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The Beaker Phenomenon and the Genomic Transformation of Northwest Europe

Iñigo Olalde, Selina Brace, Morten E. Allentoft, Ian Armit*, Kristian Kristiansen*, Nadin Rohland, Swapan Mallick, Thomas Booth, Anna Szécsényi-Nagy, Alissa Mittnik, Eveline Altena, Mark Lipson, Iosif Lazaridis, Thomas K. Harper, Nick Patterson, Nasreen Broomandkhoshbacht, Yoan Diekmann, Zuzana Faltyskova, Daniel Fernandes, Matthew Ferry, Eadaoin Harney, Peter de Knijff, Megan Michel, Jonas Oppenheimer, Kristin Stewardson, Alistair Barclay, Kurt W. Alt, Azucena Avilés Fernández, Eszter Bánffy, Maria Bernabò-Brea, David Billoin, Concepción Blasco, Clive Bonsall, Laura Bonsall, Tim Allen, Lindsey Büster, Sophie Carver, Laura Castells Navarro, Oliver Edward Craig, Gordon T. Cook, Barry Cunliffe, Anthony Denaire, Kirsten Egging Dinwiddy, Natasha Dodwell, Michal Ernée, Christopher Evans, Milan Kuchařík, Joan Francès Farré, Harry Fokkens, Chris Fowler, Michiel Gazenbeek, Rafael Garrido Pena, María Haber-Uriarte, Elżbieta Haduch, Gill Hey, Nick Jowett, Timothy Knowles, Ken Massy, Saskia Pfrengle, Philippe Lefranc, Olivier Lemercier, Arnaud Lefebvre, Joaquín Lomba Maurandi, Tona Majó, Jacqueline I. McKinley, Kathleen McSweeney, Mende Balázs Gusztáv, Alessandra Modi, Gabriella Kulcsár, Viktória Kiss, András Czene, Róbert Patay, Anna Endrődi, Kitti Köhler, Tamás Hajdu, Tamás Szeniczey, János Dani, Maya Hoole, Olivia Cheronet, Denise Keating, Petr Velemínský, Miroslav Dobeš, Francesca Candilio, Fraser Brown, Raúl Flores Fernández, Ana-Mercedes Herrero-Corral, Sebastiano Tusa, Emiliano Carnieri, Luigi Lentini, Antonella Valenti, Alessandro Zanini, Clive Waddington, Germán Delibes, Elisa Guerra-Doce, Benjamin Neil, Marcus Brittain, Mike Luke, Richard Mortimer, Jocelyne Desideri, Marie Besse, Günter Brücken, Mirosław Furmanek, João Luís Cardoso, Corina Liesau, Michael Parker Pearson, Piotr Włodarczak, T. Douglas Price, Pilar Prieto, Pierre-Jérôme Rey, Patricia Ríos, Roberto Risch, Manuel A. Rojo Guerra, Aurore Schmitt, Joël Serralongue, Ana Maria Silva, Václav Smrčka, Luc Vergnaud, João Zilhão, David Caramelli, Thomas Higham, Douglas J. Kennett, Volker Heyd, Alison Sheridan, Karl-Göran Sjögren, Mark G. Thomas, Philipp W. Stockhammer, Johannes Krause, Ron Pinhasi*, Wolfgang Haak*, Ian Barnes*, Carles Lalueza-Fox*, David Reich*

*Principal investigators who contributed centrally to this study

To whom correspondence should be addressed: I.O. (inigo_olalde@hms.harvard.edu) or D.R. (reich@genetics.med.harvard.edu)

Bell Beaker pottery spread across western and central Europe beginning around 2750 BCE before disappearing between 2200–1800 BCE. The forces propelling its expansion are a matter of long-standing debate, with support for both cultural diffusion and migration. We present new genome-wide data from 400 Neolithic, Copper Age and Bronze Age Europeans, including 234 Beaker-associated individuals. We detected limited genetic affinity between Iberian and central European Beaker-associated individuals, and thus exclude migration as a significant mechanism of spread between these two regions. However, migration played a key role in the further dissemination of the Beaker Complex, a phenomenon we document most clearly in Britain where we report 155 individuals who lived from 4000-800 BCE. British Neolithic farmers were genetically similar to contemporary populations in continental Europe and especially to Neolithic Iberians, indicating that a portion of their ancestry came from the Mediterranean rather than the Danubian route of farming expansion. Beginning with the Beaker period, all British individuals in our time transect harboured high proportions of Steppe-related ancestry and were most closely related to Beaker-associated individuals from the Lower Rhine area. The impact of the migration from the continent was profound, as we show that the spread of the Beaker Complex to Britain was associated with a replacement of ~90% of Britain's gene pool within a few hundred years, continuing the east-to-west expansion that had brought Steppe-related ancestry into central and northern Europe 400 years earlier.

During the third millennium Before the Common Era (BCE), two new archaeological pottery styles expanded across Europe, replacing many of the more localized styles that preceded them.¹ In north-central and northeastern Europe there was the 'Corded Ware Complex' associated with people who derived most of their ancestry from Yamnaya pastoralists from the Eurasian steppe^{2–4} (henceforth referred to as Steppe). In western Europe there was the equally expansive 'Bell Beaker Complex,' defined by assemblages of grave goods including stylised bell-shaped pots, copper daggers, arrowheads, stone wristguards and V-perforated buttons⁵ (Extended Data Fig. 1). The oldest radiocarbon dates associated with Beaker pottery are around 2750 BCE in Atlantic Iberia⁶, which has been interpreted as evidence that the Beaker Complex originated there. However, the geographic origin is still debated⁷ and other scenarios including an origin in the Lower Rhine or even multiple independent origins are plausible (Supplementary Information section 1). Regardless of the geographic origin, by 2500 BCE the Beaker Complex had spread throughout western Europe (and northwest Africa), and reached southern and Atlantic France, Italy and central Europe⁵, where it overlapped geographically with the Corded Ware Complex. Within another hundred years, it had expanded to Britain and Ireland⁸. A major debate in archaeology has revolved around the question of whether the spread of the Beaker Complex was mediated by the movement of people, culture, or a combination⁹. Genome-wide data have revealed high proportions of Steppe-related ancestry in Beaker Complex-associated individuals from Germany and the Czech Republic^{2–4}, showing that they derived from mixtures of populations from the Steppe and the preceding farmers of Europe. However, a deeper understanding of the ancestry of people associated with the Beaker Complex requires genomic characterization of individuals across the geographic range and temporal duration of this archaeological phenomenon.

Ancient DNA data

To understand the genetic structure of ancient people associated with the Beaker Complex and their relationship to preceding, subsequent and contemporary peoples, we enriched ancient DNA libraries for sequences overlapping 1,233,013 single nucleotide polymorphisms (SNPs) by hybridization DNA capture^{4,10}, and generated new sequence data from 400 ancient Europeans dated to ~4700-800 BCE and excavated from 137 different sites (Extended Data Table 1; Supplementary Table 1; Supplementary Information, section 2). This dataset includes Beakerassociated individuals from Iberia (n=45), southern France (n=4), northern Italy (n=3), Sicily (n=3), central Europe (n=133), The Netherlands (n=9) and Britain (n=37), and 166 individuals from other ancient populations including 118 individuals from Britain who lived both before (n=51) and after (n=67) the arrival of the Beaker Complex (Fig. 1a-b). For genome-wide analyses, we filtered out first-degree relatives and individuals with low coverage (<10,000 SNPs) or evidence of contamination (Methods) and combined our data with previously published ancient DNA data (Extended Data Fig. 2) to form a dataset of 683 ancient samples (Supplementary Table 1). We further merged these data with 2,572 present-day individuals genotyped on the Affymetrix Human Origins array^{11,12} and 300 high coverage genomes¹³. To facilitate the interpretation of our genetic results, we also generated 106 new direct radiocarbon dates (Extended Data Table 2; Supplementary Information, section 3).

Y-chromosome analysis

The Y-chromosome composition of Beaker associated males was dominated by R1b-M269 (Supplementary Table 3), a lineage associated with the arrival of Steppe migrants in central Europe during the Late Neolithic/Early Bronze Age^{2,3}. Outside Iberia, this lineage was present in 84 out of 90 analysed males. For individuals in whom we could determine the R1b-M269 subtype (n=60), we found that all but two had the derived allele for the R1b-S116/P312 polymorphism, which defines the dominant subtype in western Europe today¹⁴. In contrast, Beaker-associated individuals from the Iberian Peninsula carried a higher proportion of Y haplogroups known to be common across Europe during the earlier Neolithic period^{2,4,15,16}, such as I (n=7) and G2 (n=2), while R1b-M269 was found in four individuals (the two with higher coverage could be further classified as R1b-S116/P312). Finding this widespread presence of

the R1b-S116/P312 polymorphism in ancient individuals from central and western Europe suggests that people associated with the Beaker Complex may have had an important role in the dissemination of this lineage throughout most of its present-day distribution.

Genomic insights into the spread of people associated with the Beaker Complex

We performed Principal Component Analysis (PCA) by projecting ancient samples onto a set of present-day populations from West Eurasia and replicate previous findings¹¹ of two parallel clines, with present-day Europeans on one side and present-day Near Easterners on the other (Extended Data Fig. 3a). Individuals associated with the Beaker Complex are strikingly heterogeneous within the European cline—splayed out along the axis of variation defined by Early Bronze Age Yamnaya Steppe pastoralists at one extreme and Middle Neolithic/Copper Age European farmers at the other extreme (Fig. 1c; Extended Data Fig. 3a)—suggesting that the genetic differentiation may be related to variable amounts of Steppe-related ancestry. We obtained qualitatively consistent inferences using ADMIXTURE model-based clustering¹⁷. Beaker Complex-associated individuals harboured three main genetic components: one characteristic of European hunter-gatherers, one maximized in Neolithic farmers from the Levant and Anatolia, and one maximized in Neolithic farmers of Iran and present in admixed form in Bronze Age Steppe populations (Extended Data Fig. 3b).

Both PCA and ADMIXTURE are powerful tools for visualizing genetic structure but they do not provide formal tests of admixture between populations. We grouped Beaker Complex individuals based on geographic proximity and genetic similarity (Supplementary Information, section 6), and used $qpAdm^2$ to directly test admixture models and estimate mixture proportions. We modelled their ancestry as a mixture of Mesolithic western European hunter-gatherers (WHG), northwestern Anatolian Neolithic farmers, and Bronze Age Steppe pastoralists (the first two of which contributed to earlier Neolithic Europeans; Supplementary Information, section 8). We find that the great majority of sampled Beaker Complex individuals in areas outside of Iberia (with the exception of Sicily) derive a large portion of their ancestry from populations related to Bronze Age Steppe pastoralists (Fig. 2a), whereas in Iberia, such ancestry is present in only eight of the 39 analysed individuals who represent the earliest detection of Steppe-related genomic affinities in this region. We observe striking differences in ancestry not only at a pan-European scale, but also within regions and even within sites. Unlike other individuals from the Upper Alsace region of France (n=2), an individual from Hégenheim resembles the previous Neolithic populations and can be modelled as a mixture of Anatolian Neolithic and western hunter-gatherers without any Steppe-related ancestry. Given that the radiocarbon date of the Hégenheim individual is older (2832-2476 cal BCE (quoting 95.4% confidence intervals for this and other dates) (Supplementary Information, section 2) than other samples from the same

region (2566–2133 cal BCE), the pattern could reflect temporal differentiation. At Szigetszentmiklós in Hungary, we find Beaker-associated individuals with very different proportions (from 0% to 75%) of Steppe-related ancestry and overlapping dates. This genetic heterogeneity is consistent with early stages of mixture between previously established European Neolithic populations and migrants with Steppe-related ancestry. An implication is that, even at a local scale, the Beaker Complex was associated with people of diverse ancestries.

While the Steppe-related ancestry in Beaker-associated individuals had a recent origin in the East^{2,3}, the other ancestry component (from previously established European farmers) could potentially be derived from several parts of Europe, as genetically closely related groups were widely distributed during the Neolithic and Copper Ages^{2,4,11,16,18–23}. To obtain insight into the origin of this ancestry in Beaker Complex-associated individuals, we began by looking for regional patterns of genetic differentiation within Europe during the Neolithic and Copper Age periods. We examined whether Neolithic and Copper Age test populations predating the emergence of the Beaker Complex shared more alleles with Iberian (Iberia EN) or central European Linearbandkeramik (*LBK EN*) Early Neolithic populations. As previously described², there is genetic affinity to Iberian Early Neolithic farmers in Iberian Middle Neolithic/Copper Age populations, but not in central and northern European Neolithic populations (Fig. 2b), which could be explained by differential affinities to hunter-gatherer individuals from different regions²² (Extended Data Fig. 4). Neolithic farmers from southern France and Britain are also significantly closer to Iberian Early Neolithic farmers than to central European Early Neolithic farmers (Fig. 2b), consistent with the analysis of a Neolithic farmer genome from Ireland.²³ We ruled out the possibility that these results are driven by similarities in the proportion of huntergatherer admixture by modelling Neolithic populations and WHG in an admixture graph framework (Extended Data Fig. 5; Supplementary Information, section 7), and finding that all working models require that a portion of the ancestry of the Neolithic farmers of Britain is derived from groups related to early farmers from Iberia. Megalithic tombs document substantial interaction along the Atlantic facade of Europe, and our results are consistent with such interactions reflecting south-to-north movements of people. More data from southern Britain and Ireland (where currently data are sparse) and nearby regions in continental Europe will be needed to fully understand the complex interactions human movements between Britain, Ireland, and the continent during the Neolithic²⁴.

The distinctive genetic signatures of pre-Beaker Complex populations in Iberia compared to central Europe allow us to test formally for the origin of the Neolithic farmer-related ancestry in Beaker Complex-associated individuals in our dataset (Supplementary Information, section 8). We grouped individuals from Iberia (n=39) and from outside Iberia (n=172) to increase power, and evaluated the fit of different Neolithic/Copper Age groups with *qpAdm* under the model:

Yamnaya + Neolithic/Copper Age. For Beaker Complex-associated individuals from Iberia, the best fit was obtained when Middle Neolithic and Copper Age populations from the same region were used as a source for their Neolithic farmer-related ancestry, and we could exclude central and northern European populations (P < 0.0028) (Fig. 2c). Conversely, the Neolithic farmer-related ancestry in Beaker Complex individuals outside Iberia was most closely related to central and northern European Neolithic populations with relatively high hunter-gatherer admixture (e.g. *Poland_LN*, P = 0.18; *Sweden_MN*, P = 0.25), and we could significantly exclude Iberian sources (P < 0.0104) (Fig. 2c). These results support largely different origins for Beaker Complex-associated individuals, with no discernible Iberia-related ancestry outside Iberia.

Nearly complete turnover of ancestry in Britain

British Beaker Complex-associated individuals (n=19) show strong similarities to central European Beaker Complex-associated individuals in their genetic profile (Extended Data Fig. 3), an observation that is not just restricted to British individuals associated with the 'All Over Corded' Beaker pottery style that is shared between Britain and Central Europe, but also in 3 British individuals associated with the 'Maritime' Beaker pottery style that was the predominant early style in Iberia. The presence of large amounts of Steppe-related ancestry in British Beaker Complex-associated individuals (Fig. 2a) contrasts sharply with Neolithic individuals from Britain (n=51), who have no evidence of Steppe genetic affinities and cluster instead with Middle Neolithic and Copper-Age populations from mainland Europe (Extended Data Fig. 3). Thus, the arrival of Steppe-related ancestry in Britain was mediated by a migration that began with the Beaker Complex. A previous study showed that Steppe-related ancestry arrived in Ireland by the Bronze Age²³, and here we show that – at least in Britain – it arrived earlier in the Copper Age/Beaker period.

Among the different continental Beaker Complex groups analysed in our dataset, individuals from Oostwoud (Province of Noord-Holland, The Netherlands) are the most closely related to the great majority of the Beaker Complex individuals from southern Britain (n=27). They had almost identical Steppe-related ancestry proportions (Fig. 2a), the highest shared genetic drift (Extended Data Fig. 6b) and were symmetrically related to most ancient populations (Extended Data Fig. 6a), showing that they are consistent with being derived from the same ancestral population with limited mixture into either group. This does not necessarily imply that the Oostwoud individuals are direct ancestors of the British individuals, but a genetically closely-related group to the one (perhaps yet to be sampled) that moved into Britain from continental Europe.

We investigated the magnitude of population replacement in Britain with qpAdm,² modelling the genome-wide ancestry of Copper and Bronze Age individuals (including Beaker Complexassociated individuals) as a mixture of continental Beaker Complex-associated samples (using the Oostwoud individuals as a surrogate) and the British Neolithic population (Supplementary Information, section 8). Fig. 3a shows the results, ordering individuals by date and showing excess Neolithic farmer-related ancestry compared to continental Beaker Complex-associated individuals as a baseline. For the earliest individuals (between $\sim 2400-2000$ BCE), the Neolithic ancestry excess is highly variable, consistent with migrant communities that were just beginning to mix with the previously established Neolithic population of Britain. During the subsequent Bronze Age we observe less variation and a modest increase in Neolithic farmer-related ancestry (Fig. 3a), which could represent admixture with persisting British populations with high levels of Neolithic farmer-related ancestry (or alternatively incoming continental populations with higher proportions of Neolithic farmer-related ancestry). In either case, our results imply a minimum of 90±2% local population turnover by the Middle Bronze Age, with no further decrease observed in 5 samples from the Late Bronze Age (Supplementary Information, section 8). While the exact turnover rate and its geographic pattern will be refined with more ancient samples, our results imply that for individuals from Britain during and after the Beaker period, a very high fraction of their DNA derives from ancestors who lived in continental Europe prior to 2400 BCE. An independent line of evidence for population turnover comes from Y-chromosome haplogroup composition. While R1b haplogroups were completely absent in the Neolithic samples (n=33), they represent more than 90% of the Y-chromosomes during Copper and Bronze Age Britain (Fig. 3b; Supplementary Table 3).

Our genetic time transect in Britain also allowed us to track the frequencies of alleles with known phenotypic effects. Derived alleles at rs16891982 (SLC45A2) and rs12913832 (HERC2/OCA2), which contribute to reduced skin and eye pigmentation in Europeans, dramatically increased in frequency between the Neolithic period to the Beaker and Bronze Age periods (Extended Data Fig. 7). Thus, the arrival of migrants associated with the Beaker Complex significantly altered the pigmentation phenotypes of British populations. However, the lactase persistence allele at SNP rs4988235 remained at very low frequencies in our dataset both in Britain and continental Europe, showing that the major increase in its frequency in Britain, as in mainland Europe^{3,4,25}, occurred in the last 3,500 years.

Discussion

The term 'Bell Beaker' was introduced by late 19th-century and early 20th-century archaeologists to refer to the distinctive pottery style found across western and central Europe at the end of the Neolithic, initially hypothesized to have been spread by a genetically

homogeneous group of people. This idea of a 'Beaker Folk' became unpopular after the 1960s as scepticism about the role of migration in mediating change in archaeological cultures grew²⁶, although J.G.D. Clark speculated that the Beaker Complex expansion into Britain was an exception²⁷, a prediction that has now been borne out by ancient genomic data.

Our results prove that the expansion of the Beaker Complex cannot be described by a simple one-to-one mapping of an archaeologically defined material culture to a genetically homogeneous population. This stands in contrast to other archaeological complexes analysed to date, notably the *Linearbandkeramik* first farmers of central Europe², the Early Bronze Age Yamnaya of the Steppe^{2,3}, and to some extent the Corded Ware Complex of central and eastern Europe^{2,3}. Instead, our results support a model in which cultural transmission and human migration both played important roles, with the relative balance of these two processes depending on the region. In Iberia, the majority of Beaker-associated individuals lacked Steppe affinities and were genetically most similar to preceding Iberian populations. In central Europe, Steppe-related ancestry was widespread and we can exclude a substantial contribution from Iberian Beaker associated individuals, contradicting initial suggestions of gene flow into central Europe based on analysis of mtDNA²⁸ and dental morphology²⁹. The presence of Steppe-related ancestry in some Iberian individuals demonstrates that gene-flow into Iberia was, however, not uncommon during this period.

Other parts of the Beaker Complex expansion were driven to a substantial extent by migration. This genomic transformation is clearest in Britain due to our dense time transect. The earliest Beaker pots found in Britain show influences from both the lower Rhine region and the Atlantic façade of western Europe³⁰. However, such dual influence is not mirrored in the genetic data, as the British Beaker Complex individuals were genetically most similar to lower Rhine individuals from the Netherlands. The arrival of people associated with the Beaker Complex precipitated a profound demographic transformation in Britain, exemplified by the absence of individuals in our dataset without large amounts of Steppe-related ancestry after 2400 BCE. It is possible that the uneven geographic distribution of our samples, coupled with different burial practises between local and incoming populations (cremation versus burial) during the early stages of interaction could result in a sampling bias against local individuals. However, the signal observed during the Copper Age/Beaker period persisted, without any evidence of genetically Neolithic-like individuals among the 67 Bronze Age individuals we newly report. These results are notable in light of strontium and oxygen isotope analyses of British skeletons from the Beaker and Bronze Age periods³¹, which have provided no evidence of substantial mobility over individuals' lifetimes from locations with cooler climates or from places with geologies atypical of Britain. However, the isotope data are only sensitive to first-generation migrants, and do not rule out movements from regions such as the lower Rhine, which is

consistent with the genetic data, or from other geologically similar regions for which DNA sampling is still sparse. Further sampling of regions on the European continent may reveal additional candidate sources.

By analysing DNA data from ancient individuals we have been able to provide constraints on the processes underlying cultural and social changes in Europe during the third millennium BCE. Our results motivate further archaeological research to identify the changes in social organization, technology, subsistence, climate, population sizes³² or pathogen exposure^{33,34} that could have precipitated the demographic changes uncovered in this study.



Figure 1. Spatial, temporal, and genetic structure of individuals in this study. a, Geographic distribution of samples with new genome-wide data. For clarity, random jitter was added for sites with multiple individuals. **b**, Time ranges for samples with new genome-wide data. Sample sizes are given next to each bar. **c**, Principal component analysis of 990 present-day West Eurasian individuals (grey dots), with previously published (pale yellow) and new ancient samples projected onto the first two principal components. This figure is a zoom of Extended Data Fig 3a. E, Early; M, Middle; L, Late; N, Neolithic; CA, Copper Age; BA, Bronze Age.



Figure 2. Investigating the genetic makeup of Beaker Complex individuals. a, Proportion of Steppe-related ancestry (shown in black) in Beaker Complex-associated groups, computed with *qpAdm* under the model Steppe_EBA + Anatolia_N + WHG. The area of the pie is proportional to the number of individuals (shown inside the pie if more than one). See Supplementary Information, section 8 for mixture proportions and standard errors. b, *f*-statistics of the form f_4 (Mbuti, *Test*; Iberia_EN, LBK_EN) computed for European populations before the emergence of the Beaker Complex. The statistic takes negative values if the *Test* shares more alleles with Iberia_EN (positive values in the case of excess affinity with LBK_EN). Error bars represent ±1 standard errors. c, Testing different populations as a source for the Neolithic ancestry component in Beaker Complex individuals. The table shows the P-values (highlighted if >0.05) for the model: Steppe_EBA + Neolithic/Copper Age source population. BC, Beaker complex; E, Early; M, Middle; L, Late; N, Neolithic; CA, Copper Age; BA, Bronze Age; N_Iberia, Northern Iberia; C_Iberia, Central Iberia; SE_Iberia, Southeast Iberia; SW_Iberia, Southwest Iberia.



Figure 3. Population transformation in Britain associated with the arrival of the Beaker Complex. **a**, Modelling Copper and Bronze Age (including Beaker Complex) individuals from Britain as a mixture of continental Beaker Complex-associated individuals (red, represented by Beaker Complex samples from Oostwoud) and the Neolithic population from Britain (blue). Individuals are ordered chronologically (oldest on the left) and included in the plot if represented by more than 100,000 SNPs. See Supplementary Information, section 8 for mixture proportions and standard errors. **b**, Y-chromosome haplogroup composition in males from Britain. CA, Copper Age; EBA, Early Bronze Age; MBA, Middle Bronze Age; LBA, Late Bronze Age. BC, Beaker complex.

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Methods

Ancient DNA analysis

We screened skeletal samples for DNA preservation in dedicated clean rooms. We extracted DNA^{35–37} and prepared barcoded next generation sequencing libraries, the majority of which were treated with uracil-DNA glycosylase to greatly reduce the damage (except at the terminal nucleotide) that is characteristic of ancient DNA^{38,39} (Supplementary Information, section 4). We initially enriched libraries for sequences overlapping the mitochondrial genome⁴⁰ and ~3000 nuclear SNPs using synthesized baits (CustomArray Inc.) that we PCR amplified. We sequenced the enriched material on an Illumina NextSeq instrument with 2x76 cycles, and 2x7 cycles to read out the two indices⁴¹. We merged read pairs with the expected barcodes that overlapped by at least 15 bases, mapped the merged sequences to hg19 and to the reconstructed mitochondrial DNA consensus sequence⁴² using the *samse* command in bwa (v0.6.1)⁴³, and removed duplicated sequences. We evaluated DNA authenticity by estimating the rate of mismatching to the consensus mitochondrial sequence⁴⁴, and also requiring that the rate of damage at the terminal nucleotide was at least 3% for UDG-treated libraries⁴⁴ and 10% for non-UDG-treated libraries⁴⁵.

For libraries that were promising after screening, we enriched in two consecutive rounds for sequences overlapping 1,233,013 SNPs ('1240k SNP capture')^{2,10} and sequenced 2x76 cycles and 2x7 cycles on an Illumina NextSeq500 instrument. We processed the data bioinformatically as for the mitochondrial capture data, this time mapping only to the human reference genome *hg19* and merging the data from different libraries of the same individual. We further evaluated authenticity by studying the ratio of X-to-Y chromosome reads and estimating X-chromosome contamination in males based on the rate of heterozygosity⁴⁶. Samples with evidence of contamination were either filtered out or restricted to sequences with terminal cytosine deamination to remove sequences that derived from modern contaminants. Finally, we filtered out from our genome-wide analysis dataset samples with fewer than 10,000 targeted SNPs covered at least once and samples that were first-degree relatives of others in the dataset (keeping the sample with the larger number of covered SNPs) (Supplementary Table 1).

Mitochondrial haplogroup determination

We used the mitochondrial capture bam files to determine the mitochondrial haplogroup of each sample with new data, restricting to sequences with MAPQ \geq 30 and base quality \geq 30. First, we constructed a consensus sequence with samtools and bcftools⁴⁷, using a majority rule and requiring a minimum coverage of 2. We called haplogroups with HaploGrep2⁴⁸ based on

phylotree⁴⁹ (mtDNA tree Build 17 (18 Feb 2016)). Mutational differences compared to the rCRS and corresponding haplogroups can be viewed in Supplementary Table 2.

Y-chromosome analysis

We determined Y-chromosome haplogroups for both new and published samples (Supplementary Information, section 5). We made use of the sequences mapping to 1240k Y-chromosome targets, restricting to sequences with mapping quality \geq 30 and bases with quality \geq 30. We called haplogroups by determining the most derived mutation for each sample, using the nomenclature of the International Society of Genetic Genealogy (http://www.isogg.org) version 11.110 (21 April 2016). Haplogroups and their supporting derived mutations can be viewed in Supplementary Table 3.

Merging newly generated data with published data

We assembled two datasets for genome-wide analyses:

- *HO* includes 2,572 present-day individuals from worldwide populations genotyped on the Human Origins Array^{11,12,50} and 683 ancient individuals. The ancient set includes 211 Beaker Complex individuals (195 newly reported, 7 with shotgun data³ for which we generated 1240k capture data and 9 previously published^{3,4}), 68 newly reported individuals from relevant ancient populations and 298 previously published^{12,18,19,21–23,51–58} individuals (Supplementary Table 1). We kept 591,642 autosomal SNPs after intersecting autosomal SNPs in the 1240k capture with the analysis set of 594,924 SNPs from Lazaridis et al.¹¹.

-HOIII includes the same set of ancient samples and 300 present-day individuals from 142 populations sequenced to high coverage as part of the Simons Genome Diversity Project¹³. For this dataset, we used 1,054,671 autosomal SNPs, excluding SNPs of the 1240k array located on sex chromosomes or with known functional effects.

For each individual, we represented the allele at each SNP by randomly sampling one sequence, discarding the first and the last two nucleotides of each sequence.

Principal component analysis

We carried out principal component analysis (PCA) on the *HO* dataset using the *smartpca* program in EIGENSOFT⁵⁹. We computed principal components on 990 present-day West Eurasians and projected ancient individuals using lsqproject: YES and shrinkmode: YES.

ADMIXTURE analysis

We performed model-based clustering analysis using ADMIXTURE¹⁷ on the *HO* reference dataset, including 2,572 present-day individuals from worldwide populations and the ancient individuals. First, we carried out LD-pruning on the dataset using PLINK⁶⁰ with the flag -- indep-pairwise 200 25 0.4, leaving 306,393 SNPs. We ran ADMIXTURE with the cross validation (--cv) flag specifying from K=2 to K=20 clusters, with 20 replicates for each value of K and keeping for each value of K the replicate with highest log likelihood. In Extended Data Fig. 3b we show the cluster assignments at K=8 of newly reported individuals and other relevant ancient samples for comparison. We chose this value of K as it was the lowest one for which components of ancestry related both to Iranian farmers and European hunter-gatherers were maximized.

f-statistics

We computed *f*-statistics on the *HOIII* dataset using ADMIXTOOLS⁵⁰ with default parameters (Supplementary Information, section 6). We used *qpDstat* with f4mode:Yes for f_4 -statistics and *qp3Pop* for outgroup *f*3-statistics. We computed standard errors using a weighted block jackknife⁶¹ over 5 Mb blocks.

Inference of mixture proportions

We estimated ancestry proportions on the *HOIII* dataset using $qpAdm^2$ and a basic set of 9 *Outgroups*: Mota, Ust_Ishim, MA1, Villabruna, Mbuti, Papuan, Onge, Han, Karitiana. For some analyses (Supplementary Information, section 8) we added additional outgroups to this basic set.

Admixture graph modelling

We modelled the relationships between populations in an Admixture Graph framework with the software qpGraph in ADMIXTOOLS⁵⁰, using the *HOIIl* dataset and Mbuti as an outgroup (Supplementary Information, section 7).

Allele frequency estimation from read counts

We used allele counts at each SNP to perform maximum likelihood estimation of allele frequencies in ancient populations as in ref.⁴. In Extended Data Fig. 7, we show derived allele frequency estimates at three SNPs of functional importance for different ancient populations.

Data availability

All 1240k and mitochondrial capture sequencing data are available from the European Nucleotide Archive, accession number XXXXXXX [to be made available on publication]. The genotype dataset we analysed is available from the Reich Lab website at [to be made available on publication].

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Author Contributions

S.B., M.E.A, N.R., A.S.-N., A.M., N.B., M.F., E.H., M.M., J.O., K.S., O.C., F.C., R.P., J.K., W.H., I.B. and D.R. performed or supervised wet laboratory work. G.T.C. and D.J.K. undertook the radiocarbon dating of a large fraction of the British samples. I.A., K.K., A.B., K.W.A.,

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Y.D., Z.F., D.F., P.d.K., T.K.H., M.G.T. and D.R. analysed or supervised analysis of data. I.O.,
C.L.-F. and D.R. wrote the manuscript with input from all co-authors.

Supplementary Tables

Supplementary Table 1. Ancient individuals included in this study.

Supplementary Table 2. Mitochondrial haplogroup calls for individuals with newly reported data.

Supplementary Table 3. Y-chromosome calls for males with newly reported data.

Supplementary Table 4. Radiocarbon database.



Extended Data Figure 1. **Beaker complex artefacts**. **a**, Beaker and flint implements excavated at Newmill, Perth and Kinross District, Tayside Region, Scotland. **b**, Beaker Complex grave goods from La Sima III barrow, Soria, Spain⁶². Photo: Alejandro Plaza, Museo Numantino.



Extended Data Figure 2. Ancient individuals with previously published genome-wide data used in this study. a, Sampling locations. b, Time ranges. W/E/S/CHG, Western/Eastern/Scandinavian/Caucasus hunter-gatherers; E, Early; M, Middle; L, Late; N, Neolithic; CA, Copper Age; BA, Bronze Age.



Extended Data Figure 3. Population structure. a, Principal component analysis of 990 present-day West Eurasian individuals (grey dots), with previously published (pale yellow) and new ancient samples projected onto the first two principal components. **b**, ADMIXTURE clustering analysis with k=8 showing ancient individuals. W/E/S/CHG, Western/Eastern/Scandinavian/Caucasus hunter-gatherers; E, Early; M, Middle; L, Late; N, Neolithic; CA, Copper Age; BA, Bronze Age.



Extended Data Figure 4. **Hunter-gatherer affinities in Neolithic/Copper Age Europe**. Differential affinity to hunter-gatherer individuals (LaBraña1⁵⁷ from Spain and KO1⁶³ from Hungary) in European populations before the emergence of the Beaker Complex. See Supplementary Information, section 8 for mixture proportions and standard errors computed with *qpAdm*. E, Early; M, Middle; L, Late; N, Neolithic; CA, Copper Age; BA, Bronze Age; N_Iberia, Northern Iberia; C_Iberia, Central Iberia.



Extended Data Figure 5. Modelling the relationships between Neolithic populations. a, Admixture graph fitting a *Test* population as a mixture of sources related to both Iberia_EN and Hungary_EN. b, Likelihood distribution for models with different proportions of the source related to Iberia_EN (green admixture edge in (a)) when *Test* is England_N, Scotland_N or France_MLN.



Extended Data Figure 6. Genetic affinity between Beaker Complex-associated individuals from southern England and the Netherlands. a, *f*-statistics of the form f_4 (Mbuti, Test; BK_Netherlands_Tui, BK_England_SOU). Negative values indicate that Test is closer to BK_Netherlands_Tui than to BK_England_SOU, and the opposite for positive values. Error bars represent ±3 standard errors. b, Outgroup- f_3 statistics of the form f_3 (Mbuti; BK_England_SOU, X) measuring shared genetic drift between BK_England_SOU and other Beaker Complex groups. Error bars represent ±1 standard errors.



Extended Data Figure 7. Derived allele frequencies at three SNPs of functional importance. Error bars represent 1.9-log-likelihood support interval. The red dashed lines show allele frequencies in the 1000 Genomes GBR population (present-day people from Great Britain). BC, Beaker Complex; CA, Copper Age; BA, Bronze Age.

Extended Data Table 1. Sites with new genome-wide data reported in this study.

Site	Ν	Approx. date range (BCE)	Country
Brandysek	12	2500-2000	Czech Republic
Kněževes	2	2500-1900	Czech Republic
Lochenice	1	2500-1900	Czech Republic
Lovosice II	1	2500-1900	Czech Republic
Moravska Nova Ves	4	2300-1900	Czech Republic
Prague 5 - Mala Ohrada	14	2500-2200	Czech Republic
Prague 5, Jinonice	14	2500-1700	Czech Republic
Prague 8, Kobylisy, Ke Stírce Street	12	2500-1900	Czech Republic
Radovesice	13	2500-2000	Czech Republic
Velké Přílepy	3	2500–1900	Czech Republic
Clos de Roque, Saint Maximin-la-Sainte-Baume	3	4700-4500	France
Collet Redon, La Couronne-Martigues	1	3500-3100	France
Hegenheim Necropole, Haut-Rhin	1	2800-2500	France
La Fare, Forcalquier	1	2500-2200	France
Marlens, Sur les Barmes, Haute-Savoie	1	2500-2100	France
Rouffach Hout Phin	2	2400-1900	France
Sigrantz, Les Villas d'Aurele, Haut Phin	2	2600 2300	France
Villard Lauzet-Ubave	2	2200–2300	France
Alburg-Lerchenhaid Spedition Häring Bayaria	13	2500-2100	Germany
Augsburg Sportgelände Augsburg	6	2500-2100	Germany
Hugo-Eckener-Straße Augsburg	3	2500-2000	Germany
Irlbach County of Straubing-Bogen Bayaria	17	2500-2000	Germany
Künzing-Bruck I kr. Deggendorf Bayaria	3	2500-2000	Germany
Landau an der Isar Bayaria	5	2500-2000	Germany
Manching-Oberstimm, Bavaria	2	2500-2000	Germany
Osterhofen-Altenmarkt. Bayaria	4	2600–2000	Germany
Unterer Talweg 58-62. Augsburg	2	2500-2200	Germany
Unterer Talweg 85, Augsburg	1	2400-2100	Germany
Weichering, Bavaria	4	2800-1800	Germany
Worms-Herrnsheim, England	1	2800-1800	Germany
Aberdour Road, Dunfermline, Fife, Scotland	1	2000-1800	Great Britain
Abingdon Spring Road cemetery, Oxfordshire, England	1	2500-2200	Great Britain
Achavanich, Wick, Scotland	1	2500-2100	Great Britain
Amesbury Down, Wiltshire, England	13	2500-1300	Great Britain
Banbury Lane, Northamptonshire, England	3	3400-3100	Great Britain
Barrow Hills, Radley, Oxfordshire, England	1	2300-1800	Great Britain
Barton Stacey, Hampshire, England	1	2200-2000	Great Britain
Baston and Langtoft, South Lincolnshire, England	2	1700–1600	Great Britain
Biddenham Loop, Bedfordshire, England	9	1600–1300	Great Britain
Boatbridge Quarry, Thankerton, Scotland	1	2400–2100	Great Britain
Boscombe Airfield, Wiltshire, England	1	1800–1600	Great Britain
Canada Farm, Sixpenny Handley, Dorset, England	2	2500-2300	Great Britain
Carsington Pasture Cave, Derbyshire, England	2	3700-2000	Great Britain
Central Flying School, Upavon, Wiltshire, England	1	2500-1800	Great Britain
Clissbury, Sussex, England	1	3600-3400	Great Britain
Clachaig, Scotland	1	3500-3400	Great Britain
Clay Farm, Cambridgesnire, England	2	1400-1300	Great Britain
Covesea Cavez, Scotland	2	2100-800	Great Britain
Covesea Caves, Scotland	2	1600 1200	Great Britain
Dairy Form Willington England	1	2200 1000	Great Britain
Distillery Cave. Scotland	3	3800-3400	Great Britain
Districtly Cave, Sectional	1	2500-1900	Great Britain
Doune Perth and Kinross Scotland	1	1800-1600	Great Britain
Dryburn Bridge Scotland	2	2300-1900	Great Britain
Eton Rowing Course Buckinghamshire England	2	3600-2900	Great Britain
Eweford Cottages Scotland	1	2100-1900	Great Britain
Flying School Netherayon Wiltshire England	2	2500-1800	Great Britain
Fussell's Lodge Salisbury Wiltshire England	2	3800-3600	Great Britain
Giggleswick Scar Kelco Cave North Yorkshire	1	3700-3500	Great Britain
Great Orme Mines, Llandudno, North Wales	1	1700–1600	Great Britain
Hasting Hill, Sunderland, Tyne and Wear England	2	2500-1800	Great Britain
Hexham Golf Course, Northumberland, England	1	2000-1800	Great Britain
Holm of Papa Westray North Scotland	4	3500-3100	Great Britain
Ishister Orkney Scotland	10	3300-2300	Great Britain
Leith. Merrilees Close. City of Edinburgh. Scotland	2	1600–1500	Great Britain
Longniddry, Evergreen House, Coast Road Scotland	3	1500–1300	Great Britain
	-	20	

Longniddry, Grainfoot, Scotland	1	1300-1000	Great Britain
Low Hauxley, Northumberland, England	2	2100-1600	Great Britain
Macarthur Cave, Scotland	1	4000-3800	Great Britain
Melton Quarry, East Riding of Yorkshire, England	1	1900-1700	Great Britain
Neale's Cave, Paington, Somerset, England	1	2000-1600	Great Britain
North Face Cave, Llandudno, North Wales	1	1400-1200	Great Britain
Nr. Ablington, Figheldean, England	1	2500-1800	Great Britain
Nr. Millbarrow, Wiltshire, England	1	3600-3400	Great Britain
Over Narrows, Needingworth Quarry, England	5	2200-1300	Great Britain
Pabay Mor, Scotland	1	1400-1300	Great Britain
Point of Cott, Orkney, Scotland	2	3700-3100	Great Britain
Porton Down, Wiltshire, England	2	2500-1900	Great Britain
Quoyness, Scotland	1	3100-2900	Great Britain
Raschoille Cave, Oban, Argyll and Bute, Scotland	9	4000-2900	Great Britain
Raven Scar Cave, Ingleton, North Yorkshire, England	1	1100-900	Great Britain
Reaverhill, Barrasford, Northumberland, England	1	2100-2000	Great Britain
Rhos Ddigre, Denbighshire, Wales	1	3100-2900	Great Britain
River Thames Skulls, Mortlake, London, England	1	1900-1700	Great Britain
River Thames Skulls, Syon Reach, London, England	1	2500-2100	Great Britain
Sorisdale, Coll, Scotland	1	2500-2100	Great Britain
Staxton Beacon, Staxton, England	1	2400-1600	Great Britain
Stenchme, Lop Ness, Orkney, Scotland	1	2000-1500	Great Britain
Summerhill, Blaydon, Tyne and Wear, England	1	1900-1700	Great Britain
Thanet, Kent, England	4	2100-1700	Great Britain
Thurston Mains, Innerwick, East Lothian, Scotland	1	2300-2000	Great Britain
Tinkinswood, Glamorgan, Wales	1	4000-3300	Great Britain
Totty Pot, Cheddar, Somerset, England	1	2800-2500	Great Britain
Trumpington Meadows, Cambridge, England	2	2200-2000	Great Britain
Tulach an t'Sionnach, Scotland	1	3700-3500	Great Britain
Tulloch of Assery A, Scotland	1	3700-3400	Great Britain
Tulloch of Assery B, Scotland	1	3800-3600	Great Britain
Turners Yard, Fordham, Cambridgeshire, England	1	1700-1500	Great Britain
Unstan Chamber Tomb, Orkney, Scotland	1	3400-2800	Great Britain
Upper Swell, Chipping Norton, Gloucestershire,	1	4000-3500	Great Britain
Waterhall Farm, Chippenham, Cambridgeshire, England	1	2000-1700	Great Britain
West Deeping, Lincolnshire, England	1	2300-2000	Great Britain
Whitehawk, Brighton, Sussex, England	1	3700-3500	Great Britain
Wick Barrow, England	1	2500-1900	Great Britain
Wilsford, England	2	2500-1900	Great Britain
Windmill Fields, Ingleby Barwick, England	4	2300-2000	Great Britain
Yarnton, Oxfordshire, England	4	2500-1900	Great Britain
Budakalasz, Csajerszke (M0 Site 12)	2	2600-2200	Hungary
Budapest-Bekasmegyer	3	2500-2100	Hungary
Mezocsat-Horcsogos naiom alatt	4	2800-2400	Hungary
Szigetszentmiklós-vizmutelep Udulosor	4	2900-1800	Hungary
Szigetszentmikios, Feiso Urge-negyi dulo	6	2500-2200	Hungary
Via Cuidanaari Darma Emilia Damaana	2	2500-1900	Italy
Via Guidorossi, Parma, Emilia Komagna	3	2200-1900	Italy Deleved
Dzielnica	1	2300-2000	Poland
Iwiliy Jardanáw Élaski	1	2300-2000	Poland
Jordanow Słąski Komies	1	2500-2200	Poland
Rollice Basihárz Stara Wisá	4	2300-2100	Poland
Racibolz-Stala wies	1	2500-2000	Poland
Sallibolzec	5	2000 1800	Poland
Żorniki Wielkie	1	2000-1800	Poland
Poloras Estromadura	1	2300-2100	Portugal
Cova da Moura. Torras Vadras	1	2300-2000	Portugal
Galeria da Cisterna. Almonda	2	2500-2100	Portugal
Verdelha dos Ruivos District of Lisbon	2	2700-2200	Portugal
Arroval I Burgos	5	2600-2200	Spain
Camino de las Veseras Madrid	14	2800-1700	Spain
Camino del Molino, Caravaca, Murcia	4	2900-2100	Spain
Humaneios. Madrid	11	2900-2000	Spain
La Magdalena, Madrid	3	2800-1800	Spain
Paris Street, Cerdanvola, Barcelona	10	2900-2300	Spain
Virgazal, Tablada de Rudrón, Burgos	1	2300-2000	Spain
Sion-Petit-Chasseur Dolmen XI	3	2500-2000	Switzerland
De Tuithoorn Oostwoud Noord-Holland	11	2600-1600	The Netherlands
2. Futurooni, costword, noora nonana	1 1	2000 1000	The requiring

Extended Data Table 2. 106 newly reported radiocarbon dates

1415 2279-2033 callCF: (3740-25 BP, Mox-84460) Kaizbers Crech Regubbic 14144 2572-2512 callCF: (3955-25 BP, Pox-84553) Osterhörn-Altenmarkt Germany 14292 2336-2141 callCF: (3955-25 BP, Pox-84553) Osterhörn-Altenmarkt Germany 14292 2346-2141 callCF: (390-25 BP, MAMS 1207) Irheach LKR Germany 14292 2448-204 callCF: (384433 BP, BRAMS 1207) Irheach LKR Germany 15932 2468-204 callCF: (384433 BP, BRAMS 1217) Irheach LKR Germany 1593 2398-2146 callCF: (384433 BP, BRAMS 1217) Alburg-1-erchenhaid, Spedition Haring, Bavaria Germany 1593 2398-2146 callCF: (3817426 BP, BRAMS 1217) Alburg-1-erchenhaid, Spedition Haring, Bavaria Germany 1593 736-3602 callCF: (491+327 BP, SUREC-68704) Distillery Cave Great Henian 1264 3700-3402 callCF: (481+24 BP, SUREC-68704) Distillery Cave Great Henian 1264 3700-3402 callCF: (465+23 BP, SUREC-68704) Distillery Cave Great Henian 1265 350-3402 callCF: (465+23 BP, SUREC-68704) Distillery Cave Great Henian 1264 3700-3402 callCF: (Sample	Date	Location	Country
1392 2352-2476 call/CE (4407429 BP; MAMS-2593) Hegenheim Necropole, Haut-Rhin France E09537.1 2471-2300 call/CE (3995435 BP, AC&4553) Oxterholen-Altenmarkt Germany E09537.2 2471-2300 call/CE (3992429 BP; MAMS 2070) Unterer Talweg 58-62, Augeburg, Bovaria Germany E09537.2 2445-212 call/CE (3870240 BP; RAMS 1217) Unterer Talweg 58-62, Augeburg, Bovaria Germany E1952 2448-2180 call/CE (3870240 BP; RAMS 1217) Unterer Talweg 58-62, Augeburg, Bovaria Germany E1950 2335-2476 call/CE (3870240 BP; RAMS 1217) Alburg-Lerchenhald, Spedition Haring, Bavaria Germany E1850 2335-2476 call/CE (481242 BP; RURR-68701) Maarahur Cave Great Briain E1630 376-6362 call/CE (481242 BP; SURR-68701) Distilery Cave Great Briain E163 370-3464 call/CF (481243 BP; SURR-68701) Distilery Cave Great Briain E164 370-3464 call/CF (48124 BP; SURR-68602) Talloch of Assery A Great Briain E164 370-3464 call/CF (48124 BP; SURR-68602) Talloch of Assery A Great Briain E164 370-3462 call/CF (446132 BP; SURR-68701) Distilery Cave Great Briain <td>I4145</td> <td>2279–2033 calBCE (3740±35 BP, Poz-84460)</td> <td>Kněževes</td> <td>Czech Republic</td>	I4145	2279–2033 calBCE (3740±35 BP, Poz-84460)	Kněževes	Czech Republic
1414 2572-2512.callCE (3955:25 BP, Poz.84553) Osterhofen-Altenmarkt Germany 162957.jcl 2712-2512.callCE (3092-25 BP, RAMS1207) Interr Talveg 54-62, Augeburg, Bavaria Germany 162953 2448-2204 callCE (3872-35 BP, RAMS1217) Interr Talveg 54-62, Augeburg, Bavaria Germany 15302 2458-2204 callCE (3872-35 BP, RAMS1217) Interr Talveg 54-62, Augeburg, Bavaria Germany 15303 2308-2146 callCE (3872-26 BP, BRAMS1217) Interr Talveg 54-62, Augeburg, Bavaria Germany 15303 2308-2146 callCE (3872-26 BP, BRAMS1217) Alburg-Lerchenhaid, Spedition Haring, Bavaria Germany 15303 2308-2146 callCE (481-22 BP, SULRC-68010) Hourg-Lerchenhaid, Spedition Haring, Bavaria Germany 12637 3762-3644 callCE (481-22 BP, SULRC-68010) Distillery Cave Great Britain 12636 3200-allCE (481-32 BP, SULRC-68030) Tulloch of Assery A Great Britain 12636 3510-allCE (464-31-32 BP, SULRC-68030) Tulloch of Assery A Great Britain 12636 3300-allCE (445-32 BP, SULRC-68040) Tulloch of Assery A Great Britain 12636 3300-allCE (445-33 BP, SULRC-68040) Tulloch of Assery A	I1392	2832–2476 calBCE (4047±29 BP, MAMS-25935)	Hégenheim Necropole, Haut-Rhin	France
Engs32, di 2471–2300.allRCF. (3909-29 BP, MAMS 2007) Unterer Talweg 58-62, Augsburg, Bavaria Germany P09538 2464–2212.allRCF. (3802-26 BP, BRAMS1217) Unterer Talweg 58-62, Augsburg, Bavaria Germany P1952 2484–2150.allRCF. (3802-26 BP, BRAMS1212) Unterer Talweg 58-62, Augsburg, Bavaria Germany P1950 2348-2166 callRCF. (3825-26 BP, BRAMS1217) Unterer Talweg 58-62, Augsburg, Bavaria Germany P1950 2339-2143.allRCF. (3825-26 BP, BRAMS-1215) Margaria. Spedition Haring, Bavaria Germany P150 2339-2143.allRCF. (5825-20 BP, BRAMS-1215) Mararhur Cave Great Britain P263 3766-3642.callRCF. (4911-422 BP, SUERC-68630) Tuloch of Assery B Great Britain P264 3706-3536 callRCF. (4851-33 BP, SUERC-68630) Tuloch of Assery A Great Britain P264 3701-3602 callRCF. (4651-23 BP, SUERC-68630) Distillery. Cave Great Britain P265 350-3302 callRCF. (4651-29 BP, SUERC-68703) Distillery. Cave Great Britain P266 350-3302 callRCF. (4651-29 BP, SUERC-68703) Distillery. Cave Great Britain P263 336-302 callRCF. (4631-29 BP, SUERC-68703) Distillery. Cave	I4144	2572–2512 calBCE (3955±35 BP, Poz-84553)	Osterhofen-Altenmarkt	Germany
16249 2336-2141 calRCF (380-245 PR, BRAMS) 2075) Iribach 1 KR Germany 165938 2448-2204 calRCF (384-243 BR, BRAMS-1219) Interer Talweg Sk-62, Augebarg, Bavaria Germany 15502 2438-2204 calRCF (384-243 BR, BRAMS) 219) Interer Talweg Sk-62, Augebarg, Bavaria Germany 15502 2338-2146 calRCF (381-226 BR, BRAMS) 219) Interer Talweg Sk-62, Augebarg, Bavaria Germany 15633 2368-2146 calRCF (4014-22 PR, BURC-68701) Mararhar Cave Great Britain 12657 3952-3781 calRCF (481-22 PR, SULRC-68701) Distillery Cave Great Britain 12664 3706-3404 calRCF (481-24 PR, SULRC-68603) Tulloch of Assery A Great Britain 12635 3663-3300 calRCF (481-24 PR, SULRC-68603) Tulloch of Assery A Great Britain 12636 3500-3362 calRCF (4645-32 PR, SULRC-68643) Tulloch of Assery A Great Britain 12636 3500-3360 calRCF (4645-23 PR, SULRC-68643) Tulloch of Assery A Great Britain 12636 3500-3360 calRCF (4645-23 PR, SULRC-68642) Holim of Papa Westray North Great Britain 12637 3500-3360 calRCF (4645-23 PR, SULRC-68642) Holim of Papa Westray North Grea	E09537_d	2471-2300 calBCE (3909±29 BP, MAMS 29074)	Unterer Talweg 58-62, Augsburg, Bavaria	Germany
E0953 2464-2212 calBCC (3870-250 BP, MAMS 2075) Uniterr Talweg 58-62, Augsburg, Bavaria Germany I4250 2434-2150 calBCC (382-252 BP, BRAMS-1219) Ibburg-Lerchenhaid, Spedition Häring, Bavaria Germany I590 2339-2145 calBCC (3812-252 BP, BRAMS-1217) Aburg-Lerchenhaid, Spedition Häring, Bavaria Germany I263 3766-3642 calBCC (4911-23 2P, SUERC-68704) Distillery Cave Great Britain I263 3766-3454 calBCC (4914-23 2P, SUERC-68704) Distillery Cave Great Britain I264 3704-3536 calBCC (4851-33 BP, SUERC-68704) Distillery Cave Great Britain I264 3704-3536 calBCC (4851-33 BP, SUERC-68704) Distillery Cave Great Britain I265 3652-3360 calBCC (4651-23 BP, SUERC-68703) Distillery Cave Great Britain I266 3500-3306 calBCC (4651-23 BP, SUERC-68703) Distillery Cave Great Britain I266 3500-3306 calBCC (4651-23 BP, SUERC-68703) Distillery Cave Great Britain I2665 3520-3302 calBCC (4652-33 BP, SUERC-68703) Distillery Cave Great Britain I2665 3500-3406 calBCC (4452-34 BP, SUERC-68724) Iohon Papa Westray North Great Britain <td>I4249</td> <td>2336-2141 calBCE (3802±26 BP, BRAMS1217)</td> <td>Irlbach LKR</td> <td>Germany</td>	I4249	2336-2141 calBCE (3802±26 BP, BRAMS1217)	Irlbach LKR	Germany
1592 2458-2204 calBCC (381-235 BP, BRAMS-1218) Alburg-Lerchenhaid, Spedition Haring, Bavaria Germany 1593 2398-2146 calBCC (381-226 BP, BRAMS-1215) Alburg-Lerchenhaid, Spedition Haring, Bavaria Germany 1637 3952-3781 calBCC (302-26 BP, BRAMS-1217) Maurg-Lerchenhaid, Spedition Haring, Bavaria Germany 1267 3952-3781 calBCC (302-26 BP, BRAMS-1217) Maearthur Cave Great Britain 1268 3766-3402 calBCC (491-132 2BP, SUERC-68702) Distillery Cave Great Britain 1264 3706-3356 calBCC (4881-25 BP, SUERC-68639) Tulloch of Assery B Great Britain 1265 3503-3300 calBCC (4786-37 BP, SUERC-68642) Tulloch of Assery A Great Britain 1266 5300-3360 calBCC (463-29 BP, SUERC-68642) Holm of Papa Westray North Great Britain 1266 5300-3300 calBCC (479-53 BP, SUERC-68642) Holm of Papa Westray North Great Britain 1266 5300-3300 calBCC (4754-36 BP, SUERC-68642) Holm of Papa Westray North Great Britain 1266 532-3737 calBCC (470-53 BP, Poz-83482) Eon Rowing Coarse Great Britain 1266 330-3000 calBCC (4452-29 BP, SUERC-68723) Holm of Papa Westray Nort	E09538	2464–2212 calBCE (3870±30 BP, MAMS 29075)	Unterer Talweg 58-62, Augsburg, Bavaria	Germany
14250 243+2150 calBCE. (382-26 BP, BRAMS-1215) Irlbach LKR Germany 1590 2339-2145 calBCE. (382-26 BP, BRAMS-1217) Alburg-1-erchenhaid, Spedition Haring, Bavaria Germany 1637 352-23781 calBCE. (502-26 BP, BRAMS-1217) Alburg-1-erchenhaid, Spedition Haring, Bavaria Germa Pritain 1633 7366-3642 calBCE. (4911-232 BP, SUERC-68704) Distillery Cave Great Britain 12641 3701-3640 calBCE. (4851-233 BP, SUERC-68704) Distillery Cave Great Britain 12645 3653-3390 calBCE. (4851-233 BP, SUERC-698704) Distillery Cave Great Britain 12645 3520-3362 calBCE. (4651-233 BP, SUERC-698704) Tulloch of Assey A Great Britain 12646 3520-3362 calBCE. (4651-233 BP, SUERC-68703) Distillery Cave Great Britain 12868 3514-3353 calBCE. (4651-233 BP, SUERC-68703) Distillery Cave Great Britain 12869 3510-3340 calBCE. (4712-33 BP, SUERC-68703) Distillery Cave Great Britain 12861 310-300 calBCE. (4651-23 BP, SUERC-68703) Distillery Cave Great Britain 12863 3314-3335 calBCE. (4712-33 BP, SUERC-68703) Distiter Coheny Great Britain <	13592	2458-2204 calBCE (3844±33 BP, BRAMS-1218)	Alburg-Lerchenhaid, Spedition Häring, Bavaria	Germany
1599 2398-2146 calBCC (3817-26 PP, BRAMS-1217) Alburg-Lerchenhaid, Spedition Häring, Bavaria Germany 12657 3952-3781 calBCC (302-26 PP, BRAMS-1217) Macarthur Cave Great Britain 12653 3766-3462 calBCC (4911-32 PP, SUERC-68670) Distillery Cave Great Britain 12664 3706-3536 calBCC (481-54 33 P, SUERC-68702) Distillery Cave Great Britain 12706 3706-3536 calBCC (481-54 33 P, SUERC-68639) Tulloch of Assery A Great Britain 12636 3520-3362 calBCC (461-32 3P, SUERC-68639) Tulloch of Assery A Great Britain 12636 3520-3362 calBCC (461-52 3P, SUERC-68642) Holm of Papa Westray North Great Britain 12636 3520-3320 calBCC (470-453 3P, SUERC-68642) Holm of Papa Westray North Great Britain 12636 3520-3320 calBCC (470-453 PP, Pux-33483) Eion Rowing Coarse Great Britain 12637 3510-3040 calBCC (470-453 PP, Pux-33483) Eion Rowing Coarse Great Britain 12643 330-3090 calBCC (470-453 PP, Pux-33483) Eion Rowing Coarse Great Britain 12643 330-3090 calBCC (470-453 PP, Pux-33483) Eion Rowing Coarse Great Britain	I4250	2434-2150 calBCE (3825±26 BP, BRAMS1219)	Irlbach LKR	Germany
1590 2339-2143 callPCF (3802-26 BP, BR AMS-1217) Alburg-Lerchenhaid, Spedition Häring, Bavaria Gernamy 12657 392-5-3781 callPCF (5052-36 BP, SUERC-68604) Tulloch of Assery B Great Britain 1269 3701-3640 callPCF (4911-32 BP, SUERC-68704) Distillery Cave Great Britain 12706 3701-353 callPCF (4456-33 BP, SUERC-68603) Tulloch of Assery A Great Britain 12635 3532-330 callPCF (4456-33 BP, SUERC-68603) Tulloch of Assery A Great Britain 12646 3520-3320 callPCF (4451-29 BP, SUERC-68603) Tulloch of Assery A Great Britain 12656 3510-3340 callPCF (4451-29 BP, SUERC-68610) Dhoin of Papa Westray North Great Britain 12657 3510-3340 callPCF (4451-29 BP, SUERC-68607) Point of Can, Ohave Great Britain 12658 3510-3340 callPCF (451-35 BP, SUERC-68607) Point of Can, Ohave Great Britain 12645 3310-3002 callPCF (451-35 BP, SUERC-68672) Hohim of Papa Westray North Great Britain 12645 3330-3002 allPCF (451-35 BP, SUERC-6872) Hohim of Papa Westray North Great Britain 12645 3330-3002 allPCF (4471-229 BP, SUERC-6872) Hohim of Papa Westray North	13593	2398-2146 calBCE (3817±26 BP, BRAMS-1215)	Alburg-Lerchenhaid, Spedition Häring, Bavaria	Germany
12657 3952-3781 calBCE (505249) BP, SUERC-68701 Macarthur Cave Great Britain 12659 3762-3644 calBCE (4911+32 BP, SUERC-68702) Distillery Cave Great Britain 12691 3706-3556 calBCE (4818+23 PP, SUERC-68074) Distillery Cave Great Britain 12764 3706-3556 calBCE (4851-33 PP, SUERC-68073) Tulloch of Assery A Great Britain 12635 3502-3302 calBCE (4704-337 PP, SUERC-68673) Tulloch of Assery A Great Britain 12636 3520-3302 calBCE (4651-32 PP, SUERC-68671) Clachaig Great Britain 12680 3517-3362 calBCE (4651-32 PP, SUERC-68671) Clachaig Great Britain 12660 3514-3353 calBCE (461-32 PP, SUERC-68672) Holim of Papa Westray North Great Britain 12651 3330-3000 calBCE (4710-435 BP, SUERC-68672) Holim of Papa Westray North Great Britain 12863 3330-3000 calBCE (4461-22 PP, SUERC-68724) Isbister, Orkney Great Britain 12984 3323-3027 alBCE (4461-22 PP, SUERC-68724) Isbister, Orkney Great Britain 12985 3333-3024 calBCE (4461-22 PP, SUERC-68724) Isbister, Orkney Great Britain 12985	13590	2339-2143 calBCE (3802±26 BP, BRAMS-1217)	Alburg-Lerchenhaid, Spedition Häring, Bavaria	Germany
1263 3766-3442 callSC (4911432 BP, SUERC-68704) Distillery Cave Great Britain 1269 3701-3640 callSC (4914427 BP, SUERC-68704) Distillery Cave Great Britain 12765 3704-3553 callSC (4856133 BP, SUERC-686704) Distillery Cave Great Britain 12614 3704-3553 callSC (4951434 BP, SUERC-686703) Tulach an TSionmach Great Britain 12635 3532-3302 callSC (495423 BP, SUERC-686703) Tulach an Assery A Great Britain 12660 3514-3353 callSC (491422 BP, SUERC-686703) Distillery Cave Great Britain 12653 3630-3300 callSC (491422 BP, SUERC-686703) Distillery Cave Great Britain 12650 361-3132 callSC (491423 BP, SUERC-686703) Distillery Cave Great Britain 12651 3310-3300 callSC (491423 BP, SUERC-68673) Holm of Papa Westray North Great Britain 12651 3330-3000 callSC (491422 BP, SUERC-68723) Isbister, Orkney Great Britain 12980 336-1102 callSC (447123 BP, SUERC-68723) Isbister, Orkney Great Britain 12981 3330-3000 callSC (4471249 BP, SUERC-68723) Isbister, Orkney Great Britain 12983 3310-3104 callSC (4447249 BP, SUERC-68723) Isbister, Orkney	I2657	3952–3781 calBCE (5052±30 BP, SUERC-68701)	Macarthur Cave	Great Britain
12659 3762-3644 calBCE (4914-27 BP, SUERC-68702) Distillery Cave Great Britain 12760 3700-3535 calBCE (4856-33 BP, SUERC-68704) Point of Cott, Orkney Great Britain 12763 3700-3535 calBCE (4851-33 BP, SUERC-68703) Tulach an CSionnach Great Britain 12636 3520-3362 calBCE (4754-33 BP, SUERC-68671) Clachaige Great Britain 12648 3517-3352 calBCE (4651-33 BP, SUERC-68671) Distillery Cave Great Britain 12649 3514-3353 calBCE (4754+35 BP, SUERC-68671) Distillery Cave Great Britain 12650 3500-3360 calBCE (4754+35 BP, SUERC-68671) Distillery Cave Great Britain 12651 3310-3300 calBCE (4754+35 BP, SUERC-68672) Ibitime O Papa Westray North Great Britain 12651 3330-3000 calBCE (4754+35 BP, SUERC-68672) Ibitiser, Orkney Great Britain 12788 3335-3024 calBCE (4452+32 BP, SUERC-68721) Ibitiser, Orkney Great Britain 12984 3333-3027 calBCE (445+29 BP, SUERC-68721) Ibitiser, Orkney Great Britain 12984 3325-3024 calBCE (445+29 BP, SUERC-68721) Ibitiser, Orkney Great Britain 12984	I2633	3766-3642 calBCE (4911±32 BP, SUERC-68634)	Tulloch of Assery B	Great Britain
1269 3701–3640 calBC: (4881+25 BP, SUERC-68704) Distillery Cave Great Britain 12766 3706–3536 calBC: (4856+33 BP, SUERC-68638) Tulach an (TSionnach Great Britain 12635 3553–3390 calBC: (4851+34 BP, SUERC-68640) Holm of Assery A Great Britain 12636 3520–3362 calBC: (4631+23 BP, SUERC-68703) Distillery Cave Great Britain 12636 3514–3353 calBC: (4631+23 BP, SUERC-68703) Distillery Cave Great Britain 12637 3510–3340 calBC: (4674+36 BP, SUERC-68703) Distillery Cave Great Britain 12636 3510–3340 calBC: (4674+36 BP, SUERC-68703) Dowing Course Great Britain 12637 3510–3340 calBC: (4674+36 BP, SUERC-68703) Point of Coti, Orkney Great Britain 12645 3330–3090 calBC: (471+29 BP, SUERC-68723) Isbister, Orkney Great Britain 12945 3336–3027 calBC: (4471+29 BP, SUERC-68723) Isbister, Orkney Great Britain 12945 3325–3026 calBC: (447+29 BP, SUERC-68723) Isbister, Orkney Great Britain 12943 3326–3027 calBC: (447+32 BP, SUERC-68723) Isbister, Orkney Great Britain 12943 <t< td=""><td>I2659</td><td>3762–3644 calBCE (4914±27 BP, SUERC-68702)</td><td>Distillery Cave</td><td>Great Britain</td></t<>	I2659	3762–3644 calBCE (4914±27 BP, SUERC-68702)	Distillery Cave	Great Britain
1276 3706-3536 calBCE (4856-33 BP, SUERC-69074) Point of Cott, Orkney Great Britain 12634 3706-3535 calBCE (4851-34 BP, SUERC-68639) Tulach an Yšonnach Great Britain 12636 3520-3362 calBCE (4615-29 BP, SUERC-68673) Tulach of Assery A Great Britain 12688 3517-3362 calBCE (4645-29 BP, SUERC-68711) Clachaig Great Britain 12660 350-3360 calBCE (4754-35 BP, SUERC-68674) Holm of Papa Westray North Great Britain 12667 350-3340 calBCE (470-453 BP, SUERC-68674) Holm of Papa Westray North Great Britain 12687 330-3090 calBCE (4525-36 BP, Poz-83483) Bion Rowing Course Great Britain 12888 3316-3102 calBCE (4452-31 BP, SUERC-68724) Isbister, Orkney Great Britain 12978 3336-3040 calBCE (4464-33 BP, SUERC-68724) Isbister, Orkney Great Britain 12978 3327-3036 calBCE (4464-33 BP, SUERC-68725) Isbister, Orkney Great Britain 12933 3314-2942 calBCE (4462-39 BP, SUERC-68726) Isbister, Orkney Great Britain 12933 334-2942 calBCE (4462-39 BP, SUERC-68726) Isbister, Orkney Great Britain 129	I2691	3701–3640 calBCE (4881±25 BP, SUERC-68704)	Distillery Cave	Great Britain
1264 3704-3535 calBCE (4851434 BP, SUERC-68638) Tullach an l'Sionnach Great Britain 12655 653-3390 calBCE (4766437 BP, SUERC-68640) Holm of Papa Westray North Great Britain 12666 3514-3352 calBCE (4651±29 BP, SUERC-68703) Distillery Cave Great Britain 12660 3514-3353 calBCE (4651±29 BP, SUERC-68703) Distillery Cave Great Britain 12657 3510-3360 calBCE (4671±29 BP, SUERC-68703) Distillery Cave Great Britain 12660 3514-3353 calBCE (4710±35 BP, Poc.83483) Eion Rowing Course Great Britain 12680 3361-3102 calBCE (4712±39 BP, SUERC-68673) Point of Cott, Orkney Great Britain 12878 336-3042 calBCE (4471±29 BP, SUERC-68725) Isbister, Orkney Great Britain 12978 336-3042 calBCE (4471±29 BP, SUERC-68725) Isbister, Orkney Great Britain 12978 336-3042 calBCE (4451±29 BP, SUERC-68721) Isbister, Orkney Great Britain 12979 334-2942 calBCE (4451±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12973 334-2942 calBCE (4354±36 BP, Poce.83492) Isbister, Orkney Great Britain 12973	I2796	3706–3536 calBCE (4856±33 BP, SUERC-69074)	Point of Cott, Orkney	Great Britain
1263 $3653-3390$ calBCE (4796437 BP, SUERC-68639) Tulloch of Assery A Great Britain 12636 $3520-336c$ calBCE ($46545-29$ BP, SUERC-68711) Clachaig Great Britain 12660 $3511-335c$ calBCE ($4654-29$ BP, SUERC-68713) Distillery Cave Great Britain 12650 $3500-3360$ calBCE ($4754+36$ BP, SUERC-68642) Holm of Papa Westray North Great Britain 12667 $3510-3340$ calBCE ($4754+36$ BP, SUERC-68642) Holm of Papa Westray North Great Britain 12680 $3361-310c$ calBCE ($4754+36$ BP, SUERC-68642) Holm of Papa Westray North Great Britain 12980 $3361-310c$ calBCE ($4452+39$ BP, SUERC-68672) Isbister, Orkney Great Britain 12978 $3336-302c$ calBCE ($4464-33$ BP, SUERC-68720) Isbister, Orkney Great Britain 12935 $334-394c$ calBCE ($4452+29$ BP, SUERC-68720) Isbister, Orkney Great Britain 12935 $3314-394c$ calBCE ($4452+29$ BP, SUERC-68720) Isbister, Orkney Great Britain 12937 $301-286c$ calBCE ($4392+29$ BP, SUERC-68720) Isbister, Orkney Great Britain 12933 $301-286c$ calBCE ($4392+29$ BP, SUERC-68720) Isbister, Orkney <td< td=""><td>I2634</td><td>3704–3535 calBCE (4851±34 BP, SUERC-68638)</td><td>Tulach an t'Sionnach</td><td>Great Britain</td></td<>	I2634	3704–3535 calBCE (4851±34 BP, SUERC-68638)	Tulach an t'Sionnach	Great Britain
12636 3520-3362 callbCE (4651±33 BP, SUERC-68640) Holm of Papa Westray North Great Britain 12660 3514-3353 callbCE (4631±29 BP, SUERC-68701) Clachaig Great Britain 12660 3510-3360 callbCE (4751±36 BP, SUERC-68703) Distillery Cave Great Britain 12667 3510-3340 callbCE (4797±35 BP, SUERC-68641) Holm of Papa Westray North Great Britain 12661 3330-3090 callbCE (4507±33 BP, SUERC-68643) Holm of Papa Westray North Great Britain 12863 3330-3090 callbCE (4471±29 BP, SUERC-68724) Holm of Papa Westray North Great Britain 12978 3336-3012 callbCE (4471±29 BP, SUERC-68725) Isbister, Orkney Great Britain 12934 3327-3036 callbCE (4471±29 BP, SUERC-68725) Isbister, Orkney Great Britain 12935 3336-3012 callbCE (4461±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12935 3336-3012 callbCE (447±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12936 3336-3012 callbCE (447±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12937 3001-2886 callbCE (475243 BP, SUERC-68723) Isbister, Orkney Great Britain	I2635	3653–3390 calBCE (4796±37 BP, SUERC-68639)	Tulloch of Assery A	Great Britain
12988 3517-3356 callBCE (4645±29 BP, SUERC-68711) Clachaig Great Britain 12660 3510-3356 callBCE (47154±36 BP, SUERC-68642) Holm of Papa Westray North Great Britain 12651 3500-3360 callBCE (47154±36 BP, SUERC-68642) Holm of Papa Westray North Great Britain 12665 3622-3373 callBCE (4710±35 BP, Poz-83483) Eion Rowing Course Great Britain 12868 330-309 callBCE (471±29 BP, Poz-83484) Holm of Papa Westray North Great Britain 12988 3336-3024 callBCE (446±33 BP, SUERC-68724) Isbister, Orkney Great Britain 12978 3336-3024 callBCE (446±33 BP, SUERC-68725) Isbister, Orkney Great Britain 12933 3316-2424 callBCE (4471±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12933 3316-2102 callBCE (4451±29 BP, SUERC-68623) Jobyeness Great Britain 12933 101-2886 callBCE (4992+29 BP, SUERC-68623) Isbister, Orkney Great Britain 12932 2571-2544 callBCE (3992+29 BP, SUERC-68623) Isbister, Orkney Great Britain 12932 2571-2544 callBCE (3992+29 BP, SUERC-68721) Isbister, Orkney Great Britain <t< td=""><td>I2636</td><td>3520–3362 calBCE (4651±33 BP, SUERC-68640)</td><td>Holm of Papa Westray North</td><td>Great Britain</td></t<>	I2636	3520–3362 calBCE (4651±33 BP, SUERC-68640)	Holm of Papa Westray North	Great Britain
12660 3514–3353 calBCE (4631±29 BP, SUERC-68703) Distillery Cave Great Britain 12650 3500–3360 calBCE (4754±36 BP, SUERC-68642) Holm of Papa Westray North Great Britain 12637 3510–3340 calBCE (4697±33 BP, SUERC-68641) Holm of Papa Westray North Great Britain 12630 3361–3102 calBCE (4710±35 BP, SUERC-68073) Point of Cott, Orkney Great Britain 12651 3330–309 calBCE (471±25 BP, SUERC-68073) Point of Cott, Orkney Great Britain 12980 3336–3022 calBCE (471±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12934 3327–3036 calBCE (4461±29 BP, SUERC-68726) Isbister, Orkney Great Britain 12933 3310–302 calBCE (4451±29 BP, SUERC-68726) Isbister, Orkney Great Britain 12933 301–2886 calBCE (4304±36 BP, SUERC-68722) Isbister, Orkney Great Britain 12933 301–2464 calBCE (4304±39 BP, SUERC-68722) Isbister, Orkney Great Britain 12932 251–2446 calBCE (4304±39 BP, SUERC-68722) Isbister, Orkney Great Britain 12933 301–2886 calBCE (4364±39 BP, SUERC-68723) Isbister, Orkney Great Britain <t< td=""><td>I2988</td><td>3517–3362 calBCE (4645±29 BP, SUERC-68711)</td><td>Clachaig</td><td>Great Britain</td></t<>	I2988	3517–3362 calBCE (4645±29 BP, SUERC-68711)	Clachaig	Great Britain
12650 3500-3300 calBCE (47734-36 BP, SUERC-68642) Holm of Papa Westray North Great Britain 12637 3510-3340 calBCE (46773-35 BP, VERC-68641) Holm of Papa Westray North Great Britain 12605 3622-3373 calBCE (4710+35 BP, Poz-83483) Eton Rowing Course Great Britain 12808 3361-3102 calBCE (4520-33 BP, SUERC-68073) Point of Cont, Orkney Great Britain 13085 3330-3002 calBCE (4471=29 BP, SUERC-68725) Isbister, Orkney Great Britain 12978 3336-302 calBCE (4446-433 BP, SUERC-68725) Isbister, Orkney Great Britain 12935 3336-3012 calBCE (4441+29 BP, SUERC-68721) Isbister, Orkney Great Britain 12933 301-288c calBCE (4406-433 BP, SUERC-68722) Isbister, Orkney Great Britain 12933 310-288c calBCE (430+232 BP, SUERC-68722) Isbister, Orkney Great Britain 12933 101-886c adBCE (390+232 BP, SUERC-68722) Isbister, Orkney Great Britain 12933 2571-2434 calBCE (390+232 BP, Poz-84492) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12932 2571-2348 calBCE (380+33 BP, Poz-84492) Hamesbury Down, Wiltshire Great Britain	I2660	3514–3353 calBCE (4631±29 BP, SUERC-68703)	Distillery Cave	Great Britain
12637 3510-3340 calBCE (4697-33 BP, SUERC-68641) Holm of Papa Westray North Great Britain 12605 3523-3373 calBCE (4710-35 BP, Poz-84843) Eno Rowing Course Great Britain 12808 3361-3102 calBCE (4525-36 BP, SUERC-68723) Holm of Papa Westray North Great Britain 12815 3330-3027 calBCE (4452-93 BP, SUERC-68724) Isbister, Orkney Great Britain 12934 3327-3036 calBCE (4451-29 BP, SUERC-68723) Isbister, Orkney Great Britain 12935 3336-3012 calBCE (4451-29 BP, SUERC-68723) Isbister, Orkney Great Britain 12935 336-3012 calBCE (4451-29 BP, SUERC-68723) Isbister, Orkney Great Britain 12936 3011-2886 calBCE (4309-29 BP, SUERC-68723) Isbister, Orkney Great Britain 12937 3009-2764 calBCE (4309-29 BP, SUERC-68632) Isbister, Orkney Great Britain 12932 2571-2348 calBCE (3962-29 BP, SUERC-68621) Isbister, Orkney Great Britain 12932 2571-2348 calBCE (3862-35 BP, Poz-83492) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12612 2465-2209 calBCE (389-36 BP, SUERC-68721) Isbister, Orkney Great Britain 12614 2440-2200 calBCE (3829-35 BP, Poz-83492)	I2650	3500–3360 calBCE (4754±36 BP, SUERC-68642)	Holm of Papa Westray North	Great Britain
12605 3632-373 calBCE (4710e35 BP, 90c-83483) Eton Rowing Course Great Britain 12980 3361-3102 calBCE (4530e33 BP, SUERC-69073) Point of Cott, Orkney Great Britain 12081 3330-3020 calBCE (4471e29 BP, SUERC-68724) Isbister, Orkney Great Britain 12083 3330-3027 calBCE (4471e29 BP, SUERC-68725) Isbister, Orkney Great Britain 12978 3336-3024 calBCE (4466+33 BP, SUERC-68726) Isbister, Orkney Great Britain 12935 3336-3012 calBCE (4451±29 BP, SUERC-68726) Isbister, Orkney Great Britain 12979 3334-2942 calBCE (4451±29 BP, SUERC-68720) Isbister, Orkney Great Britain 12933 101-2886 calBCE (4390±29 BP, SUERC-68721) Isbister, Orkney Great Britain 12931 2010-2864 calBCE (390±32 BP, SUERC-68721) Isbister, Orkney Great Britain 12932 2571-2348 calBCE (390±32 BP, SUERC-68721) Isbister, Orkney Great Britain 12932 2571-2348 calBCE (380±35 BP, Poz-83402) Hasting Hil, Sunderland, Tyne and Wear Great Britain 12932 2571-2348 calBCE (3850±35 BP, Poz-83402) Hasting Hil, Sunderland, Tyne and Wear Great Britain	I2637	3510–3340 calBCE (4697±33 BP, SUERC-68641)	Holm of Papa Westray North	Great Britain
129803361–3102calBCE (4530 ± 33 BP, SUERC-69073)Point of Coft, OrkneyGreat Britain126513330–3007calBCE (4451 ± 29 BP, SUERC-68724)Holm of Papa Westray NorthGreat Britain129783330–3007calBCE (4464 ± 29 BP, SUERC-68724)Isbister, OrkneyGreat Britain129343327–3036calBCE (4464 ± 29 BP, SUERC-68725)Isbister, OrkneyGreat Britain129353334–3042calBCE (4451 ± 29 BP, SUERC-68726)Isbister, OrkneyGreat Britain129373334–2942calBCE (4451 ± 29 BP, SUERC-68726)Isbister, OrkneyGreat Britain126313098–2907calBCE (4431 ± 29 BP, SUERC-68726)Isbister, OrkneyGreat Britain126313098–2907calBCE (430 ± 29 BP, SUERC-68721)Isbister, OrkneyGreat Britain126302581–2444calBCE (3292 ± 29 BP, SUERC-68721)Isbister, OrkneyGreat Britain126122465–2209calBCE (3365 ± 25 BP, Poz-83492)Hasting Hill, Sunderland, Tyne and WearGreat Britain126122465–2209calBCE (332 ± 25 BP, NZA-3728)Amesbury Down, WiltshireGreat Britain124182440–2200calBCE (332 ± 25 BP, NZA-3728)Amesbury Down, WiltshireGreat Britain124592460–2140calBCE (339 ± 25 BP, NZA-3728)Amesbury Down, WiltshireGreat Britain124572400–2103calBCE (350 ± 35 BP, Poz-83407)Amesbury Down, WiltshireGreat Britain124582137–1930calBCE (350 ± 35 BP, Poz-83407)Amesbury Down, WiltshireGreat Britain	I2605	3632–3373 calBCE (4710±35 BP, Poz-83483)	Eton Rowing Course	Great Britain
126513330-3090callCE (4252 ± 36 BP, SUERC-68724)Holm of Papa Westray NorthGreat Britain130853330-3027callCE (4464 ± 29 BP, SUERC-68724)Isbister, OrkneyGreat Britain129783326-3024callCE (4464 ± 29 BP, SUERC-68723)Isbister, OrkneyGreat Britain129343327-3036callCE (444 ± 29 BP, SUERC-68723)Isbister, OrkneyGreat Britain129793334-3012callCE (444 ± 29 BP, SUERC-68723)Isbister, OrkneyGreat Britain129333011-2886callCE (440 ± 29 BP, SUERC-68723)Isbister, OrkneyGreat Britain129333011-2886callCE (440 ± 23 BP, SUERC-68722)Isbister, OrkneyGreat Britain129333011-2886callCE (4275 ± 33 BP, SUERC-68722)Isbister, OrkneyGreat Britain129322571-2348callCE (3962 ± 29 BP, SUERC-68721)Isbister, OrkneyGreat Britain126102465-2209callCE (385 ± 25 BP, NZA-32788)Amesbury Down, WiltshireGreat Britain124162470-2280callBC (332 ± 25 BP, NZA-32788)Amesbury Down, WiltshireGreat Britain124592460-2140callBCE (372 ± 38 BP, QAA-13562)Amesbury Down, WiltshireGreat Britain124512440-2200callBCE (373 ± 28 BP, QAA-13562)Amesbury Down, WiltshireGreat Britain124522270-2030callBCE (373 ± 28 BP, QAA-32484)Amesbury Down, WiltshireGreat Britain124522280-2030callBCE (373 ± 28 BP, QAA-32490)Amesbury Down, WiltshireGreat Britain124522277-2030<	I2980	3361–3102 calBCE (4530±33 BP, SUERC-69073)	Point of Cott, Orkney	Great Britain
13085 3333-3027 calBCE (4471±29 BP, SUERC-68724) Isbister, Orkney Great Britain 12978 3336-3024 calBCE (4464±29 BP, SUERC-68725) Isbister, Orkney Great Britain 12934 3327-3036 calBCE (4466±33 BP, SUERC-69071) Isbister, Orkney Great Britain 12935 3334-2942 calBCE (4471±29 BP, SUERC-68723) Isbister, Orkney Great Britain 12937 3304-2942 calBCE (4472+29 BP, SUERC-68723) Isbister, Orkney Great Britain 12933 3011-2886 calBCE (4309+29 BP, SUERC-68633) Quoyness Great Britain 12932 2571-2348 calBCE (3962±29 BP, SUERC-68721) Isbister, Orkney Great Britain 12012 2465-2200 calBCE (3820±35 BP, Poz-83492) Isbister, Orkney Great Britain 12161 2470-2204 calBCE (3820±35 BP, Poz-83492) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12456 2470-2140 calBCE (3820±35 BP, Poz-83492) Amesbury Down, Wiltshire Great Britain 12457 2440-2200 calBCE (3820±30 BP, SUERC-36423) Amesbury Down, Wiltshire Great Britain 12457 2400-2201 calBCE (370±35 BP, Poz-83407) Amesbury Down, Wiltshire Great Britain 12457 2200-2030 calBCE (370±35 BP, Poz-83407) Y	I2651	3330–3090 calBCE (4525±36 BP, SUERC-68643)	Holm of Papa Westray North	Great Britain
12978 3332-3024 calBCE (4464±29 BP, SUERC-68725) Isbister, Orkney Great Britain 12934 3327-3036 calBCE (4466±33 BP, SUERC-68720) Isbister, Orkney Great Britain 12935 3334-3012 calBCE (4441±29 BP, SUERC-68726) Isbister, Orkney Great Britain 12937 3334-2942 calBCE (4447±29 BP, SUERC-68722) Isbister, Orkney Great Britain 12933 3011-2886 calBCE (4497±36 BP, SUERC-68722) Isbister, Orkney Great Britain 12937 3009-2764 calBCE (4309±29 BP, SUERC-68721) Isbister, Orkney Great Britain 12630 2581-2464 calBCE (399±32 BP, SUERC-68721) Isbister, Orkney Great Britain 12612 2465-2209 calBCE (385453 SP, Poz-83492) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12416 2470-2285 calBC (3830±30 BP, Beta-432804) Amesbury Down, Wiltshire Great Britain 12457 2460-2210 calBCE (3829±33 BP, SUERC-54823) Amesbury Down, Wiltshire Great Britain 12457 2460-2140 calBCE (389±35 BP, Poz-83407) Amesbury Down, Wiltshire Great Britain 12457 2460-2140 calBCE (379±35 BP, Poz-83407) Amesbury Down, Wiltshire Great Britain </td <td>13085</td> <td>3339–3027 calBCE (4471±29 BP, SUERC-68724)</td> <td>Isbister, Orkney</td> <td>Great Britain</td>	13085	3339–3027 calBCE (4471±29 BP, SUERC-68724)	Isbister, Orkney	Great Britain
12934 3327-3036 calBCE (4456±33 BP, SUERC-6971) Isbister, Orkney Great Britain 12935 3336-3012 calBCE (4451±29 BP, SUERC-68726) Isbister, Orkney Great Britain 12979 3334-2942 calBCE (4451±29 BP, SUERC-68726) Isbister, Orkney Great Britain 12933 3011-286 calBCE (4304±36 BP, SUERC-68072) Isbister, Orkney Great Britain 12933 3011-286 calBCE (302+29 BP, SUERC-68072) Isbister, Orkney Great Britain 12932 2571-2348 calBCE (362±29 BP, SUERC-68021) Isbister, Orkney Great Britain 12932 2571-2348 calBCE (382±29 BP, SUERC-68721) Isbister, Orkney Great Britain 12416 2440-2200 calBCE (382±29 BP, SUERC-68721) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12418 2440-2200 calBCE (382±35 BP, Poz-83429) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12459 2460-2140 calBCE (382±35 BP, N2A-32788) Amesbury Down, Wiltshire Great Britain 12457 2400-2140 calBCE (382±35 BP, N2A-32788) Amesbury Down, Wiltshire Great Britain 12457 2200-2031 calBCE (379±35 BP, Poz-83407) Yarmon Great Britain 12452 2289-2041 calBCE (370±35 BP, Poz-83407) <t< td=""><td>I2978</td><td>3336–3024 calBCE (4464±29 BP, SUERC-68725)</td><td>Isbister, Orkney</td><td>Great Britain</td></t<>	I2978	3336–3024 calBCE (4464±29 BP, SUERC-68725)	Isbister, Orkney	Great Britain
129353336-3012 calBCE (4451±29 BP, SUERC-68723)Isbister, OrkneyGreat Britain129793334-2942 calBCE (4447±29 BP, SUERC-68726)Isbister, OrkneyGreat Britain126313008-2907 calBCE (4384±36 BP, SUERC-68722)Isbister, OrkneyGreat Britain129333011-2886 calBCE (4309±29 BP, SUERC-68722)Isbister, OrkneyGreat Britain126302581-2464 calBCE (3099±22 BP, SUERC-68721)Isbister, OrkneyGreat Britain126322571-2348 calBCE (362±29 BP, SUERC-68721)Isbister, OrkneyGreat Britain126122465-2209 calBCE (386±35 BP, Poz-83492)Hasting Hill, Sunderland, Tyne and WearGreat Britain124162470-2285 calBC (3830±30 BP, Beta-432804)Amesbury Down, WiltshireGreat Britain124182440-2100 calBCE (3830±30 BP, SUERC-54823)Amesbury Down, WiltshireGreat Britain124532240-2140 calBCE (352)±38 BP, 0X-32788)Amesbury Down, WiltshireGreat Britain124532200-2031 calBCE (371±28 BP, SUERC-54823)Amesbury Down, WiltshireGreat Britain124532289-2041 calBCE (376)±35 BP, Poz-83407)YarutonGreat Britain124542137-1930 calBCE (373±25 BP, NZA-32480)Amesbury Down, WiltshireGreat Britain125662210-2030 calBCE (373±25 BP, NZA-32490)Amesbury Down, WiltshireGreat Britain125662210-2030 calBCE (373±25 BP, NZA-32490)Amesbury Down, WiltshireGreat Britain125662210-2030 calBCE (356)±35 BP, Poz-83407)YarutonGreat Britain125742195-1920 calBCE (366)±35 BP, Poz-83408)	I2934	3327–3036 calBCE (4466±33 BP, SUERC-69071)	Isbister, Orkney	Great Britain
$ 12979 3334-2942 calBCE (4447+29 BP, SUERC-68726) \qquad Isbister, Orkney \qquad Great Britain \\ 12631 3098-2907 calBCE (4438±36 BP, SUERC-686722) \\ 12933 3011-2886 calBCE (4309±29 BP, SUERC-68722) \\ 12977 3009-2764 calBCE (4275±33 BP, SUERC-68722) \\ 12812 calBC (2365±32 BP, SUERC-68722) \\ 12812 calBC (2365±32 BP, SUERC-68721) \\ 12812 calBC (2365±32 BP, Poz-83492) \\ 12416 2470-2285 calBC (23805±32 BP, NZA-32788) \\ 12418 2440-2200 calBCE (3855±25 BP, NZA-32788) \\ 12418 2440-2200 calBCE (3835±25 BP, NZA-32788) \\ 12452 calBC (2380±30 BP, Bt=4-342804) \\ 12452 calBC (2380±30 BP, SUERC-68721) \\ 12453 2240-2140 calBCE (3829±38 BP, OtxA-13562) \\ 12457 2240-2240 calBCE (3809±30 BP, SUERC-54210) \\ 12457 2240-2240 calBCE (3899±30 BP, SUERC-54210) \\ 12457 2240-2230 calBCE (370±35 BP, Poz-83407) \\ 12453 2280-2031 calBCE (370±35 BP, Poz-83407) \\ 12453 2280-2030 calBCE (370±35 BP, Poz-83407) \\ 12452 2195-1920 calBCE (370±35 BP, Poz-83407) \\ 1256 2210-2030 calBCE (3734±25 BP, NZA-32484) \\ Amesbury Down, Wiltshire \\ Great Britain \\ 1256 2210-2030 calBCE (3734±25 BP, NZA-32480) \\ Amesbury Down, Wiltshire \\ Great Britain \\ 1256 2210-2030 calBCE (3734±25 BP, NZA-32490) \\ Amesbury Down, Wiltshire \\ Great Britain \\ 1256 2210-2030 calBCE (3734±25 BP, NZA-32490) \\ Amesbury Down, Wiltshire \\ Great Britain \\ 1256 2210-2030 calBCE (3734±25 BP, NZA-32490) \\ Amesbury Down, Wiltshire \\ Great Britain \\ 12574 2140-1940 calBCE (366±30 BP, NZA-32494) \\ Amesbury Down, Wiltshire \\ Great Britain \\ 12576 2140-1940 calBCE (355\pm35 BP, Poz-83405) \\ Dairy Farm, Willington \\ Great Britain \\ 12576 2140-1940 calBCE (355\pm35 BP, Poz-83405) $	I2935	3336–3012 calBCE (4451±29 BP, SUERC-68723)	Isbister, Orkney	Great Britain
12631 3098-2907 calBCE (4384+36 BP, SUERC-68633) Quoyness Great Britain 12933 3011-2886 calBCE (4309+29 BP, SUERC-68722) Isbister, Orkney Great Britain 12030 2581-2464 calBCE (4275+33 BP, SUERC-68072) Isbister, Orkney Great Britain 12032 2571-2348 calBCE (3902+29 BP, SUERC-68721) Isbister, Orkney Great Britain 12012 2465-2209 calBCE (3865+35 BP, Poz-83492) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12418 2440-2200 calBCE (3855+35 BP, Poz-83492) Hasting Hill, Sunderland, Tyne and Wear Great Britain 12418 2440-2200 calBCE (3829+30 BP, SUERC-68721) Isbister, Orkney Great Britain 12418 2440-2200 calBCE (3829+38 BP, OxA-13562) Amesbury Down, Wiltshire Great Britain 12457 2460-2140 calBCE (3829+30 BP, SUERC-54823) Amesbury Down, Wiltshire Great Britain 12457 2460-2140 calBCE (3829+30 BP, SUERC-54823) Amesbury Down, Wiltshire Great Britain 12457 2200-2031 calBCE (3717+28 BP, SUERC-6975) Amesbury Down, Wiltshire Great Britain 12453 2280-2041 calBCE (370+35 BP, Poz-83407) Yarnton Great Britain 12453 2280-2041 calBCE (370+35 BP, Poz-83407) Yarnton Great Britain 12452 2195-1920 calBCE (3739+30 BP, NZA-322490) Amesbury Down, Wiltshire Great Britain 12566 2210-2030 calBCE (373+25 BP, Poz-83407) Yarnton Great Britain 12562 2277-2030 calBCE (373+25 BP, Poz-83407) Yarnton Great Britain 12562 2277-2030 calBCE (375+25 BP, NZA-32494) Amesbury Down, Wiltshire Great Britain 12562 2277-2030 calBCE (375+25 BP, Poz-83405) Dairy Farm, Willington Great Britain 12574 1415-1228 calBCE (3650+40 BP, Poz-83405) Dairy Farm, Willington Great Britain 12574 1415-1228 calBCE (3650+35 BP, Poz-83405) Dairy Farm, Willington Great Britain 12574 1415-1228 calBCE (3650+35 BP, Poz-83405) Dairy Farm, Willington Great Britain 12564 2207-2030 calBCE (375+27 BP, SUERC-5041) Amesbury Down, Wiltshire Great Britain 12564 22077-2030 calBCE (375+27 BP, SUERC-5041) Amesbury Down, Wiltshire Great Britain 12564 22077-2030 calBCE (3550+35 BP, Poz-83405) Dairy Farm, Willington Great Britain 12574 1415-1228 calBCE (305+35 BP, Poz-83404) Srigetszentm	I2979	3334–2942 calBCE (4447±29 BP, SUERC-68726)	Isbister, Orkney	Great Britain
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117751695-1600 calBCE (3344 \pm 27 BP, OXA-14308)Great Orme Mines, Llandudno, North WalesGreat Britain125741415-1228 calBCE (3065 \pm 36 BP, SUERC-62072)North Face Cave, Llandudno, North WalesGreat Britain127862459-2206 calBCE (3850 \pm 35 BP, Poz-83639)Szigetszentmiklós,Felső Ürge-hegyi dűlőHungary127872458-2202 calBCE (3840 \pm 35 BP, Poz-83640)Szigetszentmiklós,Felső Ürge-hegyi dűlőHungary127412458-2154 calBCE (3835 \pm 35 BP, Poz-83641)Szigetszentmiklós,Felső Ürge-hegyi dűlőHungary142292289-2135 calBCE (3775 \pm 25 BP, PSU-1750)Cova da MouraPortugal108262833-2480 calBCE (4051 \pm 28 BP, MAMS-25940)Paris Street, Cerdanyola, BarcelonaSpain104622566-2346 calBCE (395 \pm 29 BP, MAMS-25936)Arroyal I, BurgosSpain108252474-2300 calBCE (3915 \pm 29 BP, MAMS-25930)Paris Street, Cerdanyola, BarcelonaSpain	12610	1930-1/40 calBCE (3515±35 BP, P0Z-83498)	Summernill, Blaydon, Tyne and Wear	Great Britain
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12780 2437-2200 calBCE (3630±55 BF, F02-63059) Szigetszentmiktos, Felső Orge-negyi dűló Hungary 12787 2458-2202 calBCE (3840±35 BP, Poz-83640) Szigetszentmiklós, Felső Ürge-hegyi dűlő Hungary 12741 2458-2154 calBCE (3835±35 BP, Poz-83641) Szigetszentmiklós, Felső Ürge-hegyi dűlő Hungary 14229 2289-2135 calBCE (3775±25 BP, PSU-1750) Cova da Moura Portugal 10826 2833-2480 calBCE (4051±28 BP, MAMS-25940) Paris Street, Cerdanyola, Barcelona Spain 10257 2571-2350 calBCE (3965±29 BP, MAMS-25937) Paris Street, Cerdanyola, Barcelona Spain 10462 2566-2346 calBCE (3950±26 BP, MAMS-25936) Arroyal I, Burgos Spain 10825 2474-2300 calBCE (3915+29 BP, MAMS-25930) Paris Street, Cerdanyola, Barcelona Spain	123/4	1413-1228 CAIBLE (3003 \pm 30 BP, SUEKU-020/2) 2450 2206 colDCE (3850 \pm 25 DD Dog 82620)	North Face Cave, Liandudno, North Wales	Great Britain
12101 2436-2202 cand CE (3640±55 BF, F02-83640) Szigetszentmikios,Felső Urge-negyi dűlő Hungary 12741 2458-2154 calBCE (3835±35 BP, Poz-83641) Szigetszentmiklós,Felső Ürge-hegyi dűlő Hungary 14229 2289-2135 calBCE (3775±25 BP, PSU-1750) Cova da Moura Portugal 10826 2833-2480 calBCE (4051±28 BP, MAMS-25940) Paris Street, Cerdanyola, Barcelona Spain 10257 2571-2350 calBCE (3965±29 BP, MAMS-25937) Paris Street, Cerdanyola, Barcelona Spain 10462 2566-2346 calBCE (3950±26 BP, MAMS-25936) Arroyal I, Burgos Spain 10825 2474-2300 calBCE (3915+29 BP, MAMS-25930) Paris Street Cerdanyola, Barcelona Spain	12/00	2437-2200 calDUE (3030±33 BF, F0Z-83039) 2459 2202 colDUE (2840+25 DD D== 82(40)	Szigetszentmiklós, reiső Urge-negyi dulo	Hungary
12/41 2436-2134 calBCE (3835±55 BF, F02-83041) Szigetszentmikios,Feiso Orge-negyi dulo Hungary 14229 2289-2135 calBCE (3775±25 BP, PSU-1750) Cova da Moura Portugal 10826 2833-2480 calBCE (4051±28 BP, MAMS-25940) Paris Street, Cerdanyola, Barcelona Spain 10257 2571-2350 calBCE (3965±29 BP, MAMS-25937) Paris Street, Cerdanyola, Barcelona Spain 10462 2566-2346 calBCE (3950±26 BP, MAMS-25936) Arroyal I, Burgos Spain 10825 2474-2300 calBCE (3915±29 BP, MAMS-25939) Paris Street Cerdanyola, Barcelona Spain	12/8/	2430-2202 calDCE (3840±35 BF, P0Z-83040) 2459 2154 colDCE (2825+25 DD D== 82(41)	Szigetszentmiklós, relső Urge-negyi dulo	Tungary
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100202655-2460 calBCE (4051±26 BF, MAINS-25940)Paris Street, Cerdanyola, BarcelonaSpain102572571-2350 calBCE (3965±29 BP, MAMS-25937)Paris Street, Cerdanyola, BarcelonaSpain104622566-2346 calBCE (3950±26 BP, MAMS-25936)Arroyal I, BurgosSpain108252474-2300 calBCE (3915±29 BP, MAMS-25939)Paris Street, Cerdanyola, BarcelonaSpain	14229	2207-2155 CALDUE $(5775\pm25 \text{ DF}, FSU-1750)$ 2822 2480 collect ($4051\pm29 \text{ DE}$ MAMS 25040)	Cova ua Moula Daris Street Cardanyola Darcelona	Spain
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IOR25 2474–2300 calBCE (3915+29 BP MAMS-25939) Alloyal I, Bulgos Spain	10257	2571-2550 CalDCE (5905=27 DF, WIAWG-25957) 2566_2376 calBCE (2050=26 RD MAMS 25026)	Arroyal I Burgos	Spain
	10402	2474_2300 calBCF (3915+20 BP_MAMS-25930)	Paris Street Cerdanvola Barcelona	Spain