

Supplementary Information for

New perspectives on Neanderthal dispersal and turnover from Stajnia Cave (Poland)

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Section S1: The Central European and Eastern Micoquian

After the Eemian (MIS 5e), the European environment during the Late Middle Palaeolithic (MIS 5d – MIS 3) was characterized by frequent climatic oscillations^{1,2}. In Central and Eastern Europe, these climatic conditions favoured the development of steppe/taiga vegetation¹ and the migration of cold adapted fauna from the Arctic (e.g. woolly rhino, woolly mammoth, reindeer)³. Thus, after a long period of behavioural adaptation to forested habitats and semi-sedentary faunal communities⁴, Neanderthals coped with new ecological conditions characterized by extreme seasonality and reduced distribution of resources with decreasing temperatures^{5,6}. In response to these new environmental conditions, Neanderthals of Central and Eastern Europe modified their technical behaviours and, in addition to the commonly prepared core technologies, started to produce a wide range of asymmetric bifacial tools, leaf-shaped artefacts and bifacial scrapers^{7,8}. This techno-complex is generally known as Micoquian, due to the similarities with the bifacial tools of the French site La Micoque⁹, or *Keilmessergruppen*, stemming from the German term for an asymmetric bifacial knife, the *Keilmesser*^{10,11}. Since the production of these bifacial knives spread between eastern France¹²⁻¹⁴ and the northern Caucasus^{15,16}, the examples recorded between the Eastern Carpathians and the lower Volga are generally called Eastern Micoquian whereas the other examples are named Central European Micoquian^{8,17-19}.

The Central European Micoquian is well documented during the interpleniglacial periods (MIS 5c, MIS 5a and MIS 3) in Poland, Germany, Czech Republic, and Slovakia^{7,17,20-23} with fringes in Hungary²⁴ and north-eastern France²⁵⁻²⁷. Although some authors support a long chronology rooted in the late Acheulean^{17,28}, the Micoquian developed across the North European Plains only after the Eemian^{7,29}. Generally, the Micoquian lithic industry is characterized by discoid, hierarchized or Levallois core technology, a high number of scrapers, small circular scrapers (called *groszaks*), bifacial tools and asymmetric bifacial backed knives³⁰. These latter tools were produced using the plano-convex reduction strategy³¹, and in the archaeological record artefacts with different shapes and sizes are documented^{9,32-36}. Typologically, these stone tools are discriminated following the morphologies found at some key sites, and divided in types Bockstein, Balver or Buhlener *Keilmesser*, *Prądnik* or *Klausennische Messer*, Lichtenberger *Keilmesser*, and Königsau (or Wolgograd) *Keilmesser*^{7,9}. A distinctive feature of the Central European Micoquian of southern Poland, Germany and eastern France is the use of the *prądnik* technique (also called lateral tranchet blow), a technical procedure for re-sharpening the distal end of bifaces and scrapers by detaching one or more spalls along the working edge^{14,36-38}.

In the Eastern Micoquian, the production of bifacial knives arose during MIS 5c/MIS 5a in Crimea at Kabazi II³⁹ and persisted up to the end of the Middle Palaeolithic from the northern Caucasus to the Urals, and from the Outer Eastern Carpathians to the Volga basin^{8,15,40-43}. The technological features of the lithic industries of the Eastern Micoquian are very similar to those recorded in Central Europe. Discoid, hierarchized or Levallois core technologies were used for the production of flakes that were successively shaped in side-scrapers and convergent tools^{41,44}. Asymmetric backed knives (*Keilmesser*), *groszaks* and the use of the *prądnik* technique are less frequent or absent in the Eastern regions whereas symmetric bifaces and leaf-shaped artefacts are widespread^{16,19,45,46}. In Crimea, the distinction between different frequencies of stone tools permitted the recognition of different facies: a) the Ak-Kaya facies shows the highest percentages of bifacial tools, simple scrapers, and large tools and the lowest percentage of unifacial convergent tools; b) the Kiik-Koba facies has the lowest percentage of bifacial tools, simple scrapers, and the highest percentage of convergent tools; c) the Staroselian facies falls intermediate between the other two for all of these attributes⁴⁴.

In Central and Eastern Europe, the Neanderthals' technical behaviour was varied and several lithic assemblages without the production of bifacial knives are also documented, and attributed to the facies Levallois-Mousterian^{17,20,45,47}. Current hypotheses on the interpretation of these techno-complexes suggest either the presence of two different cultural traditions^{17,44} or the outcome of different mobility patterns carried out by the same groups of Neanderthals during their annual land-use cycles^{30,48,49}. Beyond these different interpretations, echoing the cultural *vs* functional debate of the 1970s^{50,51}, the marked separation between the two facies is often prompted by greater attention to bifacial tools over the core reduction strategies sustaining their primary roles in defining regional patterns^{7,16,52,53}. Thus, the technological features of the Levallois-Mousterian could be comprised in the broad technological plasticity of the Micoquian of the Central and Eastern Europe. Recently, the reassessment of the lithic assemblages of Königsau open-air site (Germany), the sole example of interstratification between *Keilmessergruppen* and Levallois-Mousterian in Central Europe, evidenced a common technological background between the two facies and pointed out that the main difference is recorded in the transport of the artefacts off-site rather than being two discrete cultural traditions⁵⁴. Another example is documented at Hallera Avenue open-air site in Wrocław (Poland) where a few bifacial shaping by-products and tools are found in a Levallois-Mousterian context^{55,56}. Conversely, in Crimea, a strict separation between the two facies is favoured and the appearance of Micoquian elements in the Levallois-Mousterian assemblages at Kabazi V rock-shelter is interpreted to be the result of mechanical mixture⁵⁷. Beyond these techno-typological differences, Neanderthals from the North and Eastern European Plains share similar behaviours in land use with patterns of high mobility across the territory^{21,23,54,58-60}. These compartments do not change through time and are maintained in both periglacial and boreal environments^{21,54,59}.

Section 2: Stratigraphic sequence of Stajnia Cave

The stratigraphic sequence of Stajnia Cave is mainly characterized by cave loams consisting of limestone rubble, sand, silt and clay (Fig. 1D)⁶¹. Post-depositional frost disturbances, partial sediment sinking, and modern distortions make the stratigraphy complicated. At the base is unit G, composed of orange-brown sandy cave loam with a small amount of limestone rubble, overlaid by unit F that consists of light-grey to brown sandy cave loams with low admixture of limestone rubble. Above unit F lays unit E divided into layer E2, consisting of light-grey sandy-silty cave loams with significant limestone rubble and containing few Middle Palaeolithic lithic artefacts, and layer E1, archaeologically sterile and composed of a large amount of limestone rubble. Above layer E1, unit D is the part of the sequence richest in Middle Palaeolithic artefacts and where the Neanderthal teeth were found. Unit D is divided into four layers (D3, D2, D2b, and D1 considering an additional layer D1a for layer D1 sediments found in secondary context in some part of the cave). Layer D3 consists of ~30 cm of dark brown sandy-silty-clayey cave loam with an admixture of fine limestone rubble. Layer D2 is a light brown cave loam with rubble whereas layer D2b is a discontinuous structure, probably formed during the deposition of the sediments of layer D2, composed of light brown sandy-clayey-silty cave loam with limestone rubble. Layer D1 is ~50 cm of light brown cave loam with rubble. In trench 2, a portion of the layer is distinguished as D1b. The uppermost part of the sequence includes unit C (layers C6, C7, C18 and C19), in which the sediments are partly disturbed by cryoturbation, unit B (layers B0-B9) composed of some lenses of yellow sandy cave loam, and unit A, a grey-black humus with limestone rubble deposited during the Holocene and mostly removed during late Medieval times⁶¹.

The chronological assessment of the sequence was carried out crossing dating methods with the geological features of the different units. Unit G was accumulated in a warmer climate and probably correlated with MIS 5c, whereas the sediments of unit F are related to slightly cooler conditions and are

associated, most likely, to MIS 5b⁶¹. The accumulation of sandy-silty loam in layer E2 suggests warm climatic conditions, possibly connected with MIS 5a. The sediment of layer E1 suggests a cold and harsh environment and is associated with MIS 4. A radiocarbon date on an ungulate bone from this layer is >49,000 years (Table S1). The sediments of unit D were accumulated during MIS 3. In layer D3, two fragmented bones of a bear and an ungulate are >49,000 years (Table S1). In layer D2b, the dating of two mammoth tooth fragments by U-Th series yielded ages of ~52,900 BP, and a radiocarbon date on an ungulate bone is >49,000 years (Table S1). In layer D1, an Optically Stimulated Luminescence (OSL) date of cave loam is 45,900 BP (GdTL-1127) whereas the radiocarbon dating of a mammoth tusk fragment gave a result of $44,600 \pm 2,100$ ¹⁴C BP (OxA-24944), and of an ungulate bone yielded an age of $44,590 \pm 690$ ¹⁴C BP (Table S1). Another radiocarbon date on a bear tooth, found in layer D1, gave an age of >49,000 years (Poz-28892). In layer B, the results of $13,500 \pm 60$ ¹⁴C BP (Poz-28891) on a maxilla of a saiga by the radiocarbon method⁶² and of 8,950 years (GdTL-1126) on the cave loam by the OSL method, indicate an association with MIS 2⁶¹.

Section 3: tooth S5000

Morphological description of the tooth S5000

The S5000 specimen discovered in Stajnia Cave was described by⁶³ as a permanent maxillary right second molar (RM²). The crown is worn (wear stage 3 according to Molnar⁶⁴), and post-mortem events caused enamel loss in the lingual side near the cervix. The lingual root is well preserved (i.e., where DNA sampling was undertaken), but both buccal roots were damaged by post-mortem events. Despite being fairly worn, four main cusps can still be recognized on the occlusal surface (⁶³: Fig. 1 p. 412): the paracone (Pa), metacone (Me), hypocone (Hy) and protocone (Pr).

Specimen S5000 was diagnosed by⁶³ as belonging to Neanderthal based on the presence of a combination of traits frequently observed in Neanderthal M²s, such as: relatively large hypocone, specific pattern of the relative area of cusp base (Pr > Pa > Hy > Me)⁶⁵⁻⁶⁷ and the presence and form of the subvertical grooves on the interproximal facets (distal and mesial) of the crown⁶⁸.

The buccolingual (BL = 11.0 mm) and mesiodistal diameter (MD = 10.72 mm - value corrected for interproximal wear; 9.6 mm - uncorrected value), (⁶³: ESM 4.3) and the values of two indices (the Robustness Index (CBA = BL x MD) and the Crown Shape Index (CSI = BL/MD x 100)) of the S5000 specimen are presented in Table S2, along with data about crown metric traits of M² hominin samples collected from the scientific literature as well as the number of standard deviations (Z-scores) of the S5000 tooth from the M² hominin sample means. The results indicate that the S5000 BL diameter is nearest to the mean of recent *H. sapiens* (RHs) but it does not depart from the mean established for Early Neanderthals (EN), Late Neanderthals (LN), Skhul/Qafzeh early *H. sapiens* (SQ) and Late Upper Palaeolithic *H. sapiens* (LUPHs) (Table S2). With regard to the MD diameter, specimen S5000 is nearest the mean values established for SQ, EN, LN and EUPHs (Table S2). The Z – scores computed for the two indices, i.e. CBA and CSI, of S5000 are nearest the means established for Upper Palaeolithic *H. sapiens* and Neanderthals (for CBA), and Early *H. sapiens* and Neanderthals (for CSI) (Table S2). The results presented above do not exhibit significant taxonomic indications and are congruent to Bailey⁶⁵ Bailey⁶⁶ observation that crown diameters provide limited information for the taxonomic assessments of hominin M²s. However, the bivariate analysis of MD and BL crown diameters was carried out using equiprobable ellipses (see e.g.⁶⁹) in PAST software⁷⁰ and in the obtained bivariate plot specimen S5000 falls outside the equiprobable ellipses (95%) of all hominin groups of our comparative sample, except Neanderthals (Fig. S1).

Topographic information on the enamel-dentine junction (EDJ) surface (see main text and Fig. 2) supports a Neanderthal attribution of the tooth. The EDJ traits of the S5000 tooth were described according to the terminology and classification provided by the Arizona State University Dental Anthropology System (ASUDAS) ^{71,72} and compared to that observed in Neanderthal M²s ^{72,73}.

Section 4: Ancient DNA

Authentication of ancient DNA fragments in Stajnia S5000

Ancient specimens are often contaminated by present-day human DNA ⁷⁴⁻⁷⁶, requiring the authentication of the hominin-like fragments retrieved from the Stajnia S5000 specimen. We, therefore, determined the frequency of C to T substitutions in the sequence alignments. These substitutions arise predominantly at the ends of ancient DNA molecules through deamination of cytosines (C) to uracils (U) ⁷⁷, which are then read as thymines (T) by DNA polymerases, and are characteristic for authentic ancient DNA ^{75,78}. Fragments with terminal C to T substitutions were observed at high frequency in all ten libraries, suggesting that at least some of the fragments were of ancient origin (Table S3), including those recovered from the phosphate buffer used for decontamination.

Attributing the mitochondrial DNA of Stajnia S5000 to a hominin group and molecular DNA dating

In order to determine whether the mtDNA of Stajnia S5000 originates from a modern human or a Neanderthal, we first studied the state of DNA fragments overlapping positions in the mitochondrial genome at which these two hominin groups differ ⁷⁹. To alleviate the influence of substitutions derived from deamination, we ignored all forward strands where one of the possible states at an informative state was a C and all reverse strands where one of the possible states was G.

Given the present-day human DNA contamination estimates among all mtDNA sequences recovered from Stajnia S5000, we next reconstructed the mitochondrial genome sequence of Stajnia S5000 using deaminated fragments only and requiring a position to be covered by at least three sequences, of which two thirds had to be in agreement, and the base quality at the position was 20 or higher ⁷⁹. In order to prevent deamination-induced C to T substitutions from affecting the reconstruction of the consensus, we converted Ts on the forward strands and As on the reverse strands in the first three and the last three positions of DNA fragments into Ns. After the realignment of the mtDNA sequences to the mitochondrial genome of Vindija 33.16 ⁸⁰, five positions were still covered by two or fewer sequences and nine positions had less than two thirds of sequences supporting the same state. Thus, we exclude these positions from all comparative mtDNA genomes in our downstream analyses.

The multiple sequence alignment including Stajnia S5000 consensus sequence and the mitochondrial genomes of 54 present-day humans ⁸¹, ten ancient modern humans ^{75,82-86}, 24 Neanderthals ^{80,81,87-95}, four Denisovans ⁹⁶⁻⁹⁹, a hominin from Sima de los Huesos ⁷⁹ and the chimpanzee ¹⁰⁰ was generated using MAFFT ¹⁰¹.

We removed all the positions from the alignment containing missing data, which include positions we were unable to resolve in Stajnia S5000 mtDNA genome and the positions in other mtDNA genomes in the multiple sequence alignment which have missing data. We used jModelTest ¹⁰² to identify the best substitution model (TN93+I+G). The number of pairwise differences among the full mitochondrial genomes and after restricting the analyses to the coding region only (positions 577-16,023 of the rCRS) was calculated using MEGA7 ¹⁰³ and the maximum parsimony trees (Fig S2 and S3) were generated using Parsimony ratchet from the R package *phangorn* ¹⁰⁴.

We used Beast2 (version v2.4.7, ¹⁰⁵) to estimate the molecular age of Stajnia S5000 mtDNA genome by taking advantage of ten Neanderthals and ten ancient modern humans (Table S6) that are directly radiocarbon dated as multiple calibration points ^{82,106}. For this analysis we aligned the mitochondrial genome of Stajnia S5000 using MAFFT ¹⁰¹ to the mitochondrial genomes of 24 Neanderthals ^{80,81,87-95}, 54 present-day humans ⁸¹, ten radiocarbon dated ancient modern humans ^{75,82-86}, and Denisova 3 mitochondrial genome ⁹⁷ to be used as an outgroup. As before, all the positions containing missing data were removed from the alignment, and only the coding region of the mtDNA genome (positions 577-16,023 of the rCRS) was retained for the analysis ⁸².

The best fitting substitution model, as determined by jModelTest (version 2.1.7 ¹⁰², was Tamura-Nei (TN93) with a fraction of invariable sites and gamma distributed rate among the sites (TN93+I+G), as above. We investigated an uncorrelated log-normal distributed relaxed clock and a strict clock as two different models of rate variation, and a constant size and Bayesian Skyline as tree priors ⁸³. We used the fixed mutation rate of 1.57×10^{-8} substitutions per site per year for the coding region ⁸². We set the date of present-day human mtDNA genomes to zero, and used uniform priors for ancient modern humans and Neanderthals that were directly dated (Table S6). For the undated Neanderthals, to estimate their age, we used a prior of the age ranging from 30,000 to 200,000 years ago with an initial value of 50,000 years ⁸⁹. For each model, we carried out two independent Markov Chain Monte Carlo (MCMC) runs with 30,000,000 iterations each, sampling every 1,000 steps, and using 10% of the iterations as a burn-in. The four models were then compared to each other using the stepping stone and path sampling ¹⁰⁷. We determined that the strict clock and Bayesian skyline tree prior best fit the data. We then used these model combinations and ran three independent MCMC runs with 75,000,000 iterations each, sampling trees and parameter values every 2,000 iterations. We combined the results of these runs with LogCombiner ¹⁰⁵ and used 10% of the iterations as burn-in. The resulting Beast2 tree was visualised using FigTree (version: v1.4.2) (<http://tree.bio.ed.ac.uk/software/figtree/>).

Section 5: The faunal assemblages

The faunal remains found in Stajnia Cave include more than 13,500 bones, bone fragments and teeth identified as belonging to larger mammals and birds, and more than 31,000 determined teeth and bones of other vertebrates (including small mammals, reptiles and amphibians). The larger faunal remains were obtained directly during the excavations at Stajnia Cave and the smaller bone remains during the process of flotation, or sieving the sediments through sieves with mesh sizes of 3-4 mm. Most of larger mammals were identified to the species level, however a detailed zooarchaeological study of the total faunal assemblage is currently being conducted. Bone quantification comprises the number of identifiable specimens (NISP), if possible to species level, and otherwise grouped per size class, and minimum numbers of individuals (MNI) calculated after Lyman ¹⁰⁸. The largest bones found during excavation and wet sieving were recorded, similarly to the other finds, within the stratigraphic unit and square meter, in layers five centimetres thick. However, in most cases the three-dimensional location was recorded of specific bones excavated *in situ*.

The fauna of larger mammals is composed of at least 26 species belonging to carnivores (Carnivora) and herbivores (Artiodactyla, Perissidactyla and Proboscidea) (total NISP = 4,698, total MNI = 604). Most identified large mammals were found in the archaeological levels of unit D (NISP = 1,310, MNI = 128) and older layers of unit C (MNI = 1,873, MNI = 204) (for the stratigraphic subdivision see [SI Appendix Section 2](#) and ⁶¹, Fig. 9). Probably the deposition of at least part of the collection of larger mammal bones occurred

as a result of human activity, but as already mentioned, taphonomic and archeozoological analysis has not yet been carried out.

The fauna of herbivorous mammals in Stajnia Cave is dominated by representatives of the so-called *Mammuthus-Coelodonta* Complex^{3,109,110} and is represented by 9 species (Table S9). The reindeer (*Rangifer tarandus*) is the most abundant species found in all layers of this site, especially in archaeological units D and C. The material belonging to the reindeer are teeth, antlers and bone of the post-cranial parts of the skeleton. Based on the remains of antlers, it can be stated that the majority of individuals were represented by females¹¹¹. Steppe bison (*Bison priscus*) is also relatively common in the younger layers of unit C. Other species associated with the steppe and steppe-tundra habitat, namely the mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*) and the wild horse (*Equus ferus*) were represented by single individuals. In the material of these species, there are only teeth or teeth fragments. The woolly rhinoceros is represented mainly by the remains of young individuals. Attention should be drawn to the presence of saiga antelope (*Saiga tatarica*), found only in unit B, a rare species in Poland^{62,112}. In upper layers of unit C (end of MIS 3), there were found a few remains of red deer (*Cervus elaphus*), which may indicate the presence of forests.

The carnivore paleocommunity from Stajnia Cave consists of 18 species (Table S9). The material is strongly fragmented, and there are almost no complete or large bones of large carnivores present, rather the material is dominated by isolated teeth and smaller bones. Contrary to these, in smaller carnivores long bones and mandibles dominate, especially in mustelids. Among three canids present, the most numerous is red fox (*Vulpes vulpes*), although also the wolf (*Canis lupus*) and Polar fox (*Vulpes lagopus*) are numerous. Amongst the wolf (*Canis lupus*) remains some specimens showed morphological similarity to steppe/cave wolf, an ectomorph typical for the Late Pleistocene open grasslands.

Bears are totally dominated by individuals of the last and most advanced member of cave bear speleoid lineage, *Ursus spelaeus ingressus*. Particularly high, especially in units D and C is also the number of young individuals, represented mostly by milk dentition. Among the most unique finds is the third phalanx of speleoid bear, from layer C18, one of the youngest ever found in Europe¹¹³. The morphometric and morphological analysis confirmed the attribution of speleoid bear from Stajnia Cave to the *U. s. ingressus*. The typical individual of *U. s. ingressus* from Stajnia Cave was a very robust and large speleoid bear, with an average weight of 600-800 kg for males, and with an average weight of 250-400 kg for females. Multiple-coned and enlarged tooth cusps, broadened molar crowns and the lack of additional premolars confirmed their full herbivorous specialization. P4 morphotypes represented a multi-coned, broad type E, with enlarged main cusps. Some specimens from unit G hold many primitive features, and may partially represent an early stage of *spelaeus* lineage, transitional between *deningeri* and *spelaeus*. The brown bear (*Ursus arctos*) is much rarer, and in Late Pleistocene units E-C some material of *Ursus arctos priscus* was found, characteristic of open grasslands paleocommunities.

Mustelids are very abundant with the largest species including wolverine (*Gulo gulo*) and badger (*Meles meles*) represented by quite scarce material. The presence of steppe polecat (*Mustela eversmannii*), a typical steppe species is noteworthy. An astonishing number of stoat (*Mustela erminea*) and weasel (*Mustela nivalis*) remains are mostly correlated with the activity of birds of prey. Remains of European pine marten (*Martes martes*) from Stajnia cave belonged mostly to moderately large and quite gracile individuals, typical of the warmer periods as well as postglacial and Holocene sediments. The obtained morphotypes of the lower dentition are also typical for modern *M. martes*. Some specimens of *M. martes* from units E, D and C are large in size and are correlated with cooler phases of the Late Pleistocene

The stoat (*Mustela erminea*) from Stajnia cave is characterized by robust build, subtly marked by a longitudinal bone furrow transversely along the lower dental series on the lingual side of the mandibular shaft, strongly marked extension of the posterior part of the P4 crown, a robust crown and a long M1 trigonid and long and narrow M1 talonid. The crown broadening on the base of the protoconid is especially well marked.

The most numerous material of carnivores is represented by weasel (*Mustela nivalis*), where males strongly outnumber females. The least common material belongs to small to medium and gracile individuals. The dominance of medium sized specimens can be correlated with a mild and rather warm climate. However, the presence of the small weasels might suggest that they lived in cooler periods with harsh weather and continental climatic influence.

Among cats, the European wildcat (*Felis silvestris*) is most numerous. Quite abundant is cave hyena (*Crocota crocuta spelaea*), with the most numerous remains in unit C. The absence of coprolites and the discovery of single milk teeth suggest that in some layers the cave was not used as hyena den.

Taxonomic determination of birds, small mammals, and other remains (reptiles and amphibians) is not complete and therefore no comprehensive quantitative and spatial analysis of the fauna is currently available. The avifauna found in situ consists of almost 600 bone remains and is dominated by the genus *Lagopus* (*L. lagopus* and less frequently *L. muta*) as well as corvids, with dominant *Corvus monedula*, and the genus *Tetrao*. Many more bird remains, belonging to several smaller species, were found by wet screening in almost every sample. An extremely large number of remains of small mammals were obtained thanks to the flotation of almost all cave deposits. More than 25 species of small mammal remains were identified in all layers (ca. 50% of remains come from complex D). They include insectivorous species, first of all Soricomorpha, e.g. various species of shrews (genus *Sorex*) (NISP = 507) and bats (Chiroptera) (NISP = 377). Lagomorphs (Lagomorpha) include hares (*Lepus*) and pikas (*Ochotona*) (NISP=1,050). Rodents (Rodentia) distinctly prevail in the assemblage of Stajnia Cave and include over 31,000 items determined to the species level. In all layers of Stajnia Cave, small mammal remains represent “non-analogue” or “disharmonious” associations, typical for all sites from Kraków-Częstochowa Upland¹¹⁴⁻¹¹⁶. The mix of steppe, boreal and woodland species is the most characteristic feature of such assemblages. The small mammal associations are dominated by inhabitants of well-drained or wet tundra or other open habitats, represented by the collared lemming (*Dicrostonyx torquatus*) (NISP = 5,400), Norway lemming (*Lemmus lemmus*) (NISP = 3,727), tundra vole (*Alexandromys oeconomus*) (NISP = 4,711), common and/or field vole (*Microtus arvalis/agrestis* group) (NISP = 3,101) and the most numerous European narrow-skulled vole (*Lasiopodomys anglicus*) (NISP = 13,036), previously known mostly under the name *Lasiopodomys gregalis* (in terms of changing the nomenclature, compare¹¹⁷). These species constitute between approximately 91-94% of all remains of small mammals in all studied layers. In layers of units D and E the most numerous were *L. anglicus* (from 29 to 36%), *D. torquatus* (from 13 to 18%), *L. lemmus* (from 9 to 16%), *M. arvalis / agrestis* (from 15 to 20%) and *A. oeconomus* (from 12 to 15%). The next ecological group of taxa in the non-analogue assemblage belongs to inhabitants of steppe or other dry-open habitats, which are not very numerous in the small mammal assemblage of Stajnia Cave (frequency around 1-3%). Species such as the common hamster (*Cricetus cricetus*), grey dwarf hamster (*Cricetulus migratorius*) or steppe lemming (*Lagurus lagurus*) occur only in some layers. The third most numerous group comprise species living in diverse biotopes. In Stajnia Cave many of them are relatively moist and damp habitats. They typically inhabit densely-vegetated areas along the edges of lakes, streams and marshes which can be found in tundra, taiga and forest-steppe. Wet meadows, bogs, riverbanks and flooded shores are all important habitats. The most characteristic species belonging to this ecological group is the European

water vole (*Arvicola amphibius*). The frequency of species inhabiting various kinds of woodland is low in all samples. However, vertebrate species found in all kinds of forests, densely-vegetated clearings, woodland edges and shrubs are present in almost every layer. Among small vertebrates, the most characteristic species of this kind is the bank vole (*Clethrionomys glareolus*), occurring with a frequency between approximately 2% and 4%. To this ecological group also belong the very rare Northern birch mouse (*Sicista betulina*), field mice (*Apodemus sylvaticus/flavicollis* group) as well as dormice (Gliridae) and squirrels (Sciuridae), present mainly in the upper layers. Although complete reconstructions of past ecosystems based on the fossil mammal cave assemblages are impossible (e.g., many species of small forested mammals can be underestimated), the correlation between climatic and ecological changes, and changes concerning the species constitution of the vertebrate fauna, is possible. The more temperate fauna at the bottom of the sequence (units G, F) was succeeded by colder fauna (units E, D, C), with a distinct predomination of tundra species towards the top of the sequence. The identified assemblages of rodents in layers from units D and E are characterized by very similar species composition and proportion of individual species. This situation may result from the accumulation of the described rodent assemblages in similar environmental conditions or in a relatively short time interval. However, these preliminary studies also indicate the presence of a mosaic of habitats, with forested and open areas, water streams and lakes, and swamps, as well as rocky areas, in all studied layers.

Section 6: Stajnia Cave in the context of the Central European and Eastern Micoquian

The preliminary study of the lithic assemblages of Stajnia Cave reveals a complex situation due to post-depositional processes that clearly displaced some artefacts between different levels. However, even if the assemblages are considered as a whole, the analysis indicates a high fragmentation of the *chaînes opératoires*, and the import *on-site* of configured cores, flakes and retouched tools (Table S10-S11). These features are typical of high mobility patterns and recurrent short-term occupations^{118,119}, a type of foraging behaviour common during the Middle Palaeolithic in Central Europe^{21,54,60,120}. The opening of the cave was probably too narrow for prolonged settlement, and the site could be considered as one of the logistical locations settled by Neanderthals during their forays in the Kraków-Częstochowa Upland.

Although the lithic assemblage of Stajnia Cave is highly fragmented and bifacial backed knives (*Keilmesser*) are absent, the presence of diagnostic pieces supports the association with the Central European Micoquian. Moreover, in Poland during MIS 5c-5a, the use of discoïd and centripetal technology, and the import of few Levallois flakes is frequent in the lower levels of Wylotne rock-shelter¹²¹, Biśnik Cave²⁸, Nietoperzowa Cave¹²², Raj Cave¹²³, Piekary I¹²⁴ and at the open-air sites of Piekary II, Piekary III¹²⁴, and Zwolen¹²⁵. Conversely, in Ciemna Cave and Obłazowa Cave, cores are rare and the lithic assemblages of the lower and upper units are mostly characterized by flakes and retouched tools^{126,127}. Generally, secondary operative chains, such as hierarchized and simple unidirectional methods, are also recurrent among these sites, and their frequencies vary on the base of site function and occurrences of the occupations^{28,121,124,125}. During MIS 3, the composition of the lithic series remain unchanged with a dominance of discoïd and centripetal (hierarchized and simple) technologies over Levallois, and the production of scrapers, bifacial tools, *prądnik* scrapers, and leaf-shaped artefacts^{23,121,126,127}.

In the Northern Caucasus, the early phase (MIS 5c - MIS 4) of the Micoquian techno-complex is mostly associated with the evidences from Mezmaiskaya layer 3-2B4, Ilskaya 1 and 2, and Hadjoh-2. At Mezmaiskaya Cave, the bulk of the lithic collection is composed of scrapers, retouched points (Mousterian point and Chokurcha point), small handaxes, leaf artefacts and bifacial backed knives, some of them similar to Central European type *Bocksteinmesser*^{16,128}. Few of these stone tools are made on high-quality

Cretaceous flint from outcrops located 300 km north near the Azov sea ⁵⁸. Cores are numerous in layer 3 (n°51) and 2B4 (n°48) but a detailed description is still missing, and they are attributed to the broad unidirectional single-platform category ⁴¹. At the open-air Hadjoh-2 layer 7, the site was used as a lithic workshop and include cores (n°55) exploited using the unifacial single-platform method, and, in few examples, the centripetal and polyhedral reduction ¹²⁹. Within cortical and ordinary flakes, and two Levallois recurrent unidirectional blanks, several bifacial scrapers, handaxes and side-scrapers are documented. At open-air sites of Ilkaya 1, cores were reduced using the discoid and polyhedral methods whereas Levallois technology is rare ¹³⁰. The flake assemblage includes cortical pieces, and by-products of the preparation and re-sharpening of bifacial and unifacial tools suggesting that the knapping events were carried out at the site. The collection of retouched tools is dominated by side-scrapers, small triangular handaxes, leaf points, and by several bifacial knives, typologically attributed to *Keilmesser*, *prądnik* tools and *Wolgogradmesser* (or *Königsau messer*) ¹²⁸. At the nearby location Ilkaya 2, the lithic collection is smaller and comprises several isolated artefacts such as scrapers, triangular points and few bifacial tools ¹²⁸. At the onset of MIS 3, the main difference documented in the region is the decrease of the frequencies of bifacial backed knives and leaf-shaped artefacts, and an increase of the number of retouched points and bifacial scrapers ⁴¹. Beyond these typological differences, the character of the lithic assemblages remained Micoquian, as implied also by the presence of *prądnik* scrapers in the upper levels of Baranakha 4 ¹³¹ and Barakaevskaya Cave ¹³².

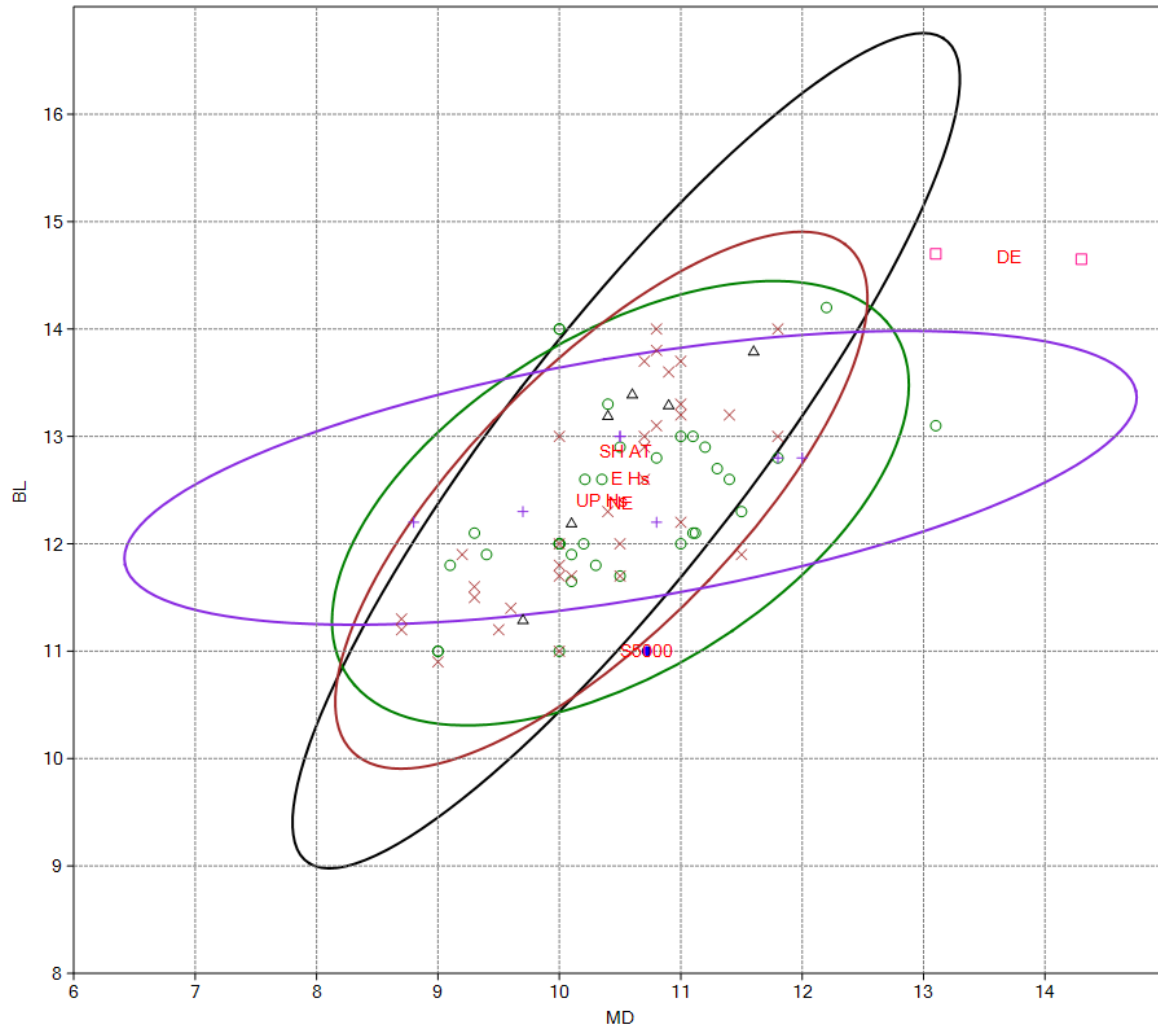


Fig. S1: Bivariate analysis of BL (buccolingual) and MD (mesiodistal) diameters of permanent upper second molars with 95% equiprobable ellipses of Atapuerca-Sima de los Huesos hominins (AT-SH, black ellipse, Δ - as specimen), Neanderthals (NE, green ellipse, ○ - as specimen), early *Homo sapiens* (E Hs, purple ellipse, + as specimen), Upper Palaeolithic *Homo sapiens* (UP Hs, brown ellipse, x as specimen), the position of the Stajnia S5000 specimen was marked as blue point, two teeth of Denisovans were presented as pink ◻. To conduct this analysis the raw data obtained from literature using in this study to calculate the two indexes (CBA and CSI) were used.

Fig. S2. Maximum parsimony tree relating the mitochondrial genome of Stajnia S5000 to the mitochondrial genomes of 24 Neanderthals, four Denisovans, 54 present-day humans, ten ancient modern humans, and one Sima de los Huesos individual. The mtDNA of Stajnia S5000 is indicated in red and the branches leading to the mtDNAs of present-day and ancient modern humans are collapsed for visualization purposes. The inferred number of substitutions per mtDNA sequence is given above each branch. A chimpanzee mtDNA was used to root the tree (not shown).

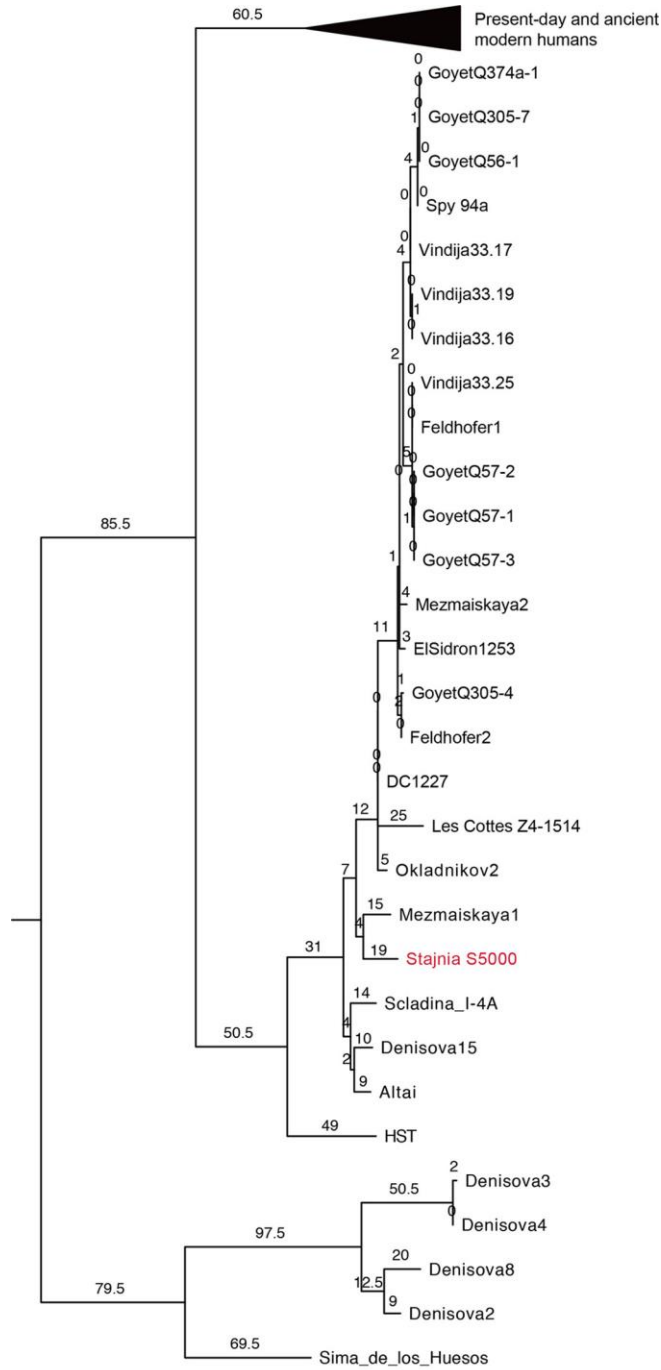


Figure S3: Maximum parsimony tree relating the mitochondrial genome of Stajnia S5000 to the mitochondrial genomes of 24 Neanderthals, four Denisovans, 54 present-day humans, ten ancient modern humans, and one Sima de los Huesos individual, restricted to the coding region. The mtDNA of Stajnia S5000 is indicated in red and the branches leading to the mtDNAs of present-day and ancient modern humans are collapsed for visualization purposes. The inferred number of substitutions per mtDNA sequence is given above each branch. A chimpanzee mtDNA was used to root the tree (not shown).

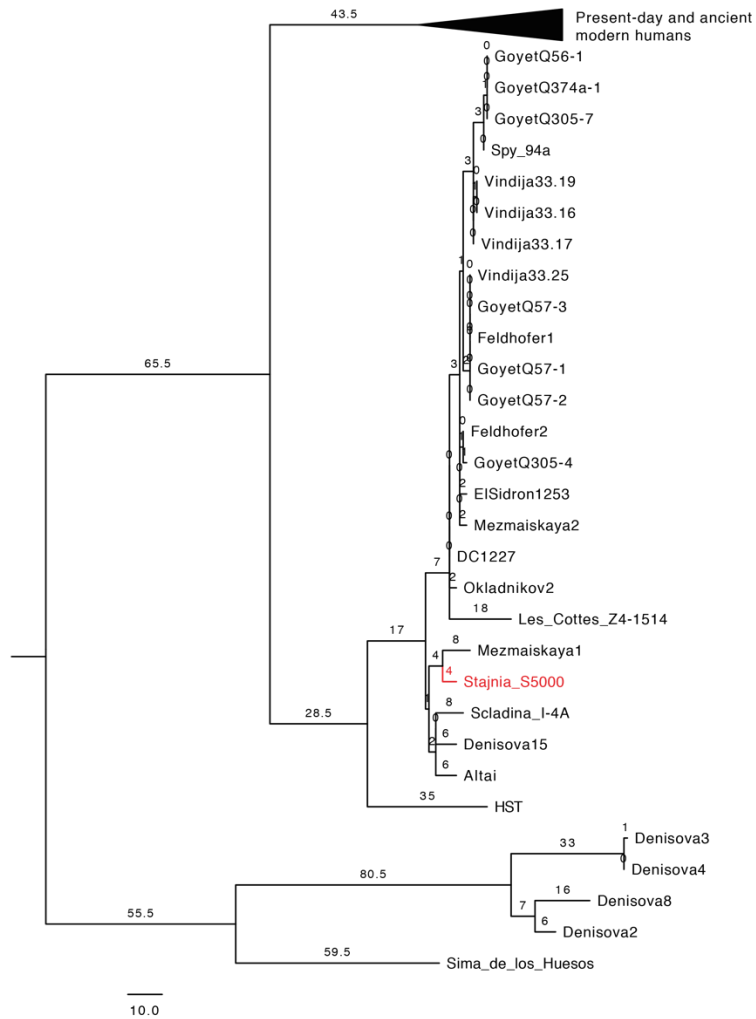


Figure S4: Map showing the location of Neanderthals' published genome, listed in Figure 3 - S2, and the extension of the ice sheets during the Weichselian in Fennoscandia, Ireland, Britain and the Alps (modified after ¹³³; base map from GeoMappApp (www.geomappapp.org)), MIS 5d – yellow, MIS 5b – orange, MIS 4 – red, early MIS 3 – blue. The glacier extension in other mountain areas is not shown.

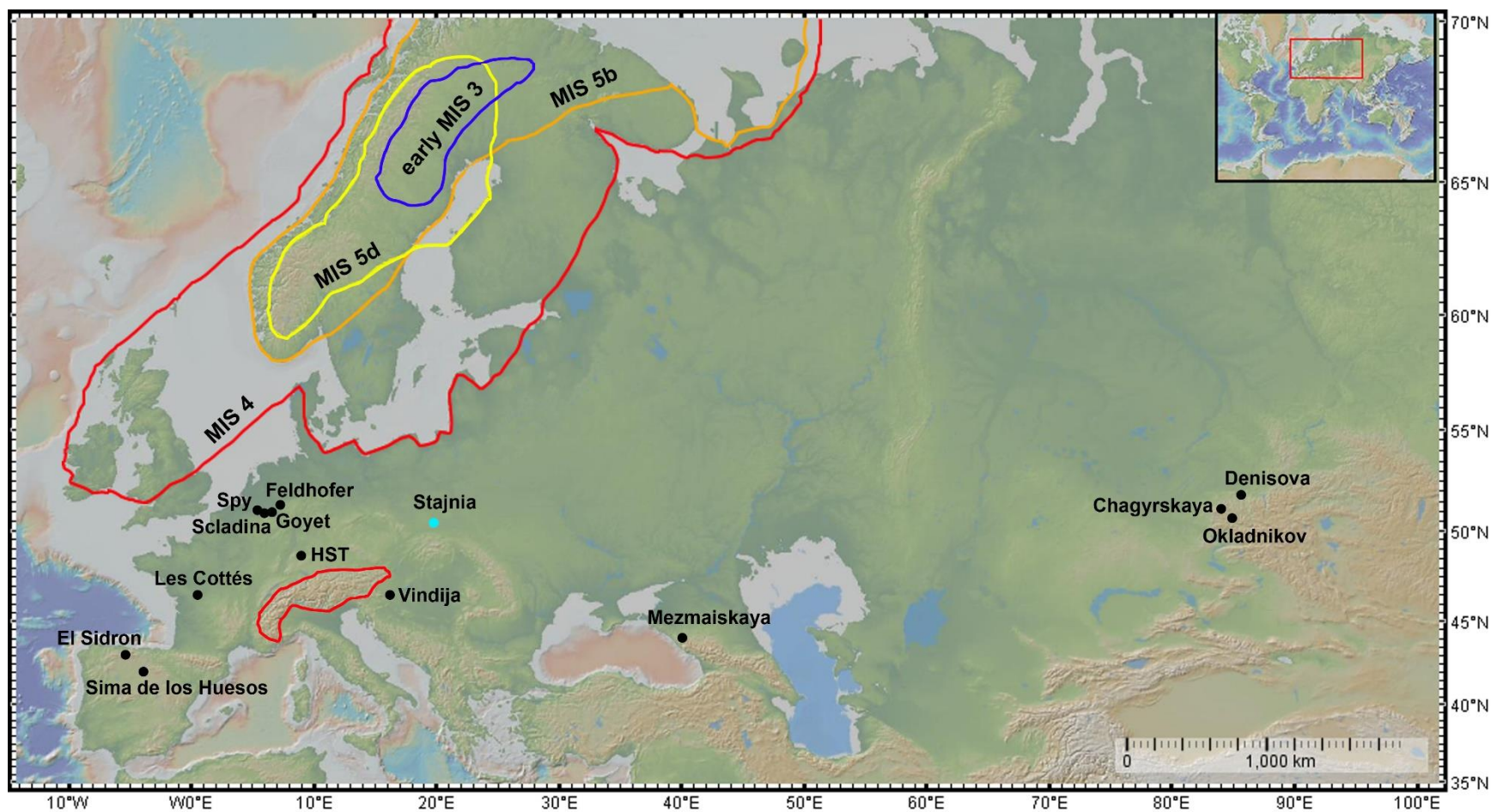


Table S1: Radiocarbon dates from previous studies and obtained for this paper are included in the table. For the samples measured at the MPI the elemental analyses were made using a Thermo Scientific Flash Elemental Analyzer, coupled to a Delta V isotope ratio mass spectrometer. The radiocarbon ages were calibrated using the IntCal20 data set ¹³⁴ and OxCal v4.4 ¹³⁵. The calibrated ranges (68.2% and 95.4%) are shown in the table. Previous OSL and U/Th dates are also added in the table.

Method	MPI Lab Code	Level	Subm. N°	Species	Element	Collagen %	C:N	Lab Code	Age	Err 1s	Modelled (cal BP)				References
											68.2%		95.4%		
											from	to	from	to	
¹⁴ C	Previous Date	B	unknown	Saiga tatarica	maxilla	unknown	unknown	Poz-28891	13500	50	16360	16180	16470	16080	⁶³
OSL	Previous Date	B	unknown					GdTL-1126	8950	Not reported					⁶¹
¹⁴ C	Previous Date	C18	unknown	Bear	3d phalanx	unknown	3.6	Poz-61719	20930	140	25550	25050	25680	24910	¹¹³
¹⁴ C	Previous Date	C18	unknown	Bear	3d phalanx	unknown	3.5	GdA-3894	21900	90	26280	26000	26370	25930	¹¹³
¹⁴ C	Previous Date	D1	unknown	Bear	tooth	unknown	unknown	Poz-28892	>49000						⁶¹
OSL	Previous Date	D1	unknown					GdTL-1127	45900	Not reported					⁶¹
¹⁴ C	Previous Date	D1	S-23101b	Mammoth	Tusk	6.9	3.1	OxA-24944	44600	2100	49850	45060	54890	44420	⁶¹
¹⁴ C	S-EVA 27827	D1	S-12182	UNG3	LB	13.2	3.2	MAMS-19879	44590	690	47610	46130	48470	45630	This paper
¹⁴ C	R-EVA 3213	D2	S-5000	Human	tooth	5.4	3.6	MAMS-40506	22480	70	27020	26490	27070	26440	This paper
¹⁴ C	S-EVA 27823	D2	S-12305	UNG5	LB	11.7	3.2	MAMS-19878	>49000						This paper
U/Th	Previous Date	D2b	unknown	Mammoth	tooth			W1400	52000	+1900 -1700					⁶¹
U/Th	Previous Date	D2b	unknown	Mammoth	tooth			W1417	52000	+500 -200					⁶¹
¹⁴ C	S-EVA 27814	D3	S-12722	BB	FE	11.1	3.1	MAMS-19871	>49000						This paper
¹⁴ C	S-EVA 27812	D3	S-11572	UNG3	LB	16.6	3.2	MAMS-19869	>49000						This paper
¹⁴ C	S-EVA 27777	E1	S-24262	UNG4	TI	10.1	3.1	MAMS-19856	>49000						This paper

Table S2. The metric traits (BL, MD, CBA, and CSI) of the S5000 M² compared to those of the different hominin M² samples.

Sample of M ² s	N	BL (mm) Mean (SD)	Z	N	MD (mm) Mean (SD)	Z
Stajnia S5000 (RM²) (a)	1	11.00	-	1	10.72*	-
Stajnia S4619 as (RM ²) (b)	1	12.10	-	1	11.20	-
Denisovans (c): DV 4 (as RM ²) DV 8 (as LM ²)	2	14.68 (-): 14.70 14.65	-	2	13.70 (-): 13.10 14.30	-
Atapuerca Sima de los Huesos (d)	28 (L & R)	12.18 (0.73)	-2.47	28 (L & R)	9.94 (0.94)	0.83
Early Neanderthals (e)	26 (L & R)	12.44 (0.83)	-1.74	26 (L & R)	10.98 (1.10)	-0.24
Late Neanderthals (e)	30 (L & R)	12.47 (0.98)	-1.50	30 (L & R)	10.52 (0.83)	0.24
Qafzeh/Skhul (fossil <i>H. sapiens</i>) (f)	10 (L & R)	12.00 (0.7)	-1.43	10	10.5 (1.10)	0.20
Early Upper Palaeolithic <i>H. sapiens</i> (e)	12 (L & R)	12.24 (0.50)	-2.47	13 (L & R)	10.45 (1.07)	0.25
Late Upper Palaeolithic <i>H. sapiens</i> (e)	56 (L & R)	12.18 (0.87)	-1.36	56 (L & R)	10.15 (0.84)	0.68
Recent <i>H. sapiens</i> (e)	100 (L & R)	11.15 (0.67)	-0.22	100 (L & R)	9.20 (0.68)	2.24
Sample of M ² s	N	CBA (mm ²) Mean (SD)	Z	N	CSI (scale-free) Mean (SD)	Z
Stajnia S5000 (RM²)	1	117.92	-	1	102.61	-
Denisovans (c): DV 4 (as RM ²) DV 8 (as LM ²)	2	201.04 (-): 192.57 209.50	-	2	107.33 (-): 112.21 102.45	-
Atapuerca Sima de los Huesos (g)	6 (L & R)	136.20 (17.65)	-1.04	6 (L & R)	121.94 (4.12)	-4.70
Neanderthals (h)	34 (L & R)	130.37 (17.26)	-0.72	34 (L & R)	118.36 (8.78)	-1.79
Early <i>H. sapiens</i> (i)	7 (L & R)	133.72 (16.42)	-0.96	7 (L & R)	120.17 (11.42)	-1.54
Upper Palaeolithic <i>H. sapiens</i> (j)	33 (L & R)	128.93 (18.88)	-0.58	33 (L & R)	120.14 (6.58)	-2.66

Abbreviations: * the corrected value of MD diameter; SD – standard deviation; Z – Z score value calculated for metric traits of S5000 tooth using appropriate statistics by subtracting the hominin sample mean value of the metric trait and dividing by the hominin sample standard deviation for this trait (Z score value was calculated when sample N > 2); L – left; R – right; BL – buccoligal crown diameter; MD - mesiodistal crown diameter; the data about the metric traits used in this study were obtained from literature: (a) – ⁶³; (b) – ¹³⁶; (c) – ⁹⁹; (d) – ¹³⁷; (e) – ⁶⁹; (f) – ¹³⁸; (g) – ^{139,140} (Atapuerca - Sima de los Huesos specimens); (h) – ¹³⁶ (Stajnia 4619), ¹⁴¹ (La Quina 5, Le Moustier, Spy 1, 2, Saccopastore 2, Amud 1), ¹⁴² (Palomas 1), ¹⁴³ (Shanidar 1, 2, 6), ¹⁴⁴ (Tabūn), ¹⁴⁵ (Krapina – 10 individuals); (i) – ¹³⁸ (Misliya -1), ¹⁴⁶ (Herto), ¹⁴⁴ (Skhul 5), ¹⁴⁷ (Qafzeh 6); (j) – ¹⁴⁸ (Předmostí: I, III, IV, V, VII, IX, X, XIV); ¹⁴⁹ (Brno III); ¹⁵⁰ (Dolní Věstonice: 3, 13, 14, 15), ^{151,152} (Mladeč: 1, 2, 8, 47); ¹⁵³ (Sunghir 2, 3). The different techniques of taking the measurements of molar crown: MD and BL may influence of the reliability of the comparisons, but the comparison of these metric traits obtained from different data sources is commonly practiced by scientists (e.g. ¹⁵⁴).

Table S3: Characteristics of the DNA libraries generated from Stajnia S5000 and frequencies of C to T substitutions at the terminal positions of sequence alignments.

Library ID	Description	Powder used for DNA extraction (mg)	Nr. of molecules in library	Nr. of sequences generated	Nr. of unique mtDNA fragm.	Avr. sequence coverage of the mtDNA genome	Nr. of deaminated mtDNA fragments	Avr. coverage of the mtDNA genome by deaminated fragm.	All fragm.	
									5' C→T (%) [observations]	3' C → T (%) [observations]
A9059	Stajnia S5000 regular extraction	40.6	4.09E+10	754,756	13,212	76.45	2,789	7.55	15.2 [746/4,908]	32.9 [1,637/4,977]
R5019	Phosphate washes of tooth powder		2.55E+09	15,940,974	53,776	180.43	14,659	45.98	46.8 [6,165/13,173]	36.9 [4,211/11,411]
R5020	Stajnia S5000 extraction after powder pre-treatment		4.31E+08	15,459,829	5,538	17.57	1,541	4.79	42.1 [617/1,465]	37.5 [423/1,127]
R5043	Phosphate washes of tooth powder	19.8	3.65E+09	17,156,937	60,482	207.27	17,381	55.51	45.1 [7,129/15,807]	39.7 [5,126/12,912]
R5044	Stajnia S5000 extraction after powder pre-treatment		4.35E+08	19,996,314	4,964	15.59	1,477	4.57	44.5 [570/1,281]	42.3 [445/1,053]
A22366	Stajnia S5000 regular extraction	10.7	1.60E+09	313,108	78,191	228.51	26,234	77.37	48.5 [11,222/23,139]	38.4 [7,852/20,448]
A22367	Stajnia S5000 regular extraction	11.0	9.88E+08	336,790	68,814	195.95	23,324	67.21	51.2 [9,966/19,465]	40.3 [7,159/17,764]
A22368	Stajnia S5000 regular extraction	11.1	2.26E+09	317,196	50,194	170.71	8,013	22.87	30.3 [3,390/11,188]	20.0 [2,502/12,512]
A22369	Stajnia S5000 regular extraction	11.2	1.09E+09	306,442	58,601	181.43	13,152	37.66	35.0 [5,479/15,654]	27.2 [4,131/15,186]
A22370	Stajnia S5000 regular extraction	8.8	6.88E+08	311,996	43,737	125.46	13,624	38.86	47.9 [5,695/11,890]	37.0 [4,254/11,498]
A9067	Extraction negative control	-	1.59E+08	103,122	354	1.26	3	0.01	1.4 [1/69]	0 [0/86]
R5050	Extraction negative control	-	2.66E+07	81,198	154	0.46	4	0.01	0 [0/35]	3.2 [1/31]
A9070	Library negative control	-	1.71E+08	98,447	30	0.1	-	-	0 [0/7]	0 [0/5]
R5051	Library negative control	-	1.36E+07	51,856	19	0.05	-	-	0 [0/2]	0 [0/5]

Nr – number; Avr – Average; fragm. – fragments

Table S4: Phylogenetic assignment of mitochondrial DNA fragments overlapping 63 diagnostic positions, at which 311 present-day human mtDNA sequences differ from those of 18 Neanderthals. Results are shown for all fragments and only those fragments with terminal C to T substitutions (deaminated fragments).

Library ID	Description	All fragments		Deaminated fragments	
		%Neanderthal [observations]	%Human [observations]	%Neanderthal [observations]	%human [observations]
A9059	Stajnia S5000 regular extraction	57.98 [923/1,592]	42.02 [669/1,592]	100 [98/98]	0 [0/98]
R5019	Phosphate washes of tooth powder	66.64 [2,407/3,612]	33.36 [1,205/3,612]	88.75 [568/640]	11.25 [72/640]
R5020	Stajnia S5000 extraction after powder pre-treatment	69.01 [1,335/1,441]	30.9 [106/1,441]	90.11 [74/91]	9.89 [9/91]
R5043	Phosphate washes of tooth powder	61.89 [2,537/4,099]	38.11 [1,562/4,099]	84.73 [649/766]	15.27 [117/766]
R5044	Stajnia S5000 extraction after powder pre-treatment	70.34 [204/290]	29.66 [86/290]	85.54 [59/83]	14.46 [12/83]
A22366	Stajnia S5000 regular extraction	90.82 [3,095/3,408]	9.18 [313/3,408]	99.15 [931/939]	0.85 [8/939]
A22367	Stajnia S5000 regular extraction	97.02 [2,934/3,024]	2.98 [90/3,024]	99.27 [815/821]	0.73 [6/821]
A22368	Stajnia S5000 regular extraction	24.37 [975/4,001]	75.63 [3,026/4,001]	92.22 [249/270]	7.78 [21/270]
A22369	Stajnia S5000 regular extraction	44.65 [1,604/3,592]	55.35 [1,988/3,592]	94.68 [463/489]	5.32 [26/489]
A22370	Stajnia S5000 regular extraction	84.24 [1,758/2,087]	15.76 [329/2,087]	98.66 [517/524]	1.34 [7/524]
A9067	Extraction negative control	0 [0/32]	100 [32/32]	0 [0/0]	0 [0/0]
R5050	Extraction negative control	0 [0/21]	100 [21/21]	0 [0/0]	0 [0/0]
A9070	Library negative control	0 [0/5]	100 [5/5]	0 [0/0]	100 [1/1]
R5051	Library negative control	0 [0/0]	0 [0/0]	0 [0/0]	0 [0/0]

Table S5: Unresolved positions in the mitochondrial consensus sequence of *Stajnia* S5000.

Position in rCRS coordinates	Coverage	Consensus support
191	2	
193	2	
194	1	
195	1	
196	1	
310	130	58.5%
8,468	13	61.5%
16,129	58	51.7%
16,148	25	60.0%
16,171	12	50.0%
16,209	17	52.9%
16,278	17	52.9%
16,304	9	66.7%
16,320	17	52.9%

Table S6: Frequencies of C to T substitutions at the terminal positions of DNA sequences identified as originating from present-day humans or Neanderthals.

Description	Human sequences		Neanderthal sequences	
	5' C→T (%) [observations]	3' C → T (%) [observations]	5' C→T (%) [observations]	3' C → T (%) [observations]
Stajnia S5000 all libraries merged	7.0 [304/4,331]	4.6 [205/4,462]	48.2 [4,086/8,477]	38.4 [2,796/7,281]

Table S7: Mitochondrial genomes of ancient modern humans and Neanderthals and their respective radiocarbon dates that were used for Bayesian phylogenetic analyses. All radiocarbon dates were calibrated using IntCal13¹⁵⁵ and OxCal v4.3¹⁵⁶.

Individual	mtDNA accession number	Date	95.4% confidence intervals	Reference
<i>Ancient modern humans</i>				
Ust'-Ishim	-	45,045	43,212-46,878	83
Tianyuan	KC417443	39,008	37,761-40,254	85
Kostenki 14	FN600416	37,473	36,262-38,684	75
Dolní Věstonice 13	KC521459	31,071	30,884-31,249	82,157
Dolní Věstonice 14	KC521458	30,934	30,741-31,120	82,157
Oberkassel 998	KC521457	14,077	13,755-14,105	82
Boshan 11	KC521454	8,234	8,152-8,316	82
Loschbour	KC521455	8,054	7,948-8,160	82
Iceman	EU810403	5,300	5,275,-5,325	84
Saqqaq Eskimo	EU725621	4,504	4,423-4,585	86
<i>Neanderthals</i>				
Goyet Q305-4	KX198087	44,236	43,386-45,085	94
Mezmaiskaya 2	MG025537	43,834	42,038-45,630	87,158
Feldhofer 1	FM865407	43,707	42,670-44,744	90,159
Vindija 33.16	AM948965	43,707	39,234-48,179	80,160
Feldhofer 2	FM865408	43,268	42,193-44,342	90,159
Les Cottés Z4-1514	MG025536	43,230	42,720-43,740	87
Goyet Q56-1	KX198082	42,515	42,03-42,967	94
Goyet Q57-3	KX198083	42,407	41,964-42,867	94
Goyet Q57-2	KX198088	41,185	40,595-41,775	94
Spy 94a	MG025538	40,463	39,234-48,179	87,161

Table S8: Estimated molecular ages of Neanderthal specimens and divergence times. The estimates are based on the coding region only and from three independent MCMC runs with 75,000,000 iterations.

Individual	Mean value	95% HPD lower	95% HPD upper	ESS
Hohlenstein-Stadel	122,950	69,236	186,830	3,097
Altai Neandertal	132,430	94,378	170,950	1,058
Denisova 15	120,680	80,812	168,150	1,084
Scladina I-4A	121,520	81,699	160,870	1,173
<i>Stajnia S5000</i>	<i>116,609</i>	<i>83,101</i>	<i>152,515</i>	<i>1,349</i>
Mezmaiskaya 1	98,831	62,159	135,496	1,567
Okladnikov 2	92,891	68,293	117,657	1,910
Denisova 11 (DC1227)	99,867	76,681	122,792	1,451
El Sidron 1253	57,515	42,731	74,704	6,904
Vindija 33.17	49,681	42,538	57,801	8,316
Vindija 33.19	44,969	37,442	51,950	8,289
Vindija 33.25	43,912	35,397	52,991	7,982
Goyet Q305-7	40,677	33,564	45,643	19,461
Goyet Q374a-1	40,663	33,640	45,712	19,086
TMRCAs	Mean value	95% HPD lower	95% HPD upper	
Neanderthal – modern human TMRCA	419,091	367,751	468,857	
Neanderthal TMRCA	276,000	233,369	320,263	
Altai Neanderthal (Denisova 5), Scladina I-4A, Denisova 15, Mezmaiskaya 1 and Stajnia S5000 TMRCA	170,030	138,954	202,865	
Mezmaiskaya 1, Stajnia S5000, Okladnikov 2, Denisova 11 and later Neanderthals TMRCA	152,168	123,800	181,918	

Table S9: Number of Identified Specimens (NISP) and Minimal Numbers of Individuals (MNI) of the carnivores and ungulates of Stajnia Cave divided by stratigraphic units.

Taxon	Unit E1 (MIS 4) NISP/MNI	Unit E1/D (MIS 4/3) NISP/MNI	Unit D (MIS 3) NISP/MNI	Unit D/C (MIS 3/2) NISP/MNI	Unit C (MIS 2) NISP/MNI	Unit C/A (MIS 2/1) NISP/MNI	Unit A (MIS 1) NISP/MNI	Dump NISP/MNI	Unknown NISP/MNI
<i>Canis lupus</i> sp.	6/2	2/1	34/3	13/5	11/2	2/1	1/1	4/1	2/1
<i>Vulpes vulpes</i> ¹⁶²	14/2	11/2	56/4	219/11	141/8	15/2	7/1	16/3	13/3
<i>Vulpes lagopus</i> ¹⁶²	3/1	2/1	47/8	198/12	166/10	2/1		5/2	3/1
<i>Ursus spelaeus ingressus</i> ¹⁶³	27/4	4/2	143/7	44/5	3/1			6/1	11/4
<i>Ursus arctos priscus</i> s. l.	1/1	2/1	1/1	3/2	2/2				
<i>Ursus arctos arctos</i> ¹⁶²						2/1	2/1	1/1	2/1
<i>Ursus</i> sp.	187	15	314	947	16	5	8	5	11
<i>Gulo gulo</i> ¹⁶²	1/1	1/1	1/1	2/1	1/1				
<i>Meles meles</i> ¹⁶²	1/1	2/1	1/1	2/2	1/1	1/1	2/1	1/1	
<i>Martes martes</i> ¹⁶²	22/3	5/2	3/1	5/2	2/1	4/1	2/1	2/1	
<i>Mustela eversmanii</i> ¹⁶⁴			1/1	1/1	1/1				
<i>Mustela putorius</i> ¹⁶²	1/1	1/1	3/1	2/2	25/2	14/3	2/1	1/1	3/1
<i>Mustela erminea</i> ¹⁶²	19/6	85/25	196/18	112/13	59/6	12/3	18/4	5/2	4/2
<i>Mustela nivalis</i> ¹⁶⁵	25/10	7/3	345/66	297/138	64/25	14/3	27/9	11/3	12/5
<i>Panthera spelaea spelaea</i> ¹⁶⁶			2/1						1/1
<i>Lynx lynx</i> ¹⁶²	1/1		1/1		1/1	1/1			
<i>Felis silvestris</i> ¹⁶⁷	2/1	1/1	12/2	4/2	3/1	1/1	5/2	2/1	3/1
<i>Crocuta crocuta spelaea</i> ¹⁶⁸	4/2	3/2	18/3	9/2				2/1	3/1
<i>Mammuthus primigenius</i> ¹⁶⁹	-	-	-	1/1	2/1	1/1	-	4/1	-
<i>Coelodonta antiquitatis</i> ¹⁷⁰	-	-	5/1	1/1	3/1	1/1	-	-	2/2
<i>Equus ferus</i> ¹⁷¹	-	-	1/1	4/1	4/1	5/1	-	5/2	-
<i>Sus scrofa</i> ¹⁶²	-	-	-	-	-	-	-	7/2	-
<i>Cervus elaphus</i> ¹⁶²	-	-	-	1/1	1/1	-	-	3/1	-
<i>Rangifer tarandus</i> ¹⁶²	7/1	2/1	126/7	4/1	98/4	26/2	2/1	64/5	6/4
<i>Bison priscus</i> ¹⁷²	-	-	-	4/1	13/3	38/3	-	9/1	-
<i>Saiga tatarica</i> ¹⁶⁵	-	-	-	-	-	2/1	-	1/1	-
<i>Ovis/Capra</i>	-	-	-	-	-	-	-	2/1	-

Table S10: Preliminary number and percentage of the lithic assemblages (>2cm) of the Middle Palaeolithic layers of Stajnia Cave.

	D1		D2		D3		E1		E2		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Cortical flake	9	4.0	3	3.9							12	3.6
Ordinary flake	25	11.2	10	13.0	2	20			1	20	38	11.5
Predetermining Lev. flake	2	0.9									2	0.6
Levallois rec. uni. flake	3	1.3									3	0.9
Levallois rec. bid. flake	2	0.9									2	0.6
Levallois rec. centr. flake		0.0	1	1.3							1	0.3
Levallois point	1	0.4									1	0.3
Levallois flake undeter.	2	0.9	2	2.6							4	1.2
Core-edge removal flake	5	2.2	3	3.9					1	20	9	2.7
Pseudo-Levallois point	1	0.4									1	0.3
Unidirectional flake	11	4.9	4	5.2	1	10					16	4.8
Centripetal flake	13	5.8	3	3.9							16	4.8
Orthogonal flake	1	0.4									1	0.3
Reshaping flaking surface	1	0.4	2	2.6							3	0.9
Kombewa-type flake	2	0.9									2	0.6
Bifacial shaping flake	1	0.4	1	1.3							2	0.6
Knapping accident	1	0.4	1	1.3							2	0.6
Flake frag.	59	26.5	21	27.3	5	50	8	50	2	40	95	28.8
Debris	7	3.1	4	5.2							11	3.3
Preform of bifacial tool	5	2.2					1	6.25			6	1.8
Bifacial tool	3	1.3	1	1.3							4	1.2
Bifacial tool frag.	2	0.9	1	1.3							3	0.9
Leaf point frag.	1	0.4									1	0.3
Scrapers	12	5.4	3	3.9					1	20	16	4.8
Groszak	1	0.4									1	0.3
Notched tool	3	1.3									3	0.9
Point	1	0.4									1	0.3
Retouched tool frag.	9	4.0	2	2.6			1	6.25			12	3.6
Core	38	17.0	15	19.5	2	20	5	31.25			60	18.2
Tested pebbles	2	0.9									2	0.6
Total	223	100	77	100	10	100	15	100	5	100	330	100

Table S11: Preliminary number and percentage of the core assemblages of the Middle Palaeolithic layers of Stajnia Cave.

	D1		D2		D3		E1		Total	
	N	%	N	%	N	%	N	%	N	%
Levallois	1	2.6	1	6.7	1	50			3	5
Discoïd	8	21.1	4	26.7	1	50	2	40	15	25.0
Hierarchized uni.	1	2.6	1	6.7					2	3.3
Hierarchized bid.	4	10.5							4	6.7
Hierarchized centr.	6	15.8	1	6.7					7	11.7
Unidirectional	8	21.1	4	26.7			2	40	14	23.3
Orthogonal			1	6.7					1	1.7
Centripetal			1	6.7			1	20	2	3.3
Polyhedral	1	2.6	1	6.7					2	3.3
Core-on-flake	4	10.5	1	6.7					5	8.3
Fragment	5	13.2							5	8.3
Total	38	100	15	100	2	100	5	100	60	100

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