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An Annotated Compilation of Chronometric Dates for the Middle-Upper Palaeolithic Transition (45-30 ka BP) in Northern Iberia (Spain)

DATA PAPER

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ABSTRACT

The dataset described in this paper presents an annotated compilation of absolute dates obtained from archaeological sites located in northern Iberia corresponding broadly to the Cantabrian region (Spain). It consists mainly of radiocarbon dates chronologically framed between 45–30 ka BP. This is the period when the last Neanderthals disappeared and the first Anatomically Modern Humans dispersed into northern Iberia, widely considered a key region for understanding the patterns and processes of this transition. Providing chronological information as well as serving as palaeodemographic proxies, this novel compilation facilitates new analyses of this key period. The dataset contains 224 dates from 37 archaeological sites and more than 87% of the dates included have been positively assessed for use. It is available at Github and linked to Zenodo with the aim to ensure accessibility, reproducibility and continued extension.

(1) OVERVIEW

CONTEXT

Between ~50–35 ka cal BP years ago, Neanderthals were replaced by Anatomically Modern Humans (AMH) [1], [2], which is seen in the disappearance of Neanderthal remains from the fossil record and their associated material culture [3]. The extinction of Neanderthals [3], [4] coincided with the arrival of AMHs and a temporally and spatially varying overlap between these two human species took place during this period [5]. The Cantabrian region of the Iberian Peninsula contains one of the richest archaeological records on the presence of late Neanderthals and early AMHs.

Recently, a variety of archaeological studies have developed and implemented statistical techniques based on radiometric data [6]. Such dates-as-data (DAD) approaches are founded on the assumption that changes in the frequency of radiocarbon dating are associated with anthropogenic events and thus act as proxies that can be applied to the analysis of relative change in past populations [7]. These approaches are used to shed light on the extinction of Neanderthals in key occupational areas such as the Cantabrian region.

To apply DAD approaches, it is necessary to have a corpus of dates that is, ideally, both large in size and robust in quality – especially for periods close to the limits of radiocarbon dating. There are repositories that pool existing dates [8, 9], but they are designed to meet the requirements of large-scale diachronic analyses or studies of very broad cultural or temporal processes. Since these analyses usually encompass large datasets, minor inaccuracies in single dates and a heterogeneous quality of the chronological data may be negligible. When focussing on smaller regions or shorter time intervals, however, the reduced size of the datasets increases the analyses' sensitivity to erroneous entries and chronological data with poor quality. Analyses on smaller scales therefore require diligent revision and curation of each individual date to produce reliable results. With that in mind, we here present a duly curated dataset of chronometric dates from sites inhabited by Neanderthals and AMHs from 45–30 ka uncalibrated BP in the Cantabrian region.

Spatial coverage

Description: The curated dataset covers the region of Northern Iberia (Figure 1, Table 1). This region has been delimited on the basis of river basins, namely of the Miño River in the east and the Ebro river in the west, following the HydroSHEDS project [10]. The archaeological sites are located in the current provinces of Álava, Asturias, Cantabria, Guipúzcoa, Lugo, Navarra and Vizcaya. Furthermore, the study area also includes parts of the provinces A Coruña, Burgos, La Rioja, León and Palencia.

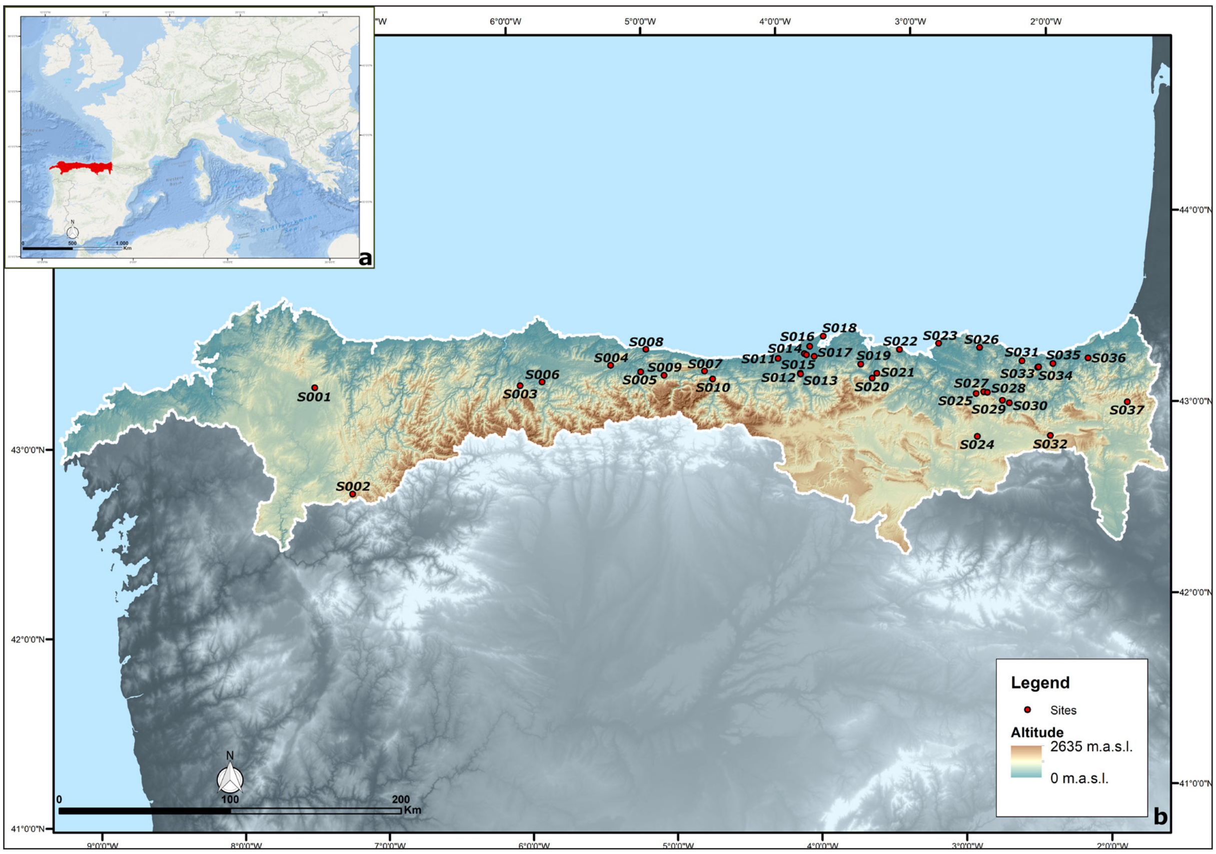

Figure 1 a) Location of the study area in Europe. **b)** Map of the study area with the archaeological sites from which the dates are collected.

SITEID	SITE NAME	NO. OF DATES	NO. OF LAYERS DATED
S001	A Valiña	3	1
S002	Cova Eirós	3	2
S003	El Conde	6	5
S004	El Sidrón	8	1
S005	La Güelga	16	5
S006	La Viña	13	7
S007	Llonin	1	1
S008	Tito Bustillo	4	1*
S009	Sopeña	9	7
S010	El Esquilleu	11	11
S011	Altamira	1	0*
S012	El Castillo	41	7*
S013	La Flecha	1	1**
S014	Covalejos	13	6
S015	El Pendo	6	6
S016	El Ruso	2	2
S017	Cueva Morín	10	6
S018	Arenillas	2	1
S019	Cobrantes	4	2
S020	El Mirón	1	1
S021	Pondra	2	0*
S022	El Cuco	10	6
S023	Kurtzia	1	1
S024	Arrillor	3	2
S025	Axlor	3	2
S026	Antolinako Koba	1	1
S027	Askondo	2	2
S028	Bolinkoba	2	2
S029	Lezetxiki	2	1
S030	Labeko Koba	19	8
S031	Prelaitz	1	1
S032	Mugarduia Sur	1	1
S033	Ekain	4	2
S034	Amalda 1	3	1
S035	Altxerri	2	1
S036	Aitzbitarte III	12	3
S037	Abauntz	1	1

Table 1 Table with information about the sites and dates included in the dataset. (*) Some dates correspond to art panels and therefore are not related to any layer. (**) The layer with which it is associated is unknown.

The coordinates of the study region are provided in World Geodetic System 1984 (WGS84):

Northern boundary: +43.79
Southern boundary: +42.30
Eastern boundary: –1.39
Western boundary: –9.29

Temporal coverage

The temporal span of the dataset presented in this study ranges from 45 ka to 30 ka ago. These are uncalibrated chronometric dates spanning the Middle/Upper Palaeolithic Transition period. In the original publications, the chronometric dates have been attributed to various chronocultural stages, often based on the available archaeological information. The stages are: Mousterian, Châtelperronian, Protoaurignacian, Early Aurignacian, Aurignacian, Evolved Aurignacian and Gravettian.

(2) METHODS

The dataset has been assembled through a review of existing published secondary sources and online datasets. In some cases, the reviewed literature corresponds to studies published many decades ago in volumes that can be difficult to access for researchers outside of the region and includes many papers published in Spanish.

STEPS

The chronometric dates were collected in different steps. First, various existing repositories were sampled [8, 9]. Subsequently, further information was gathered from papers published in scientific journals, monographs and various publications related to the study area and its chronology.

SAMPLING STRATEGY

The sampling strategy aimed at a complete recording of all known chronometric data with uncalibrated ages between 45 and 30 ka BP from the area of interest, published until May 2023. To this end, all available repositories and publications were systematically surveyed starting with the latest publications and working backwards towards the earliest to ensure maximum coverage and the possibilities to compare entries, e.g., regarding copying errors in laboratory numbers or transposed digits. We have chosen this time range, 45–30 ka BP, because it best suited the issues we seek to address. It is based on the disappearance of Neanderthals and the arrival of AMHs in Northern Iberia, marking the temporal period during which both species coexisted in the same territory. This chosen extent of the chronological window is vital for maintaining a temporal balance between the populations in the study area and therefore, it directly impacts the analysis results. Expanding the time boundaries could lead to an overrepresentation of one population over the other. Consequently, we decided that this timeframe maintains this balance. Additionally, we opted to base our selection on uncalibrated dates, as calibrated dates may vary depending on the calibration curve and method used. These methodological decisions are essential for understanding population dynamics and interactions between both populations in the temporal context addressed in this study, ultimately exerting a direct impact on the results.

QUALITY CONTROL

Despite recent advances, radiocarbon dating of organic material older than 50 thousand years remains challenging [11–13]. Also, dates obtained on samples coming from old excavations with unclear contexts are to be treated with due caution [6, 14]. To mitigate these source-critical factors, we have performed an exhaustive review of all the pertinent dates, selecting only those confidently placed between 45–30 ka uncalibrated BP. The majority of the dataset consists of radiocarbon dates (^{14}C AMS), but dates obtained by other chronometric methods such as Electron Spin Resonance (ESR), Amino Acid Racemisation Dating (AARD), Uranium-series (U-series) or Uranium-Thorium (U-Th) have been included (Figure 2a). We incorporated all the dates regardless of the method by which they have been obtained so that they are available in the same dataset. Most dates are made on bone (55%) and charcoal (21%) samples, followed by tooth (8%) and antler (3%) samples (Figure 2b). We have included available chronometric dates regardless of their individual standard deviations. Previous studies have recommended that standard deviation should not exceed 300 years in order to, for instance, obtain reliable summed probability distributions (SPDs) following calibration [15]. However, given the temporal scope of this dataset at the fringe of the radiocarbon method, standard deviations regularly exceed this number. Notably, a standard deviation of 400 years, for instance, merely represents only 1% of a measured age of 40.000 years.

The criteria of Pettitt et al. [14] have been applied in order to evaluate and score all radiocarbon dates. If each sample is evaluated by each of these criteria and scored accordingly, a total score of between 0 and 36 can be obtained. The evaluation criteria are divided into (technical) chronometry and (contextual) interpretation (see Table 2). Regarding chronometry, the following criteria are analysed: contamination by older/younger carbon and measurement of irrelevant carbon fractions, ^{14}C dating of different chemical fractions, accuracy, sample materials and ^{14}C measurement, sample measurement and reporting. In terms of interpretation, the following criteria are assessed: certainty of association of dated sample with human activity, relevance of dated sample to specific archaeological entity of concern, quantity and nature of dates for archaeological horizon, sample materials and stratigraphic issues. Pettitt et al. [14] suggest that samples scoring 27 or above can be considered reliable enough to use in modelling without further question. By the same token, those with scores of 9 or less should be rejected as highly unreliable. Those with scores from 10–26 should be accepted with a degree of caution and ideally modelling should occur both including and excluding dates that fall into this range.

Evaluating the association of dated samples with human activities can be a complex and often uncertain process. One of the key variables in Pettitt et al.'s workflow is the 'Certainty of association of dated sample with human activity.' In the present study, we meticulously reviewed each dated sample, considering the available archaeological evidence. This includes the presence of artefacts, structures and other indicators of human activity within the context of the archaeological site. Our interpretation influenced the assignment of scores and in cases where the association was ambiguous or there was uncertainty, a lower score was assigned. Additionally, we contextualised the association of the sample with human activity using existing publications and other datasets related to the specific sites in question. We want to emphasise here that our decisions

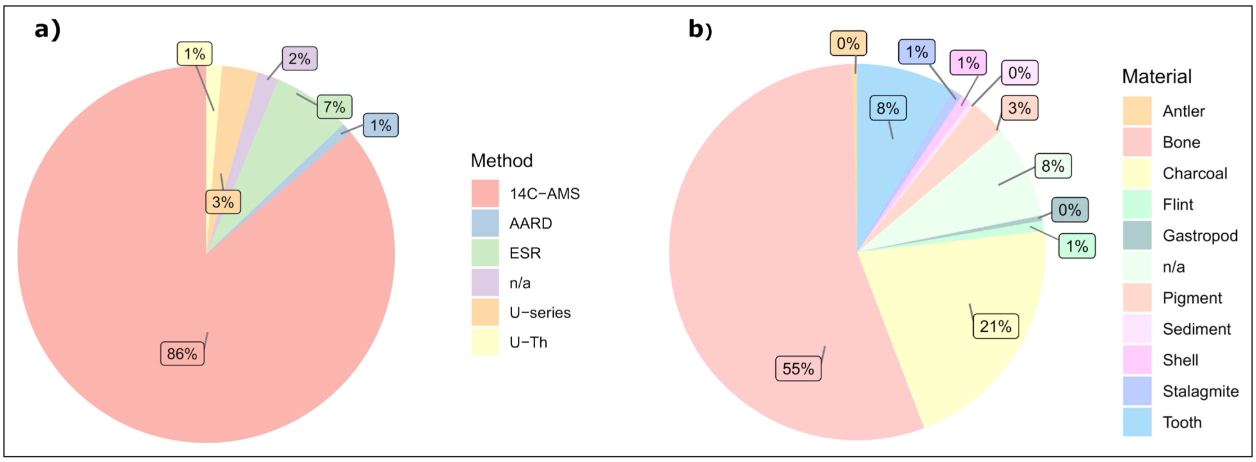

Figure 2 a) Percentage of chronometric methods in the dataset. **b)** Percentage of materials dated.

CHRONOMETRY	DESCRIPTION
Contamination by older/younger carbon and measurement of irrelevant carbon fractions	The origin of the carbon sample is evaluated. Scoring is based on the following criteria: questionable chemical fraction (0); quantity of carbon too small (1); carbon derived from a complicated sample (2); carbon derived from bone, antler or ivory (3); carbon derived from a specific amino acid which makes it possible to reject the "old age" effect (4).
^{14}C dating of different chemical fractions	The following criteria are evaluated based on the measurement of the samples: measured samples of the same material out of chronological sequence (0); samples of the same material without cross-checking (1); samples of the same material with clear chronological sequence (2); samples measured in at least one pair of charcoal or bone/antler/ivory with the same age (3); more than one sample in several discrete materials with the same age (4).
Accuracy	Accuracy is assessed following these criteria: a single sample dated to >30,000 BP (0); >2 samples dated to >30,000 BP and with a chronological sequence with outliers (1); >2 samples of >30,000 BP and with a sequence with few outliers (2); samples with <30,000 BP falling into a chronological sequence with few outliers (3); samples with <20,000 BP and with a clear sequence (4).
Sample materials and ^{14}C measurement	Sample materials and ^{14}C measurement are evaluated against the following criteria: sample overestimation cannot be ruled out (0); carbon measured from a problematic chemical fraction (1); relatively low collagen/cellulose yield and/or carbon yield (2); sample from collagen/cellulose with no pre-treatment problems (3); relatively low collagen/cellulose yield and/or carbon yield and same age as other samples from the same stratigraphic horizon (4).
Sample measurement and reporting	The sample measurement and reporting is assessed as follows: sample was created from a bulked sample or measured conventionally before 1970 (0); sample was pre-treated or measured at a laboratory that does not participate in International Radiocarbon Laboratory intercomparisons (1); sample published without pre-treatment/measurement or without laboratory analysis criteria (2); sample published with such data but with criteria outside acceptable limits (3); sample published with satisfy accepted criteria (4).
INTERPRETATION	**DESCRIPTION**
Certainty of association of dated sample with human activity	The association between samples and human activity is scored as follows: low possibility of association (0); reasonable possibility (1); probability of association (2); high possibility of association (3); full certainty (4).
Relevance of dated sample to specific archaeological entity of concern	The relevance of the dated sample is scored as follows: sample material is unknown (0); no existing/published traces of hominin manufacture or modification (1); sample with diagnostic archaeological association (2); sample with high archaeological association (3); sample with cultural association, hominin fossil or clear traces of hominin modification (4).
Quantity and nature of dates for archaeological horizon	The relevance of the dated sample is scored as follows: the sample material is unknown (0); no traces of hominin manufacture or modification are present/not published (1); sample with diagnostic archaeological association (2); sample with high archaeological association (3); sample with cultural association, hominin fossil or clear traces of hominin modification/manufacture (4).
Sample materials and stratigraphic issues	Sample materials and their stratigraphic issues are evaluated as follows: sample is a small fragment (0); sample <10 cm without clear stratigraphic integrity (1); sample <10 cm with high probability of stratigraphic integrity (2); sample >10 cm and clearly stratified within an identifiable feature (3); sample >10 cm associated with comparable items (4).

Table 2 Detailed information on the criteria used by Pettitt et al. [14].

were made following standard archaeological practices and based on the evidence currently available in each specific case. In sum, this methodology allows us to enhance our understanding of the complex population dynamics and human interactions in the past while promoting transparency in archaeological research.

Following our assessment, 75% of dates score between 10–26 and 12% between 27–36. An additional 13% of dates were obtained with methods different from radiocarbon and therefore have not been evaluated in this way; they have been indicated as n/a in this field (Figure 3). The detailed information on the scores attributed to each date has been included in the repository associated with this contribution, together with the dataset.

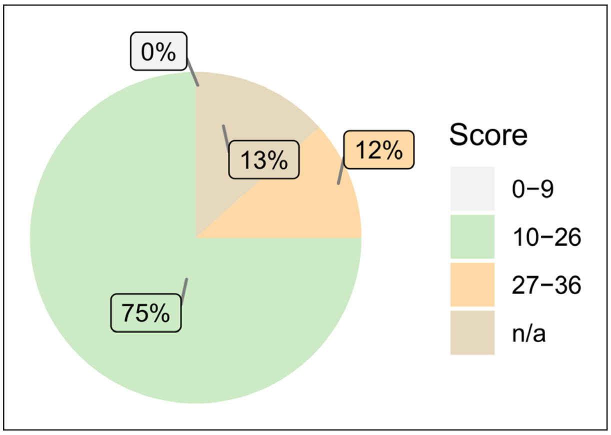

Figure 3 Percentage of grouped dates based on the score attributed.

CONSTRAINTS

Despite our meticulous efforts in scrubbing and scrutinising the dataset, the possibility of residual errors persists. These errors may arise due to the incorporation and comparison of diverse resources or even the ever-present potential for human error. The chronological information gathered for this study originates from an array of distinct sources spanning numerous decades. Consequently, the quality and comprehensiveness of available metadata vary significantly between individual measurements. This inherent variability poses a challenge in establishing a standardised framework for data processing and analysis, necessitating careful consideration.

Moreover, it is worth highlighting a particular limitation associated with charcoal dating methods when dealing with samples older than 50 ka [11–13]. Charcoal exhibits constraints that restrict accurate measurements beyond this temporal threshold. Consequently, in order to ensure the integrity and reliability of our results, we made a decision to impose a time limit of 45 ka during the collection of dating samples to avoid possible errors.

It is crucial to recognise these potential limitations and sources of uncertainty. While we have made considerable strides in minimising errors and enhancing data quality, the inherent complexities of multi-source data integration and the intrinsic limitations of certain dating methods cannot be entirely eliminated. Therefore, in our subsequent analyses and interpretations, we take these factors into careful consideration, heeding the nuances and uncertainties that accompany the temporal aspects of our study.

(3) DATASET DESCRIPTION

The dataset contains a set of six files providing (1) the chronometric dates (dataset_northern_Iberia_dates.csv and dataset_northern_Iberia_dates.xls), (2) two files in different format with the scores of each date (dates_score.csv and dates_score.xls), (3) a file with the list of references (References.txt) and (4) a metadata field description for the repository and the attributes of the chronometric dates (README.md).

OBJECT NAME

dataset_northern_Iberia_dates.csv

This file contains the essential information for each of the collected dates. Each has a unique identifier (*Iddates*) and other archaeological information as described in Table 3.

dates_score.csv

This file contains the individual scores attributed to each of the dated samples based on the criteria proposed by Pettitt et al. [14]. The rows of this file are explained in detail in Table 4.

References.txt

Bibliographical references of each date.

README.md

This file contains basic information about the repository.

DATA TYPE

Secondary data and processed data from originally published materials.

FORMAT NAMES AND VERSIONS

.csv, .xls, .txt, .md.

CREATION DATES

Data information has been created from January 2022 to May 2023. All the existing dates up to the date of submission of the article have been incorporated.

DATASET CREATORS

The corresponding author has been the responsible of gathering the data. All the authors have been involved in the revision and curation of the information compilated.

LANGUAGE

English.

LICENSE

Creative Common License CC-BY 4.0: https://creativecommons.org/licenses/by/4.0/.

DATA ACCESSIBILITY

Following emerging best practices for data accessibility and reproducibility in archaeology, we provide our data in a format that facilitates easy access and utilisation. The data is presented in a clear and understandable manner, ensuring that it can be readily used, converted and reproduced. To ensure proper disclosure, we adhere to a series of basic principles and guidelines outlined in previous works on reproducible research in archaeology [16–18].

In technical terms, the data is available in Zenodo and Github repositories. Github is a web service that contains collaborative tools and allows hosting repositories that can be shared and modified by the authors or contributors of those repositories. Zenodo enables the creation of a DOI that can be cited and give credit to the authors of the repository. The former can be accessed via a DOI and the latter via a URL link. These links are provided below.

Furthermore, we firmly believe in the democratisation of research and the importance of making data widely accessible. By embracing transparent and inclusive data sharing practices, we aim to empower researchers and

DATAFIELD	DESCRIPTION
SiteID (character)	Unique identifier for each archaeological site from which the sample has been collected.
Site (character)	Name of the archaeological site.
Country (character)	Name of the country where the site is located.
Province (character)	Name of the province where the site is located.
Town (character)	Name of the town where the site is located.
Latitude (numeric)	Latitude coordinate in decimal degrees format (WGS84).
Longitude (numeric)	Longitude coordinate in decimal degrees format (WGS84).
Eastings_X (numeric)	UTM X coordinate in standard UTM format.
Northings_Y (numeric)	UTM Y coordinate in standard UTM format.
Stage (character)	Chronocultural phase to which the sample has been attributed and collected based on the available archaeological information.
Iddates (character)	Unique identifier for each sample.
Score (numeric)	Score of each sample.
LabNumber (character)	Unique identifier of the laboratory reference for each sample.
Method (character)	Dating method.
AGE (numeric)	Result of each sample in years before present (BP).
STD (numeric)	Standard error of each date in years.
Delta13C (numeric)	Isotopic fractionation of stable carbon isotopes (Carbon 13).
Delta15N (numeric)	Isotopic fractionation of stable nitrogen isotopes (Nitrogen 15).
Material (character)	Material of the dated sample.
Context (character)	Original archaeological context from which the sample was collected (archaeological layer).
Size_m^2 (numeric)	Total excavated area of the archaeological site from which the sample has been collected.
Species_45-30ky (character)	Species attributed to each sample based on the archaeological information.
Species_all (character)	Species attributed to each archaeological site based on the archaeological information.
Type (character)	Type of the archaeological site.
Function (character)	Functionality of the archaeological site based on the archaeological information available.
Source (character)	Source from which the dating sample has been collected.
Observations (character)	Observations about each sample.

Table 3 Description of the rows contained in database_northern_Iberia_dates.csv.

DATAFIELD	DESCRIPTION
Iddates (numeric)	Unique identifier for each sample.
Score (numeric)	Total score of each sample.
Contamination (numeric)	Older/younger carbon pollution level and measurement of irrelevant carbon fractions (scored 0–4).
Chemical fraction (numeric)	^{14}C dating of different chemical fractions (scored 0–4).
Accuracy (numeric)	Level of accuracy of the sample (scored 0–4).
Relevance to human activity (numeric)	Certainty of association of the dated sample with human activity (scored 0–4).
Relevance to specific archaeological entity (numeric)	Relevance of the dated sample to the specific archaeological entity of interest (scored 0–4).
Quantity/Nature of dates (numeric)	Quantity and nature of dates for the archaeological horizon (scored 0–4).
Materials/stratigraphic issues (numeric)	Sample size and stratigraphic association (scored 0–4).
Materials/measurement (numeric)	Sample origin and ^{14}C measurement (scored 0–4).
Methods and reporting (numeric)	Evaluation of the sample measurement and the reporting associated with it (scored 0–4).

Table 4 Description of the rows contained in dates_score.csv.

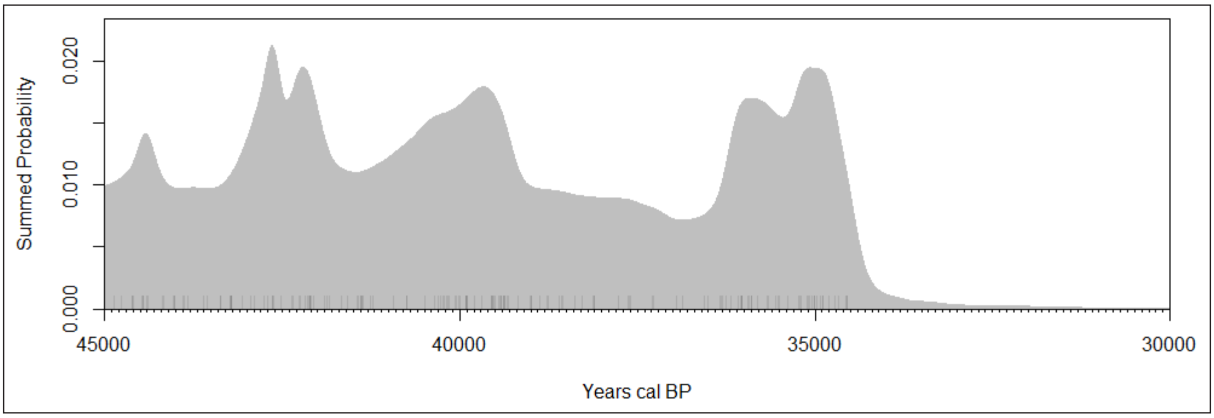

Figure 4 SPD for radiocarbon dates with barcodes showing the median values of calibrated bins. This plot has been created with the R software package called Rcarbon [19]. This package allows the calibration and analysis of radiocarbon dates.

foster collaboration within the field. This commitment to data democratisation is in line with the best practices for data accessibility and reproducibility in archaeology.

REPOSITORY LOCATION

https://doi.org/10.5281/zenodo.8334722.

GITHUB LOCATION

https://github.com/mikeldiazrodriguez/northern_iberia_dates.

PUBLICATION DATE

04/07/2023

(4) REUSE POTENTIAL

To our knowledge, the dataset presented here contains all currently available chronometric dates from archaeological sites located in Northern Iberia between 45–30 ka uncalibrated BP.

The compilation of dates presented in this study has been carefully curated and an attempt has been made to ensure the highest possible quality standards. The scoring given to each sample will allow for different approaches depending on the research objectives that other researchers may have. The data curation process is described in more detail in the Methods section. The dataset has been licensed as open source and can be reused for revising established typo-chronological schemes and building new ones. It is possible to combine these dates with other scientific data (e.g., palaeoclimatic records or fossil pollen cores) with the objective of opening new perspectives in the study of long-term human-environment interactions and the disappearance of the Neanderthals in the Cantabrian region.

As an example, the radiometric dating dataset presented here serves as the basis for calculating a summed probability distribution (SPD), which in turn provides valuable insights into the chronological distribution of the samples and – by inference – fluctuating levels of hominin activity in the study area. Figure 4 presents an initial result of such an SPD analysis. To generate this SPD, we utilised the *rcarbon* package [19] in conjunction with the IntCal20 calibration curve [20]. It is important to note that this initial approximation can be further enhanced by conducting more specific analyses focused on the inclusion of chronocultural periods, by dividing the dataset into smaller spatial units and by including pertinent palaeoclimatic proxies. Such complementary analyses would provide a deeper understanding of the temporal patterns inherent in the dataset.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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