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ABSTRACT BOOK

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Contamination study: a possibly Holocene mammoth tooth appears to be from just another old mammoth

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As part of a larger research project, fourteen mammoth molars from the Naturalis Biodiversity Center collection (Leiden, Netherlands) were radiocarbon dated at the Centre for Isotope Research (Groningen University, Netherlands). These molars were all collected from the North Sea near the Dutch west coast. Thirteen molars yielded ¹⁴C dates between 30 and >45 ka BP, which was within the expected age range for fossils from the North Sea. However, the fourteenth specimen [registration number RGM.338276] dated to 9,005±45 BP (GrA-50857). In the literature, the youngest dates from Western Europe are around 12,000 BP (Stuart et al., 2002). If correct, RGM.338276 would have been the youngest woolly mammoth ever discovered in Western Europe. In such cases a closer investigation is required.

Due to its peculiar Holocene ¹⁴C age the molar was thus redated and geochemically investigated to test two hypotheses: (1) the 9005 \pm 45 BP (uncal.) date is correct or (2) the ¹⁴C age is too young and resulted from post mortem contamination of the tooth with young carbon, due to either diagenetic processes and/or contamination with allochtonous carbon.

In order to remove any preservatives, new molar samples were subjected to an acetone ultrasonic bath and the so-called soxhlet procedure. The extracted collagen was re-dated to 18,750±70 BP and 21,650±90 BP, respectively. Clearly younger carbon has been removed by both pretreatment procedures resulting in Late Pleistocene ages.

Phosphate oxygen isotope composition ($\delta^{18}O_{PO4}$) of the enamel was analysed to determine whether the mammoth ingested drinking water during interglacial (i.e. Holocene) or glacial periods. These results were then compared to the values obtained from a mammoth molar dated to 42,690 +550/-470 BP from the same locality. The $\delta^{18}O_{PO4}$ values are around 16‰ for both bulk and serial sampled enamel of the RGM.338276 tooth. This is also the case for a 42,690 +550/-470 BP-old mammoth molar. In very general terms, one can argue that these ¹⁸O values show similar climatic regimes for both specimens, the 42.7 kBP and the 21.7 kBP. The temporal resolution of both calibration of ¹⁴C dates and the rapid climate changes (D/O events) during the glacial however make firm conclusions impossible.

In situ elemental analysis using XRF was performed on both enamel and dentine of the molar to investigate the degree of diagenetic alteration. These results were compared to XRF data of teeth from four other woolly mammoths from the North Sea, a modern, diagenetically unaltered, Asian elephant and a ± 1 Mya-old *Stegodon trigonocephalus* from Java as an outgroup. According to statistical PCA analysis of the dentine XRF data the RGM.338276 specimen is slightly closer to the modern Asian elephant in comparison to the other woolly mammoths and *Stegodon*. Thus no exceptionally intense diagenesis could be detected for this molar which could account as cause for the >10ka offset of the radiocarbon date. However, contamination by young carbon from preservatives remains a possibility.

All analyses combined did not provide a well-supported date for this molar. It is possible that the soxhlet procedure did not remove all contaminating organic carbon. Therefore, bioapatite ¹⁴C-dating and applying ultrafiltration during collagen extraction will be applied in the near future to test this.

References

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