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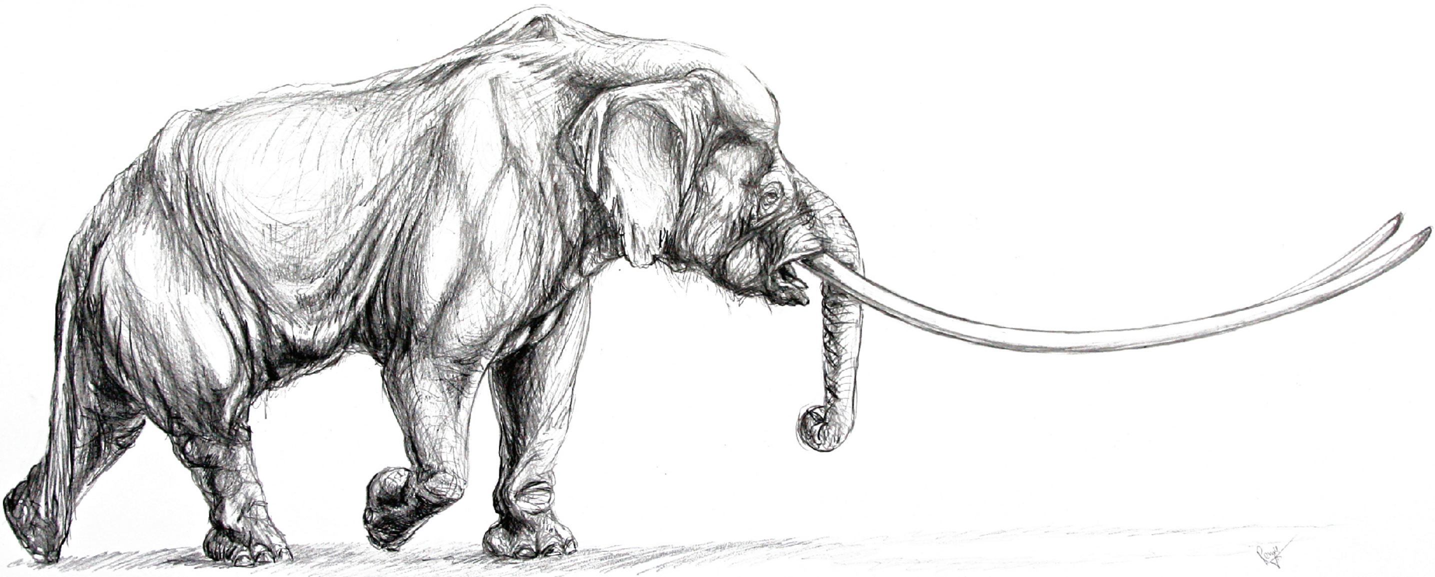

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ABSTRACT BOOK

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Radiocarbon and fossil bones: what's in a date

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The Radiocarbon method was developed around 1950 by W.F. Libby, who received the Nobel Price in chemistry for this important discovery in 1960. The method became the main chronological dating tool for many disciplines. Organic matter such as fossil bones can be directly dated by a physical measurement, rather than by cultural, stratigraphic or other inferences. The method is obviously also of crucial importance for dating mammoth bones. But this is often hampered by the dating range which is limited to roughly 50.000 years ago. The method is also admittedly sensitive to contamination of foreign material. For paleontology, dealing mostly with pre-Holocene bones, both age range and contamination can easily result in problematic dates; methodological problems amplify for dates closer to the dating limit, as well as for degraded sample materials. The result is that the validity of the ^{14}C method for Late Pleistocene samples is often questioned, in cases when the outcome is not what is expected. But whether this is justified is not always clear.

In terms of sample integrity, there are good bones and bad bones; likewise, there are good dates and bad dates. Unfortunately, there is no simple one-to-one correlation between these. The aim of this contribution is to shed some light on the matter, discuss methodological aspects and pitfalls. The datable fraction for bones is the organic collagen. The inorganic bioapatite usually produces only good dates for samples which do not exchange carbon with the environment. In practice this is (not degraded) tooth and tusks. For bone collagen, quality parameters are the content of Carbon and Nitrogen, their C/N ratio, and the stable isotope ratios for ^{13}C and ^{15}N. The parameter values are derived from fresh and pristine bone.

Bone chemistry and contamination are a main issue. Collagen preparation follows similar procedures in the ^{14}C laboratories. Recently, additional purification (the so-called ultrafiltration) was introduced, with the purpose of removing contaminants not removed by the standard chemical protocols. Not all laboratories use this method, because their effectiveness can be questioned. This is hotly debated, in particular concerning Palaeolithic human bones (modern humans and Neanderthals). Problematic young dates became older after applying filters, making archaeologists happy, justified or not. On the other hand, inter-laboratory tests (with and without filters) show that good quality bones usually yield similar dates, within error. Backgrounds is another key issue. The "blanks" of the laboratory are usually determined by measuring samples of infinite age. Traditionally this is anthracite, which is of geological age and thus infinite for the ^{14}C method. Nevertheless ^{14}C counts will be registered; they are there because the sample treatment can not be made completely 100% ^{14}C-free. These "noise registrations" determine the blank or background and correspond to ^{14}C ages of about 50.000 BP. Anthracite works fine for the majority of samples in the practice of ^{14}C dating: botanical samples. But also for old bone? Infinitely old charcoal is not the same as infinitely old bone, the latter being the ideal blank. For the Groningen laboratory, bones known to be much older than the ^{14}C range measure 45.000 BP which then is the background for bones, whereas the background for charcoal is 50.000 BP. The consequence: a bone can yield a date of 47.000 BP when charcoal is taken as the blank, while in reality it is older than 45.000 BP (thus can also be, for example, 100.000). Why not take infinitely old bone as background? This does not help, because this requires good quality old bones (for example from the permafrost). And this is not a good blank for bones preserved under completely different conditions, like on the bottom of the North Sea.

A similar issue is known for fossil shells, creating complications

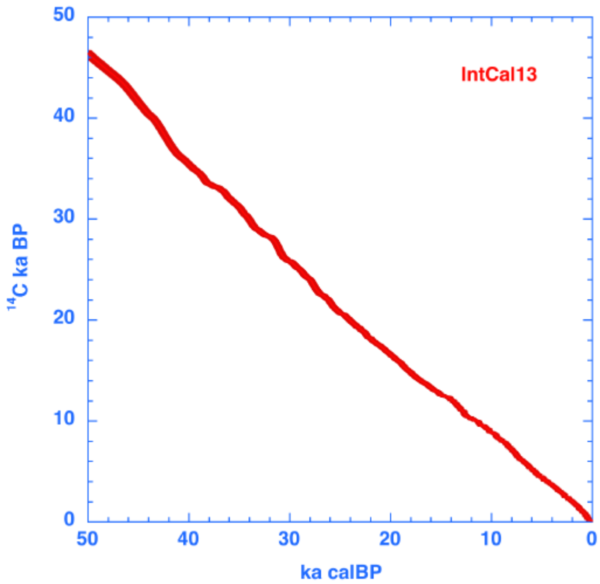

Fig. 1. The Radiocarbon calibration curve Intcal13.

and confusion on dating issues from the marine environment. This is the case for the North Sea, obviously a marine environment today, but a dry area during the last ice age. It was part of the mammoth steppe at the time, so that many faunal remains (predominantly mammoth and rhinoceros) are recovered today. Carbon exchange easily causes ^{14}C dates of 35.000 BP for infinitely old shells, depending on the shell species. Therefore, comparing ^{14}C dates for shells and fauna is a classic case of comparing apples and oranges for the oldest part of the ^{14}C dating range.

At present, all ^{14}C laboratories participate in a cross-check program known as SIRI (Sixth International Radiocarbon Intercomparison). This is expected to shed light on some of the issues raised above. A final chronological issue for dates towards the end of the ^{14}C range is calibration. The natural ^{14}C content is varying through time, which causes the ^{14}C timescale to be different from the real calendar. Beyond the Holocene, this difference can be several millennia. We know this because of calibration: the comparison of ^{14}C dates with independent dates for the same sample. The classic method for this is tree-ring analysis: wood dated by both dendrochronology and ^{14}C. But this stops beyond the Glacial/Holocene boundary.

During recent years, however, remarkable progress has been made, resulting in a newly developed calibration curve for the complete 50.000 years. It is based on mainly laminated sediments containing ^{14}C datable samples. The curve is called IntCal13, and is approved by the ^{14}C community for general use (Reimer et al., 2013). The calibration curve is shown in the figure above. The vertical axis shows the ^{14}C ages (in thousands of BP), the horizontal axis the calendar ages (in thousands of years calBP, i.e. relative to 1950 AD).

Reference

Reimer R.J. et al., 2013. IntCal13 and Marine13 Radiocarbon age calibration curves 0-50,000 years cal BP. Radiocarbon 55, 1869-1887.

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