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Amalthea: A Database of Isotopic Measurements on Archaeological and Forensic Tooth Dentine Increments

DATA PAPER

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ABSTRACT

Amalthea is a global database of stable isotope measurements on tooth increments from archaeological and modern individuals spanning more than 7,000 years. The dataset includes c. 15,000 isotopic measurements from more than 700 individuals. In addition to isotopic data the database also includes information on the archaeological context and osteological features of recorded individuals. This database allows for the reconstruction of individual iso-biographies. In particular, the database allows for meta-studies on childhood diet and nutrition across time and space. The database is a collaborative effort and will be regularly updated.

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KEYWORDS:
Tooth Sections; Dentine Collagen; Carbon and Nitrogen Stable Isotopes; Childhood Diet and Physiology

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(1) OVERVIEW

CONTEXT

Amalthea is a global database of carbon and nitrogen stable isotope measurements on human tooth dentine sections previously reported in archaeological and forensic scientific publications. The database is made available via Hebe, a data repository for the study of past human childhood (*https://pandoradata.earth/organization/hebe-data-repository-for-the-study-of-past-childhood*). Hebe is itself integrated within the Pandora and IsoMemo Big Data initiatives.

Stable isotope analysis has now been employed for more than four decades to the reconstruction of past human diets and nutritional status [1, 2]. A relatively recent development has been the measurement of stable isotopes on tooth sections allowing for a high-temporal reconstruction of human diets within the formation period of different teeth [3]. This makes this technique particularly relevant for the study of past childhood diets and nutrition, allowing for the reconstruction of infant feeding practices and the timing of breastfeeding and weaning [4]. Malnutrition and metabolic imbalances are known to impact stable isotope values and their study has also been the subject of previous archaeological research [5]. Given the higher temporal resolution achievable using isotopic measurements on tooth sections, the method has been employed to investigate historical famines [6, 7].

The temporal reconstruction of diet and nutritional status using isotopic measurements on tooth sections is made possible since tooth dentine retains the isotopic signature of its formation [8] whereas other skeletal tissues may undergo remodelling [9]. The approximate tooth dentine growth rates are also known (4–8μm per day [10]) making it possible to approximately associate a temporal interval within the lifetime of an individual to each sampled tooth section, although some limitations may apply [11]. Improvements in sampling methods and the reduction of the amount of sample necessary for stable isotope analyses have permitted the achievement of temporal resolutions of only a few months [7]. Human tooth sectioning for stable isotope analysis began in 2003 [12] and the method for higher-resolution sampling was established in 2011 [13] and later on subject to further technical improvements [3, 14, 15, 16, 17]. Given the research potential of the technique, there has been a growing number of scientific publications in which its use is reported, especially during the last three years (***Figure 1***).

SPATIAL COVERAGE

The dataset has a global coverage with site distribution shown in ***Figure 2***.

TEMPORAL COVERAGE

The dataset has a temporal range from 5600 B.C.E. to 2020 C.E. (***Figure 3***).

(2) METHODS

STEPS

We made a global collection of previously published carbon and nitrogen stable isotope measurements ($\delta^{13}C$ and $\delta^{15}N$) on tooth sections. We included all $\delta^{13}C$ and $\delta^{15}N$ measurements on dentine sections, regardless of the number of measured sections and their thickness. Data retrieved from collected publications also included information on the osteological description of the sampled individuals, archaeological contexts, tooth

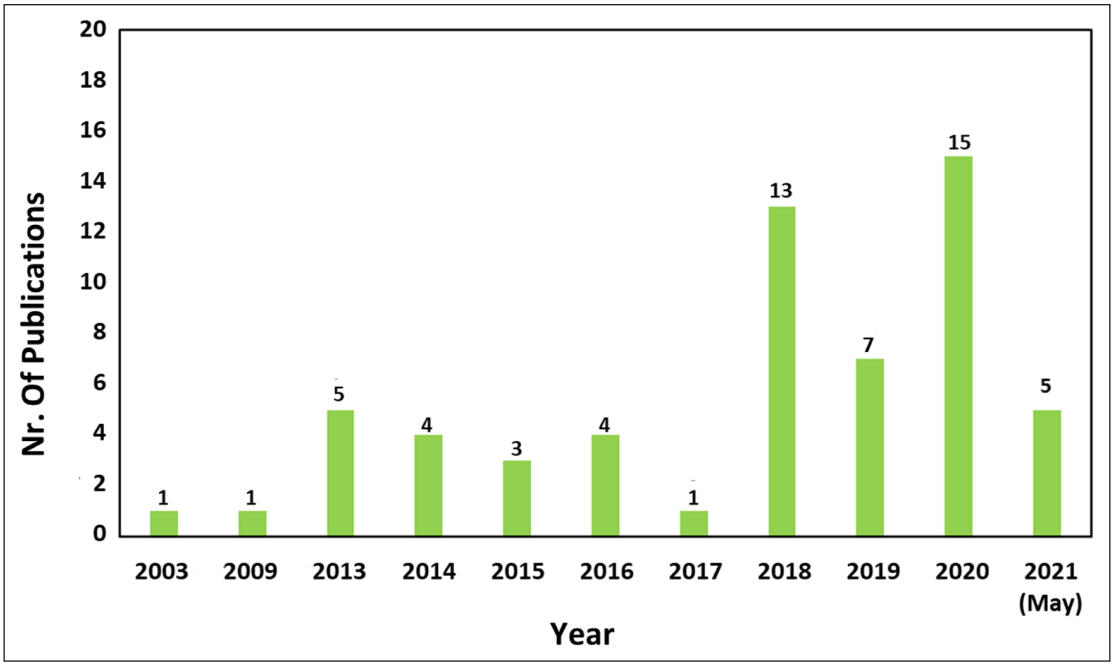

Figure 1 Number of publications by year on isotopic analysis of tooth increments.

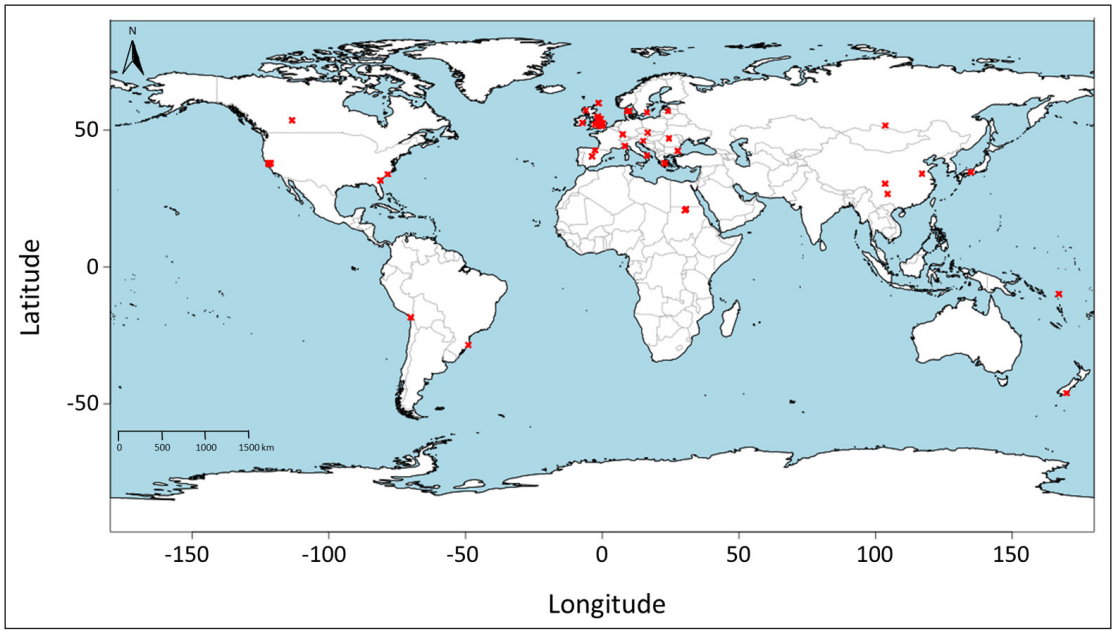

Figure 2 Spatial distribution of sites reported in data sources for isotopic analyses of tooth increments.

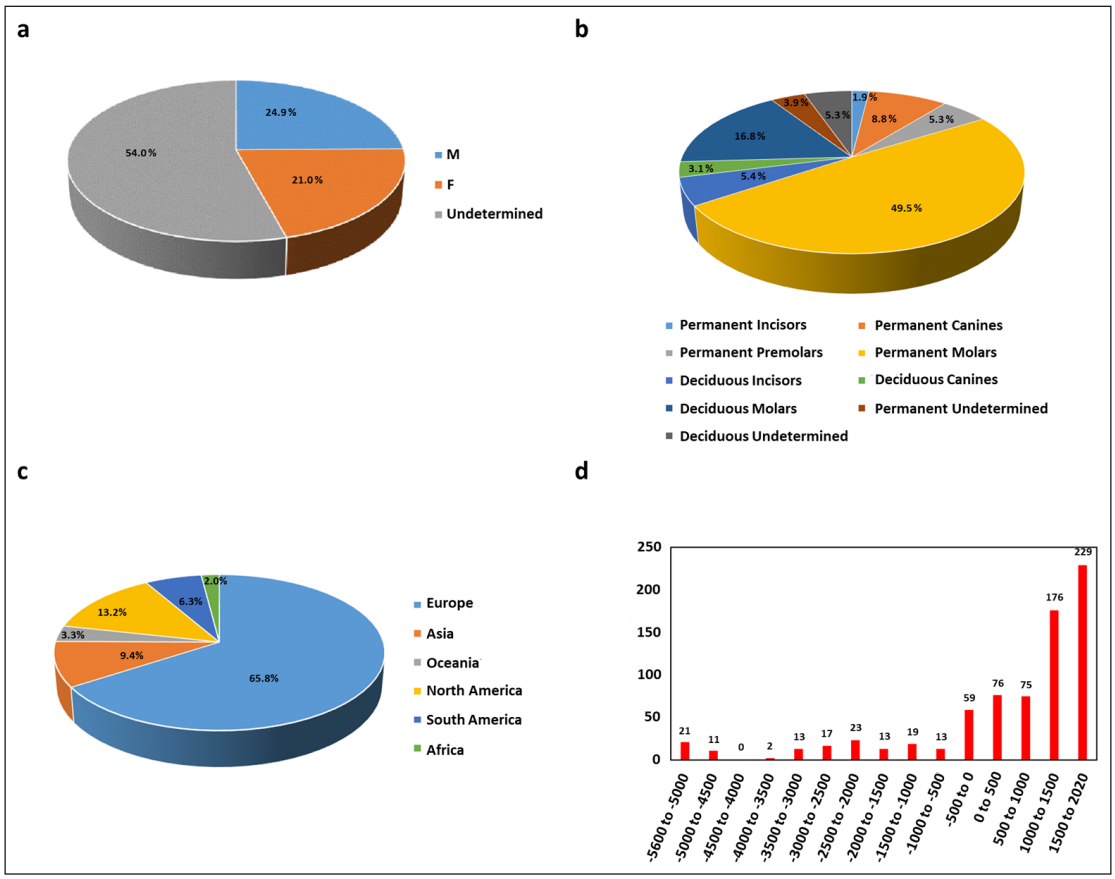

Figure 3 Summary statistics for Amalthea dataset. **a)** Identified sex through osteological analysis; **b)** type of tooth; **c)** geographical distribution of investigated sites; **d)** distribution of chronology for investigated sites.

sectioning methods, geographical coordinates of the archaeological site and its dating range. Geographical coordinates, whenever not directly reported within publications, were estimated using Google Maps. For the latter we report an uncertainty radius in kilometres.

SAMPLING STRATEGY

Relevant publications were located using the web search engine Google Scholar (search up to May 2021). Different combinations of key words such as "analysis", "dentin/dentine", "human", "increment/incremental", "isotope/

isotopic", "section/sections" were used. We also located any additional relevant data sources following the references given within each collected publication.

QUALITY CONTROL

Among the collected data we included the standard parameters (collagen yield, %C, %N, atomic C/N ratios) for assessment of dentine collagen preservation [18]. In some instances, these were not reported in the original source or their values were outside of the recommended ranges. The latter data entries were still included in the dataset since these can be employed in future studies of tooth diagenesis.

CONSTRAINTS

Our dataset lists measurement results obtained using different tooth sectioning methods which is reflected on the variety of reported tooth thicknesses and temporal resolutions. Moreover, in several cases the entire tooth was not sectioned and, for older individuals, it is not clear whether secondary dentine forming in a later period was removed. In addition, sample typology and position affects the incremental age assignation, due to different formation periods, and imprecise tooth determinations in either sampling or publication can be another potential constraint. This limits to an extent the research potential although recent modelling developments allow for a larger inter-comparability of dietary histories obtained from isotopic results obtained through different sectioning methods [4].

Another constraint is the sampling distribution of our dataset. Although global in reach (***Figure 2***), most of the isotopic research on tooth sections has been reported for Europe (***Figure 3***). As new isotopic data on tooth sections becomes available we will add this to our datasets. We also welcomed direct contributions from other researchers.

(3) DATASET DESCRIPTION

Amalthea consists of a single spreadsheet file (Amalthea.xlxs) and a bibliography (Amalthea-bibliography.docx) deposited at the data platform of the Pandora initiative (*https://pandoradata.earth/*) within the Hebe repository (*https://pandoradata.earth/organization/hebe-data-repository-for-the-study-of-past-childhood*). The spreadsheet file consists of columns representing the different metadata categories (see below). Each row represents a tooth increment for which $\delta^{13}C$ and $\delta^{15}N$ measurements were reported.

We collected data from 58 publications for a total of 746 individuals, 886 different teeth, 7,997 increments, and 15,994 isotopic measurements. A summary description of the datasets for tooth typology, sex of the sampled individuals (determined through osteological analysis), and spatial and temporal coverage is shown in ***Figure 3***.

The fields of the Amalthea database are organized into thematic units described below.

DATA IDENTIFIERS

Each row within Amalthea has a unique identifier which follows an integer sequence. This identified each tooth increment within the database (Entry ID). In addition, there are identifiers to identify each individual (Database Individual ID) to which the tooth increment corresponds and each analysed tooth for an individual (Database Tooth ID). The data submitter is also identified (Submitter ID) and a field for additional comments is also available (Comments).

BIBLIOGRAPHY

Each data source is cited using the Harvard citation style (Reference). Whenever available, a link to the source (Link) and a digital object identifier (DOI) are given. Also included is the year of publication (Publication Date). We expect that future data additions to Amalthea may include contributions from other researchers. Respective data files can be assigned individual DOIs prior to the inclusion of the new data into the Amalthea master file. Thus within this master file we also included fields for references (Reference compilation) and DOIs (DOI compilation) to previous compilations.

SITE DESCRIPTION

Several fields are employed to describe the site and its geographical location from which the tooth material is reported to have originated (Continent; Modern Country; Site Name; Site Description). Geographical coordinates (Latitude, Longitude) are reported using decimal GPS coordinates. A database field is used to establish if an exact site location is reported in the original data source (Exact Site Location?). If not, a radius of uncertainty (unc. Radius (km)) in kilometres is given.

DESCRIPTION OF INDIVIDUAL

Most of the collected data is from skeletal remains recovered during archaeological excavations which typically would have been subject to osteological analysis. We report the original skeleton identified as given in the original data sources (Individual ID) plus the biological sex (Sex) and a numeric range for age at death (Min. Age Individual (Years); Max. Age Individual in (Years)). When available, other contextual information such as the socioeconomic status (Social Status), likely religion (Religion), and cultural assignment (Culture) are given.

CHRONOLOGY

A numeric CE/BCE date range (Min. Year (CE); Max. Year(CE)) is given for each individual. Negative values are used for BCE dates. Whenever direct dating of skeletal material is available this is reported (e.g. from biographical written sources or by radiocarbon dating). If this is not available,

the known range for the site's chronology is given instead. The type of employed dating is also reported (Dating Method). Whenever radiocarbon dates are employed, and if reported in original publication, we reported radiocarbon lab code (14C lab code), uncalibrated mean value for date (Uncalibrated ^{14}C (BP)) plus its standard deviation (Uncalibrated ^{14}C (BP) Unc.). Traditional historical periods tags are also given (Historical Period).

SAMPLING METHODS

We describe the sample typology, specifying whether the sample is a deciduous/permanent and/or mandibular/maxillary tooth (Tooth Type). Also reported is if a tooth was found fully formed and preserved (Tooth Completeness) and the number of isotopic analyses made on each tooth (Nr. of Analysed Tooth Samples). The latter can differ from the number of original tooth sections since some may have been combined to provide enough collagen for an isotopic measurement.

Bibliographic references are given for the sectioning protocol (Sectioning Methodology (Reference)), the method used for age assignment (Age Estimation Methodology (Reference)), and tooth growth rate (Assumed Growing Rate (References)).

DESCRIPTION OF INCREMENTS

We report the increment identifier as given in the original data source (Incremental ID) and, if available, which ages are assigned to each (Reported Min. Increment Age (Years); Reported Max. Increment Age (Years); Reported Median Increment Age (Years)). We also report data relative to the thickness of the increment (Median Section Thickness (mm); Interval Range Section Thickness (mm)).

STABLE ISOTOPE AND ELEMENTAL MEASUREMENTS

For each dentine increment(s) the measurement result of carbon ($\delta^{13}C$ Collagen; $\delta^{13}C$ Collagen unc.) and nitrogen ($\delta^{15}N$ Collagen; $\delta^{15}N$ Collagen unc.) stable isotope ratios plus respective uncertainties are given. Also reported are the results for the indicators of collagen preservation, i.e. collagen yield (Collagen yield), percentage of elemental carbon (%C), percentage of elemental nitrogen (%N) and the carbon to nitrogen atomic ratio (Atomic C:N Ratio). The laboratory where the measurements were carried out is also identified (Lab).

OBJECT NAME

Amalthea dataset 29.05.2021; Amalthea Bibliography 29.05.2021.

DATA TYPE

Secondary data

FORMAT NAMES AND VERSIONS

.xlsx; .docx.

CREATION DATES

Records created from June 2020 to May 2021.

DATASET CREATORS

Ricardo Fernandes was responsible for the metadata structure while Carlo Cocozza collected the data.

LANGUAGE

English.

LICENSE

Creative Commons Attribution-ShareAlike.

REPOSITORY LOCATION

https://www.doi.org/10.48493/sak5-9487

PUBLICATION DATE

First publication date: 05.03.2021. Current version publication date: 29.05.2021.

(4) REUSE POTENTIAL

The data collected within the Amalthea database can be employed to reconstruct individual dietary histories and is particularly useful for the study of past children's diets and nutrition. Given that each tooth can be set in a formation period interval, the combination of different teeth such as the three permanent molars potentially allow the reconstruction of dietary inputs from birth to early adulthood. Some limitations still exist as concerning the age assignation of increments and alignment of different teeth, but new modelling techniques are being employed to address such issues [4, 11]. Our dataset can be used to carry out meta-analyses that compare children feeding practices across time and space and within varied cultural contexts. The data can also be combined with other existing isotopic datasets to compare, for instance, dietary differences among children and adults.

Our aim is to continuously update Amalthea as new relevant data is released. The database aims at being a collaborative research effort within the spirit of the Pandora communities and it welcomes new data submissions to the Hebe repository (*https://pandoradata.earth/organization/hebe-data-repository-for-the-study-of-past-childhood*). Individual data contributions can be deposited at Hebe and assigned a DOI so that data collection efforts are easily recognized. Individual datasets are combined in the Amalthea master file which also includes references to previous compilations.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

1. **Schoeninger, MJ** and **Moore, K** 1992 Bone stable isotope studies in archaeology. *Journal of World Prehistory*, 6: 247–296. DOI: *https://doi.org/10.1007/BF00975551*
2. **Lee-Thorp, JA** 2008 On isotopes and old bones. *Archaeometry*, 50: 925–950. DOI: *https://doi.org/10.1111/j.1475-4754.2008.00441.x*
3. **Beaumont, J, Gledhill, A, Lee-Thorp, J** and **Montgomery, J** 2013 Childhood diet: A closer examination of the evidence from dental tissues using stable isotope analysis of incremental human dentine. *Archaeometry*, 55: 277–295. DOI: *https://doi.org/10.1111/j.1475-4754.2012.00682.x*
4. **Cocozza, C, Fernandes, R, Ughi, A, Groß, M** and **Alexander, MM** 2021 Investigating infant feeding strategies at Roman Bainesse through Bayesian modelling of incremental dentine isotopic data. *International Journal of Osteoarchaeology*. DOI: *https://doi.org/10.1002/oa.2962*
5. **D'Ortenzio, L, Brickley, M, Schwarcz, H** and **Prowse, T** 2015 You are not what you eat during physiological stress: Isotopic evaluation of human hair. *American Journal of Physical Anthropology*, 157: 374–388. DOI: *https://doi.org/10.1002/ajpa.22722*
6. **Beaumont, J** and **Montgomery, J** 2016 The Great Irish Famine: Identifying Starvation in the Tissues of Victims Using Stable Isotope Analysis of Bone and Incremental Dentine Collagen. *PLoS ONE*, 11: e0160065. DOI: *https://doi.org/10.1371/journal.pone.0160065*
7. **Petersone-Gordina, E, Montgomery, J, Millard, AR, Roberts, C, Gröcke, DR** and **Gerhards, G** 2020 Investigating the dietary life histories and mobility of children buried in St Gertrude Church cemetery, Riga, Latvia, 15th–17th centuries AD. *Archaeometry*, 62: 3–18. DOI: *https://doi.org/10.1111/arcm.12520*
8. **Alqahtani, SJ, Hector, MP** and **Liversidge, HM** 2010 Brief communication: The London atlas of human tooth development and eruption. *American Journal of Physical Anthropology*, 142: 481–490. DOI: *https://doi.org/10.1002/ajpa.21258*
9. **Hedges, REM, Clement, JG, David, C, Thomas, L** and **O'Connell, TC** 2007 Collagen turnover in the adult femoral midšhaft: Modeled from anthropogenic radiocarbon tracer measurements. *American Journal of Physical Anthropology*, 133: 808–816. DOI: *https://doi.org/10.1002/ajpa.20598*
10. **Kawasaki, K, Tanaka, S** and **Ishikawa, T** 1979 On the daily incremental lines in human dentine. *Archives of Oral Biology*, 24: 939–943. DOI: *https://doi.org/10.1016/0003-9969(79)90221-8*
11. **Tsutaya, T** 2020 Blurred time resolution of tooth dentin serial sections. *American Journal of Physical Anthropology*, 173: 748–759. DOI: *https://doi.org/10.1002/ajpa.24113*
12. **Fuller, BT, Richards, MP** and **Mays, SA** 2003 Stable carbon and nitrogen isotope variations in tooth dentine serial sections from Wharram Percy. *Journal of Archaeological Science*, 30: 1673–1684. DOI: *https://doi.org/10.1016/S0305-4403(03)00073-6*
13. **Eerkens, JW, Berget, AG** and **Bartelink, EJ** 2011 Estimating weaning and early childhood diet from serial micro-samples of dentin collagen. *Journal of Archaeological Science*, 38: 3101–3111. DOI: *https://doi.org/10.1016/j.jas.2011.07.010*
14. **Burt, NM** and **Garvie-Lok, S** 2013 A new method of dentine microsampling of deciduous teeth for stable isotope ratio analysis. *Journal of Archaeological Science*, 40: 3854–3864. DOI: *https://doi.org/10.1016/j.jas.2013.05.022*
15. **Henderson, RC, Lee-Thorp, J** and **Loe, L** 2014 Early Life Histories of the London Poor Using d13C and d15N Stable Isotope Incremental Dentine Sampling. *American Journal of Physical Anthropology*, 154: 585–593. DOI: *https://doi.org/10.1002/ajpa.22554*
16. **Czermak, A, Schermelleh, L** and **Lee-Thorp, J** 2018 Imaging-assisted time-resolved dentine sampling to track weaning histories. *International Journal of Osteoarchaeology*, 28: 535–541. DOI: *https://doi.org/10.1002/oa.2697*
17. **Czermak, A, Fernández-Crespo, T, Ditchfield, PW** and **Lee-Thorpe, J** 2020 A guide for an anatomically sensitive dentine microsampling and age-alignment approach for human teeth isotopic sequences. *American Journal of Physical Anthropology*, 173: 776–783. DOI: *https://doi.org/10.1002/ajpa.24126*
18. **Van Klinken, GJ** 1999 Bone collagen quality indicators for palaeodietary and radiocarbon measurements. *Journal of Archaeological Science*, 26: 687–695. DOI: *https://doi.org/10.1006/jasc.1998.0385*

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