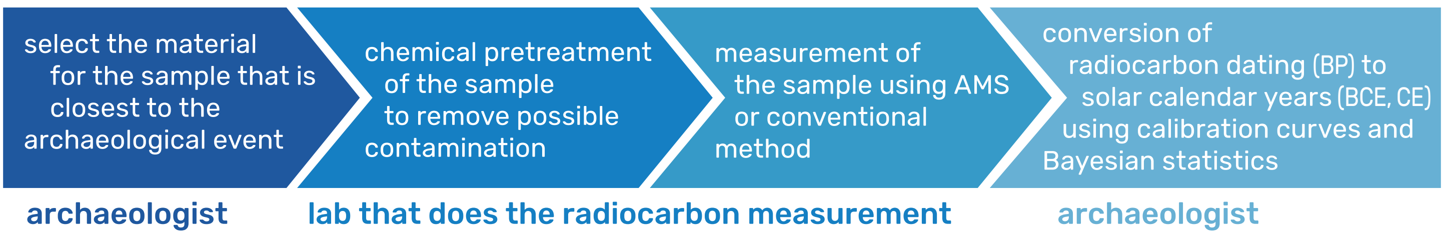
Recommendations for selecting a sample to date an archaeologically significant event

- Selecting the sample to be analysed is a very important responsibility of the archaeologist. Most dating-related problems stem from this step.
- Clear and unambiguous archaeological context.
- For bones, choose the best-preserved bone element possible; the same applies to other materials. Select material that has not been treated with preservatives.
- If possible, take multiple samples from the same context.
- When dating bones, prefer the bones of terrestrial herbivores if possible.
- For each sample, consider whether it may be contaminated (e.g. by preservatives or other substances).

Note: When taking a sample from an archaeological object, **always fill out the sampling protocol:** Archaeological Collections of Tallinn University and the Archaeological Collection of the University of Tartu.

Packaging the sample for shipment to the laboratory

- For bones, prefer a piece over powder.
- Wrap all materials in foil and place them in a ziplock bag.
- Label the sample with contextual information according to the laboratory's requirements.
- Always request the return of any leftover sample if possible.
- Consult the laboratory if necessary.



The four main stages of the radiocarbon dating process and their responsible parties (Adapted from Becerra-Valdivia & Higham 2023).

Materials dated using the AMS method in archaeology.

MATERIAL	SAMPLE QUANTITY	ADDITIONAL ANALYSES	DATED EVENT	NOTES
unburnt bone, tooth (collagen)	0.5–1 g	IRMS: $\delta^{13}C$, $\delta^{15}N$; for small fragments ZooMS	moment of organism's death	▪ prefer terrestrial herbivores for dating if possible ▪ the bone element chosen for dating determines whether the moment of death or an earlier life stage is dated (e.g. collagen in human teeth does not change, so the formation of teeth is dated) ▪ it is necessary to know from which reservoir the organism obtained carbon. If the carbon does not come from the atmosphere, the reservoir effect must be considered and necessary corrections made when calibrating the date to solar years
burnt bone (structural carbonate in the mineral part of the bone)	1.5–3 g	FTIR	moment of organism's burning + age of the fuel used for burning the bone	▪ since structural carbonate is based on carbohydrates and fats, the reservoir effect is almost non-existent ▪ due to the recrystallization of structural carbonate during burning, the dating is minimally affected by external conditions (e.g. fuel) * It is necessary to know what fuel was used (peat, old wood, or branches), as the so-called old wood effect somewhat affects the dating
charred plant remains	4–10 mg	morphological & microscopic analysis	moment of organism's death	▪ dates a very small/precise moment in time
uncharred plant remains	4–10 mg	morphological & microscopic analysis, IRMS	moment of organism's death	▪ dates a very small/precise moment in time
organic residues	10–100 mg	ORA	moment of death of the organism that formed the organic residue + moment of burning for charred residues	▪ it is necessary to know which organism's residues are being dated (e.g. reservoir effect of aquatic organisms) ▪ in recent years, the possibility of component/molecule-specific dating has been added (e.g. compound-specific radiocarbon dating), such as fatty acids deposited in pottery
leather / parchment	50–100 mg	IRMS: $\delta^{13}C$, $\delta^{15}N$, ZooMS	moment of organism's death	▪ it is necessary to know which organism is being dated ▪ it is necessary to know what the leather/parchment has been treated with to exclude external contamination
hair	20–100 mg	ZooMS	moment of hair removal from the carbon cycle	▪ dates a very small/precise moment in time ▪ it is necessary to know which organism is being dated
textiles	20–100 mg	ORA, ZooMS	moment of harvesting/removal of plant/animal fibre used to make the textile	▪ important to know if the textiles have been conserved and with what

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See also: www.archemy.ee

This leaflet has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101079396, and from UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee (grant agreement No. 10063975).
Text Mari Tõrv, English editing Enn Veldi, design Jaana Ratas.