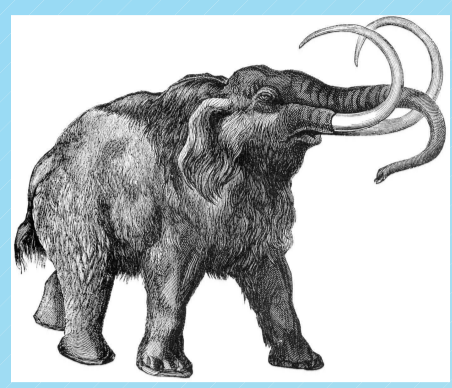


Dating Bones near the limit of the radiocarbon dating method: Study case Mammoth from Niederweningen



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Fig. 1. The reconstruction of mammoth skeleton found in 1891 at Niederweningen, near Zurich (Zoological Museum of Zurich University).

In this study we repeated radiocarbon dating of A/V 4430 bone sample by using preparation method with ultra filtration of gelatin by VivaSpin™, 30kD MWCO filters. This method was proposed by Brown et al. (1988) with the aim of removing contamination by selecting only proteins with molecular weight higher than 30 kD. The preparation included following steps:

- treatment of powdered sample by 0.5M solution of hydrochloric acid in room temperature for several hours (as long as reaction is visible),
- wash by demineralized water and centrifuge,
- collagen extraction using 0.01M solution of HCl in 80°C for 24 hours or longer,
- filtration of molecules greater than 30kD by ultrafilter (VivaSpin™) using centrifuge (4000 rpm, at least 20min),
- freeze dry of the filtrate.

Moreover before preparation each sample was divided into two parts the first part was prepared in the way described above, whereas the second part was additionally treated before step c. by 0.1M solution of NaOH base for about half an hour and then washed by demineralized water. Our intention was to test influence of this additional treatment on the results. After preparation each part of the sample (called fraction UF and BUF) was combusted and converted into graphite. Measurements were done using a new AMS system constructed at the Laboratory for Ion Beam Physics MICADAS (Synal et al., 2007). They were repeated twice in January and March 2008.

Mammoth bones found in 1891 in a peat section at Niederweningen, near Zurich (see Fig. 1), provide excellent material for dating using ¹⁴C method. The bones (sample A/V 4430, ETH-28092) contain sufficient amount of collagen and have been found in peat section that is rich in wood fragments which can be dated for comparison. They were dated in years 2003–2005, but the results showed ages 38000–45000 BP, which were incoherent with the age of peat and wood fragments and clearly depended on a preparation method (Hajdas et al., 2007). The first radiocarbon ages (40910±830 BP and 37910±520 BP) were obtained on organic 'collagen' fraction (COL) prepared by treatment of powdered bones with hydrochloric acid (see Fig.2). These ages differed significantly from the age of peat section, which was dated to about 45000 BP. The following preparation method included pre-cleaning organic fraction using the base step and separation of collagen in the form of gelatin by Longin method (GB fraction). It resulted in age 45870±1080 BP - very close to the age of the peat section. These results suggested that the organic 'collagen' fraction was contaminated by young humic acids, which may migrate with groundwater and attach to porous bone structure.

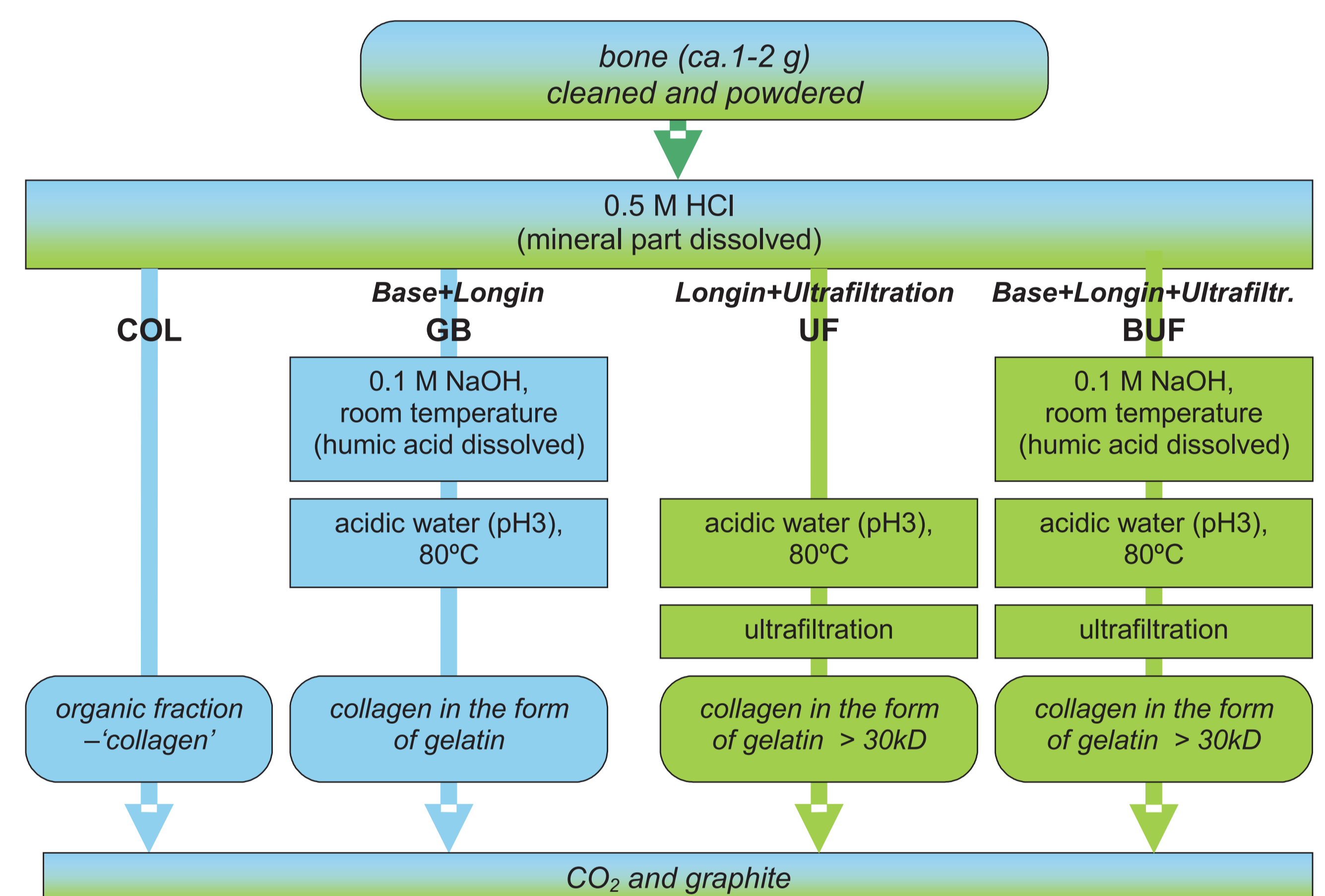


Fig. 2. Schematic diagram of the chemical preparation of the dated bones. Blue colour marks steps of preparation methods applied in previous studies (Hajdas et al. 2007), while green colour indicates steps of methods used in this study.

Table 1. Results of radiocarbon dating obtained for sample A/V 4430 (bone of the mammoth from Niederweningen found in 1891) in previous and present studies.

Sample symbol	Laboratory number	Measurement date	Fraction	Radiocarbon age (BP)	Radiocarbon age - weighted mean (BP)	$\delta^{13}\text{C}$ (per mil)
Previous results						
A/V 4430	ETH-28092	2003	COL	40910 ± 830		-24.2 ± 1.2
		2004	COL	37910 ± 520		-19.8 ± 1.2
		2005	GB	45870 ± 1080		-19.3 ± 1.2
Results from this study						
		Jan 2008	UF	46760 ± 1470	45600 ± 1000	-23.7 ± 1.2
		Mar 2008	UF	44605 ± 1365		-14.9 ± 1.2
		Jan 2008	BUF	46765 ± 1370	45830 ± 1010	-21.5 ± 1.2
		Mar 2008	BUF	44720 ± 1500		-17.9 ± 1.2

Table 2. Results of radiocarbon dating obtained for samples A/V 4500 and A/V 4580 (mammoth bones and teeth found in 2003 about 100m west of the first Niederweningen mammoth pit).

Sample symbol	Laboratory number	Measurement date	Fraction	Radiocarbon age (BP)	Radiocarbon age - weighted mean (BP)	$\delta^{13}\text{C}$ (per mil)
A/V 4500						
A/V 4500	ETH-33630	Jan 2008	UF	39385 ± 615	39240 ± 430	-20.8 ± 1.2
		Jan 2008	BUF	39100 ± 590		-20.9 ± 1.2
A/V 4580						
A/V 4580	ETH-33628	Jan 2008	UF	39990 ± 585	39560 ± 400	-20.9 ± 1.2
		Jan 2008	BUF	39190 ± 540		-20.5 ± 1.2

CONCLUSIONS

- There are not statistically significant differences between radiocarbon ages obtained for parts of samples prepared using ultrafiltration with and without base treatment. Both methods provide good cleaning of prepared collagen.

- The final radiocarbon age of the first mammoth from Niederweningen (sample A/V 4430) calculated in this study is equal **45720 ± 710 BP** and is consistent with the age of the peat section.

- The final radiocarbon age of sample A/V 4580 calculated in this study is equal **39560 ± 400 BP**

whereas the final age of A/V 4500 is equal

39240 ± 430 BP

These results are statistically identical.

The results are presented in Table 1. They show, that radiocarbon ages obtained for samples prepared with ultrafiltration are older than values obtained previously for organic 'collagen' fraction (COL) and similar to the age for GB fraction. It confirms important influence of young humic acids on the radiocarbon dating results for COL fraction. Moreover it was found that there are not statistically significant differences between dating results for parts of sample prepared with and without additional base treatment (UF and BUF). Therefore we may calculate radiocarbon age of sample A/V 4430 as a weighted mean of four individual results obtained in this study (we checked their concordance using χ^2 test) and obtain final radiocarbon age equal to 45720 ± 710 BP. It should be emphasized that this age is consistent with the radiocarbon age of the peat section.

In our study we dated also two another samples of mammoth bone (A/V 4580) and tooth (A/V 4500). These samples were collected from a site excavated in 2003 about 100 m west of the first Niederweningen mammoth site (Furrer et al., 2007). The samples were treated the same way as the sample A/V 4430 but each fraction of those samples (UF and BUF fraction) was measured only one time. The results are presented in Table 2. They confirm that there are no significant differences between radiocarbon ages for UF and BUF fraction.

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