Population Genomics of Stone Age Eurasia:
Supplementary Information (Part 2)

5) From forager to farmer in western Eurasia: an archaeological overview

Anders Fischer[1,2], T. Douglas Price[3], Karl-Göran Sjögren[1] and Kristian Kristiansen[1]

[1]Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

[2]Sealand Archaeology, Gl. Røsnæsvej 27, 4400 Kalundborg, Denmark

[3]Laboratory for Archaeological Chemistry, University of Wisconsin-Madison, Madison, United States of America

Introduction

Our human samples cover a vast territory, from Lake Baikal to the Atlantic oceanfront (Figure S5.1), and a time span from the early Holocene to the introduction of metals. They derive from a variety of contexts, including burial mounds, caves, bogs and the sea-floor. Here we summarise some of the main archaeological developments relating to the Mesolithic-Neolithic transition, as a background and reference to the genetic data.

The Mesolithic (Middle Stone Age) in central and western Europe is the period of fisher-hunter-gatherer societies between the end of the Pleistocene (the last Ice Age) and the introduction of agriculture. By convention it is the climatic amelioration c. 9700 BC that defines the beginning of the Mesolithic. The duration of fisher-hunter-gatherer lifestyles is highly variable. In some areas, the Near East or northern China, the beginning of agriculture is virtually co-terminus with the end of the Pleistocene. In other areas, beyond the limits of agriculture — much of northern Eurasia — a Mesolithic way of life continued, in some cases until historical times. In the eastern parts of our focus area, the Neolithic is - according to local research tradition - defined by the introduction of pottery, while agriculture comes later. However, for our purposes, we utilise the arrival of farming to define the local onset of the Neolithic.

Figure S5.1. Location of sites sampled in this study. *For detailed maps of Danish sites, see section 2.*

Broadly, we can divide our research area into three large regions based on the differing archaeological material and trajectories. The first consists of central, western and northern Europe, the second of eastern Europe including western Russia and Ukraine, and the third of the Urals and western Siberia. The Denmark area will be described in greater detail, due to the dense genetic sampling and the high quality of archaeological information from this area.

Western and central Europe

Western Europe is defined here as that portion of the continent west of a line from the North Sea to the Adriatic, including the nations of Ireland, Britain, the Netherlands, Belgium, Luxembourg, France, Portugal, Spain, and Italy, a region comparable in size to modern Mexico. Western Europe is today, and was in the past, a mosaic of landscapes, of diverse topography, climate, environment, and culture. This area stretches from the chilly highlands of northern Scotland to the balmy beaches of southern Italy and the Mediterranean islands. Western Europe is roughly parallel in latitude to Labrador and New England in North America; Madrid and Rome are at roughly the same latitude as New York City. In spite of its northerly location, much of Western Europe is warmed by the Gulf Stream. Palm trees grow along the southwestern coasts of Ireland and England. Much of the region is dominated by maritime climatic regimes, of either Atlantic or Mediterranean origin. Close to the Atlantic there is ample rainfall, productive soil, and mild temperatures, while inland and to the south, semidesert conditions prevail in southern Spain and Italy.

The landscape itself has undergone dramatic changes in fauna, vegetation, soils and sea levels (Fig. S5.2). The marked shift toward warmer and more stable climate at the end of the

Pleistocene was largely responsible for these changes. The large herds of migratory ungulates that characterised the Pleistocene were replaced in the Holocene by forest-adapted species that are less mobile and more dispersed across the landscape, including red deer, roe deer, aurochs, wild pig, ibex, and beaver. Faunal evidence indicates that aurochs and elk were predominant in northern Europe during the Preboreal and that red deer, wild pig, and roe deer became the terrestrial animals of major economic importance during the Atlantic climatic phase.

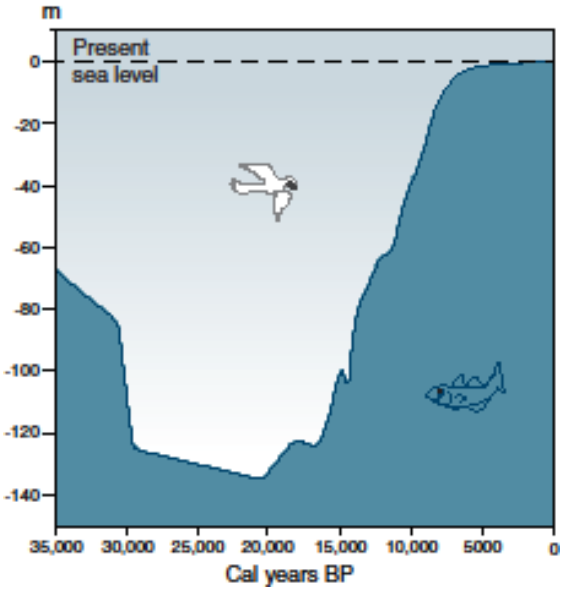

***Figure S5.2**. **Changes in global sea level over the last 35,000 years**. Reproduced from Fischer and Jensen [1], based on Lambeck et al. [2].*

One of the relevant questions about the Mesolithic concerns the distribution of human populations across the landscape. Essential to this discussion is an awareness of the rise in sea level that accompanied the warming temperatures of the Holocene (the current geological period since the end of the Pleistocene). During the Mesolithic period global sea levels rose 60 m or more — in the north inundating huge areas of land and reaching modern levels by 4000 BC. As a result, most Mesolithic coastal sites from that period are under water and largely unknown. At the same time there is growing evidence of population decline during the Late Mesolithic and a reasonable argument can be made that the increasingly dense mixed oak-lime-elm forest of the Atlantic climatic phase would have discouraged human use.

Within the varied postglacial environment, societies at the edge of the Neolithic world hunted, fished, and collected the wild produce of the landscape. Remains of their activities have been differentially preserved and recorded throughout Western Europe. Large coresident group

size and permanent occupation are hallmarks of Mesolithic settlement in a number of areas of Western Europe. Early evidence for permanent occupation from Ireland, Italy, and elsewhere suggests that year-round occupation of more limited territories may be the norm, particularly in coastal areas. Settlement location, clearly associated with the nature and distribution of food resources, most frequently exhibits a littoral or riverine orientation and is associated with a greater reliance on aquatic species. There is a distinct and dramatic shift from an emphasis on marine to terrestrial food sources from the Late Mesolithic to the Early Neolithic in many areas, likely the result of transition to mixed dairy farming [3].

Subsistence equipment, both implements and facilities, became more diverse in form, more specialised in function, and more abundant in number. An incredible range of fishing gear, including nets, weirs, leisters, hooks, and harpoons, is known. Ground stone artefacts appear as axes, celts, plant processing equipment, and other tools. Projectile weapons, primarily bow and arrow, appear replete with a vast array of specialised tips made of bone, wood, antler, and stone.

A focus on one or a few species of fish, molluscs, plants, or other foods characterises many later Mesolithic settlements [4]. Examples are numerous and remarkable: cod at Morton in eastern Scotland, saithe at Oronsay in western Scotland, salmon/eel at Mount Sandel in northern Ireland, hare at Chateauneuf in southern France, ibex at Peschio Romano in inland southern Italy, land snails in a number of sites in southern Europe, species-specific shell middens in Portugal, and plant use in south-central France. The list is extensive.

Although the evidence for exchange in the Mesolithic pales beside the extensive trade networks of the Neolithic, source-specific materials provide the best evidence for such interactions [1,5]. For example, lithic artefacts made of Portland chert are found at distances of up to 240 km from the source on the island of Portland in southern England. Wommersom quartzite from an outcrop in Belgium spreads over an area some 250 km in diameter. The evidence that certain items spread very rapidly throughout Western Europe suggests that trade/exchange networks must have been operating as one form of interaction. Certain technological innovations diffused quite rapidly across most of the continent. One example of such a spread is the dissemination of trapeze microlith technology in a period of less than 500 years during the first half of the sixth millennium.

Through the Mesolithic, there are several grand changes in lithic projectile points that provide horizon markers for all of Western Europe [6]. Early Mesolithic points continue the tradition of oblique retouching across a flake or blade blank [7]. Assemblages in the Boreal period after 7000 BC are characterised by geometric microliths: narrow scalene triangles, triangles (retouched on three sides), Sauveterre points, backed bladelets, crescents, blades and

trapezes [8]. Transverse points are generally associated with the late Mesolithic in the north and the earliest Neolithic horizons in the south of Europe, after 4500 BC.

The chronology of the Mesolithic in Western Europe is complex and often oriented toward national, rather than international, perspectives. Most of the chronological schemes are based on changes in lithics and much of what is known comes from a limited number of archaeological sites. These schemes also utilise the nomenclature of archaeological cultures where names, heuristically useful, become reified and difficult to avoid. The chronological framework used in our study does not employ these named archaeological cultures but relies on direct AMS radiocarbon dates on the human skeletal remains we have analysed.

Agriculture arrived over a rather long period in western Europe, coming to the Mediterranean coast of Italy, France, Spain and the Atlantic coast of Portugal between 6200 and 5500 BC before expanding to the north. At the same time an inland spread of the Linearbandkeramik (LBK) across Central Europe brought domestic plants and animals and village life to northern France, Belgium, and the Netherlands sometime before 5000 BC. Farming did not reach the British Isles and Ireland until 1000 years later, around 4000 BC, similar to events in northern Europe.

The Origins and Spread of Agriculture to Europe

It is necessary to consider the arrival of farmers and the Neolithic on a continental scale rather than the regional reviews of the Mesolithic [9–11]. The origins and spread of agriculture and a Neolithic way of life was a major turning point in the evolution of human society. Farming changed everything. Our heritage as food collectors, consuming the wild products of the earth, extends back many thousands of years. Nevertheless, at the end of the Pleistocene, some human groups began to produce their own food rather than collecting it, to domesticate and control wild plants and animals, achieving what is perhaps the most remarkable transformation in our entire human past.

Agriculture is a way of obtaining food that involves domesticated plants and animals. But the transition to farming is much more than simple herding or cultivation. It also entails major, long-term changes in the structure and organisation of the societies that adopt this new way of life. With the transition to agriculture, humans began to truly change their environment as well as their reproduction rates, social organisation, etc.

The cultivation of plants and herding of animals, village society, and pottery, did not originate in Europe. Domestication arrived from the ancient Near East. The Neolithic began in southwest Asia some 11000 years ago and eventually spread into the European continent, carried by expanding populations of farmers. The area from Israel and Lebanon to northern

Syria and southwestern Turkey, into the Zagros Mountains of western Iraq, has been described as the Fertile Crescent. A variety of wild plants grow here in abundance. This region was the natural habitat of many of the wild ancestors of the first species of plants and animals to be domesticated at the end of the Pleistocene — the wild wheats and barleys, the wild legumes, and the wild sheep, goats, pigs, and cattle that began to be exploited in large numbers at the origins of Old World agriculture.

In the period just preceding domestication, there was intense utilisation of wild plant foods. Between 9000 and 8000 BC, changes in the size, shape, and structure of several cereals indicate that they were domesticated. The Neolithic, defined by the appearance of domesticated plants, began at that time. Eight species of plants were domesticated during the period 9000–7000 BC, including three cereals—emmer wheat, einkorn wheat, and barley—and at least four pulses—lentils, peas, bitter vetch, and chickpeas. (Pulses are the edible seeds of leguminous plants, such as peas and beans). In this same time period, animals were domesticated, and herding became part of human activity. Goats may have been the first domesticates, soon joined by sheep, pigs, and cattle.

The first large settlement communities appeared. Major changes in human diet, and in the organisation of society as well, began to take place. The number and the size of prehistoric communities expanded greatly during the Early Neolithic, as populations apparently concentrated in settlements. By 8000 BC, new forms of residential architecture (rectangular houses) appeared, and early public constructions were seen. Pottery came into use around 7500 BC to serve as easily produced containers for holding liquids, cooking, and storage. Shrines and ritual paraphernalia appear frequently, suggesting the formalisation of religious activity. The complete Neolithic package of domesticates, village architecture, and pottery was thus in place shortly before 7000 BC, as the Neolithic began to spread to Europe and Asia [9].

Spreading Neolithic farmers gradually replaced Mesolithic fisher-hunter-gatherers across the continent. One can consider the arrival of farming in Europe divided in terms of millennia (1000-year periods). Plants and animals were domesticated in Southwest Asia after 11,000 years ago, in the tenth millennium BC. The Neolithic village complex of square houses, pottery, and agriculture first moved to Europe in the 7th millennium BC. This spread took place both by land, across the Bosporus from Turkey to the Balkan Peninsula, and by sea from Cyprus and Anatolia, through the Aegean, to the Greek mainland.

The 6th millennium BC witnessed an expansion of farmers out of the Balkans along two major routes (Fig. S5.3). One was along the north coast of the Mediterranean, probably by ship with intermittent stops that left behind communities of farmers and pastoralists. The

second arm of the spread went inland, crossing Central Europe almost to the shores of the Atlantic. These farmers introduced cultivation and stock rearing, large, permanent houses, and a distinctive pottery to much of Central Europe. Linearbandkeramik villages are found along the middle Danube and its tributaries in eastern Hungary to Holland and Belgium in the west, to the edge of the North European Plain to the north, and the Ukraine to the east. The LBK has for many years been regarded as a classic example of migration by farmers, expanding into new territory. The Mediterranean group is usually described from its pottery as the Cardial Culture; the inland group also has a distinctive pottery that provides its name, the Linearbandkeramik culture.

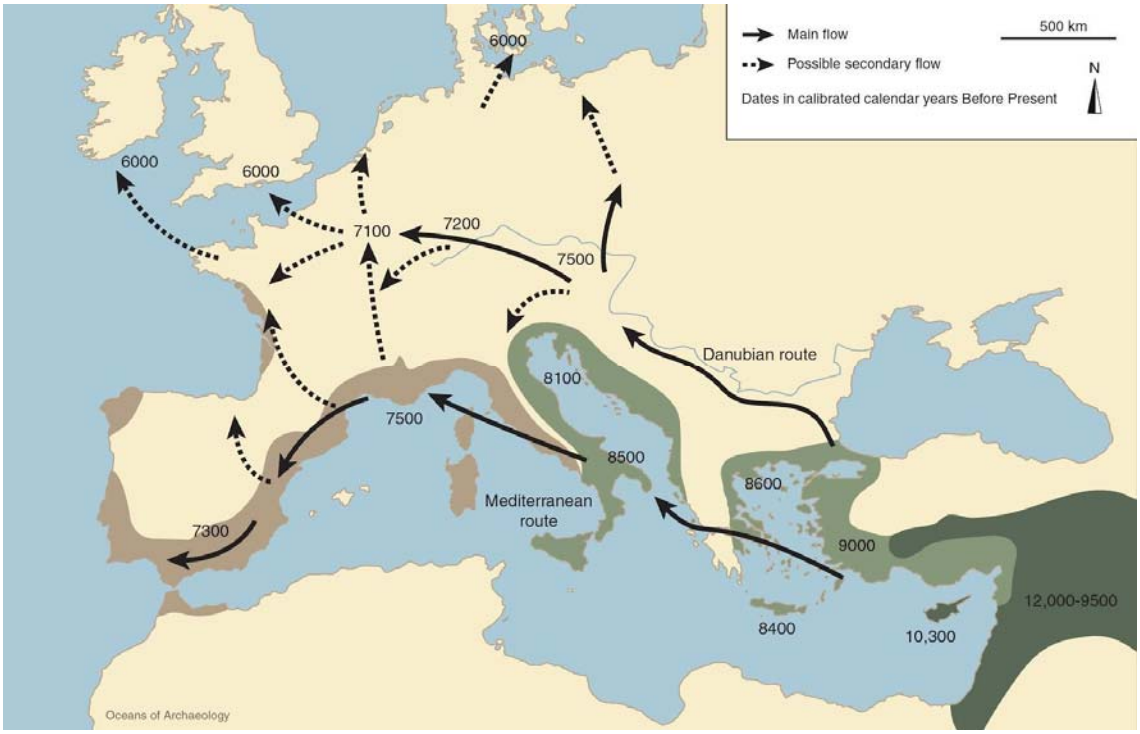

Figure S5.3. Expansion of agricultural groups through Europe. *Reproduced from Fischer [12].*

Groups of Cardial farmers spread inland to the north and probably founded the Neolithic in much of France and parts of Germany. The cultures of La Hoguette and Limburg may have been the earliest farmers in these areas. In the Netherlands the Swifterbant Culture emerged with connections to both Cardial farmers and hunter-gatherers from the Ertebølle Culture of Northern Europe. The subject continues to be a source of debate [13].

The final stage, expansion into the Alpine areas, the British Isles (Early Neolithic) and Northern Europe (Funnel Beaker Culture) to the environmental limits for cultivation, took place during the 4th millennium. The entire journey from the plains of Thessaly in Greece to Scandinavia (c. 2000 km) and Britain (2300 km) took about 3000 years. These dispersals

from Asia to Europe, from southeast Europe to Central Europe and the Mediterranean, and to the northern limits took place quickly as rapid leaps or spreads, followed by long periods of stability and adjustment.

One of the more pronounced trends in the European Neolithic was regionalization, the development of distinctly local traditions. Initial farming cultures expanded over broad regions. Settlements were generally located in open and unprotected spaces, and pottery styles were similar across very large areas. Very quickly, however, population growth and the development of permanent field systems resulted in competition and conflict between groups. By 3000 BC, the continent was occupied by well-entrenched farming populations making stone tools and pottery, cultivating, trading, and fighting.

In southeastern Europe developments in the Neolithic were dramatic, witnessing the rise of large settlements often on tells — huge mounds of human refuse and building material, accumulated in the same place over generations. This was a time of major cultural fluorescence among a series of cultures in Serbia, Romania, Bulgaria, and eastern Hungary — population numbers increased, large villages and towns appeared, technological innovations including the first copper production flourished, long distance trade expanded, and social inequality was pronounced.

Later Neolithic settlements across Europe were often located in defensible positions and heavily fortified. Pottery-making traditions became more limited in their distribution. At the same time, trade and exchange expanded in scope. A variety of materials and finished goods were moved long distances across Europe. Obtaining raw materials, manufacturing trade items, and transporting finished goods became an important part of Neolithic economic systems. Flint, for example, was mined in Denmark, Belgium, England, and elsewhere and polished into fine axes for trade.

After 5000 BC another branch of farming colonists chose to move north and northeast into Ukraine, forming the Trypillia Culture. They maintained communal settlements of the previous tells, and after 4100 BC they constructed increasingly large mega-settlements, before they finally collapsed and vanished after 3400 cal BC [14].

Danish Stone Age Archaeology

Chronological and environmental frame

By definition the Mesolithic begins with the sharp transition from the last Ice Age to the present warm period, dated c. 11700 years ago. The defining element of the Neolithic, a local

food producing economy based on domesticates of Middle Eastern origin, was indisputably present from c. 3900 cal BC [15–18].

Faunal composition reacted nearly instantaneously to the rapid climatic amelioration in the beginning of the Mesolithic [19], whereas the immigration of trees and the establishment of a blanket-covering deciduous climax forest lasted millennia [20]. During the Mesolithic, global sea-level rise in the order of 60 m gradually changed the general geographic setting of the flat landscape from continental lowland to archipelago [21,22]. By the onset of the Neolithic a land-sea configuration nearly similar to the present was reached, where no part of the country is any further than 52 km distant from the sea.

’Cultures’ and ’migrations’

For decades archaeologists have busily grouped the archaeological record from the Stone Age into complexes, based on stylistic traits and find associations. These groupings are often termed cultures. Traditionally they were considered equivalents to ethnic entities - specific groups of humans with a shared cultural and genetic history. After the Second World War the latter part of the interpretation got a bad reputation. None-the-less, the archaeological ‘cultures’ can still be valid aids in gaining chronological and stylistic-historical overview of the archaeological record. They can roughly be divided in two, representing hunter-gatherer-fisher and farming subsistence respectively. Excluding a faintly known late stage of the Ahrensburg Culture the archaeological Stone Age cultures of Holocene Denmark are as follows, mentioned in chronological order:

The *Maglemose Culture, c. 9000-6400 cal BC,* is an archaeological complex found in present-day Denmark and its vicinity. In its early stages, close parallels are seen in the archaeological records of coastal West Sweden and Norway. The Maglemosian is characterised by relatively small flint projectile points in more or less geometric shapes: lanceolate and triangles. The complex passes through several chronological stages of flint manufacture for the production of cutting edges - from the knapping of medium sized blades in direct percussion, via small ones in pressure technique to large, soft percussion flaked ones. In the latter stage trapeze-shaped projectile points appear but form less than 50% of the flint tips.

The Maglemose Culture in Denmark is mainly known from inland locations along lakes, bogs and rivers of its time. This is probably simply a result of the submergence of the contemporaneous coasts [22,cf. 23].

On the Scandinavian Peninsula the introduction of the technology for producing small pressure flaked blades seems to have been introduced from the east and it has recently

been suggested to link with an immigration of a population of eastern European ancestry [24,cf. 25]. As will appear from other parts of this study, we see no traces of such an eastern gene flow at the time this blade technology reached Denmark. With only four nuclear genetic profiles from the Danish Maglemosian, our basis for population-historical generalisations for this epoch is, however, far from perfect.

As seen on the basis of lithic technology the *Kongemose Culture, c. 6400-5400 cal BC,* is a direct continuation from the Maglemosian. Trapeze shaped flint points dominate the assemblages of arrowheads [6]. Another characteristic is (a continuation of) the production of excellently manufactured long blades in soft percussion technique. Most of the larger settlements cluster at good fishing locations along the coasts [26]. In addition there are specialised hunting camps in the interior [27].

The Late Mesolithic complex of the *Ertebølle Culture, c. 5400-3900 cal BC,* is characterised by flint points with transverse edges. All aspects of material culture, economy and settlement systems indicate a direct continuation in population from the previous archaeological culture. Pottery was introduced from the east and perhaps the southwest during the middle stage of the Ertebølle Culture [28,29]. Cooking pots with a markedly pointed bottom are characteristic of the later half of the culture [30,31]. Imports of exotic looking shaft-hole axes etc. during these centuries show that members of this culture engaged in trade with farming societies south of the Baltic Sea [32,33]. A series of apparently chronologically well-delimited settlement assemblages from the last centuries of this culture include bones of domestic cattle and typologically early funnel beakers, which may possibly also represent imports from an external cultural source [15].

With the arrival of the Funnel Beaker Culture (FBC), c. 3900-2800 cal BC, a boom of new shapes and types in material culture was introduced. The characterising ceramic type is a funnel-shaped beaker [34]. An also frequent and characteristic element is the polished flint axe, which - like the pottery - ran through a rapid typological evolution. The dominant means of subsistence apparently developed from small scale farming, possibly also from slash-and-burn agriculture into ard-ploughing agriculture, with manuring from the later Early Neolithic onwards [35,36]. Habitation deposits on top of shell middens of the Ertebølle Culture may be seen as a local continuation of marine gathering and fishing [37–39].

From the initial stage of the FBC there are remarkably few burials, and these are of non-monumental nature [17,40]. From c. 3800 cal BC monumental long barrows of wood and earth are added to the repertoire. c. 200 years later monumental burials built of soil, surrounded by raised stones and including a stone-built coffin for one or a small number of individuals, are

erected [41]. Around 3400 cal BC a boom is seen in the erection of the larger and more complex stone-constructed passage graves in large earthen tumuli [42].

The *Pitted Ware Culture (PWC)* – in Denmark preliminarily dated *c. 3000-2700 cal BC* - is characterised by coarse pointed-bottom pottery that is often decorated with pits (thus the origin of the archaeological name). Settlements are known from the coastal zone of the northern and eastern part of the country. Its subsistence seems to have been based on a combination of marine species and farm products [43]. There are currently no burials known from Denmark. Within the present study two individuals can nonetheless be attributed to this archaeological complex (NEO33 Vittrup and NEO898 Svinninge Vejle [44]).

This culture introduced a decisively new type of flint point: an elegantly shaped slender tanged point. Such ones are frequently found in passage graves. The messing up of human bones and artefacts in these multi-burial chambers, used for centuries, does not allow saying if the projectile heads were deposited as grave gifts or were lodged in the flesh of individuals that were killed during hostilities between separate groups of FBC and PWC affiliation [45]. However, the position of single tanged points within four Jutland SGC graves and within a PWC grave at Visby, Gotland, render possible that these points were lodged in the body of the deceased at the time of burial and therefore the result of interpersonal violence [88].

With the *Single Grave Culture (SGC), c. 2800-2300 cal BC*, a new burial tradition, single graves in round tumuli, was introduced in western and central Jutland and gradually expanded north and east within the country [46]. Markedly novel designs also emerge in pottery and ‘battle axes’ in western parts of the country. Additionally, new varieties of polished flint axes showed up all over Denmark.

For generations archaeologists have argued that the SGC reflects immigration of new people [e.g. 47,48]. The SGC has often been suspected of having had an aggressive relationship with the local FBC population, ending in the complete takeover of territories at least in Jutland [e.g. 49–51]. Numerous polished flint axes in SGC style from Zealand and adjacent islands speaks to a high population density in this part of the country during the period in question. Until the publishing of the genetic results from the present project it could only be guessed what was the population substrate of this habitation.

According to previous generations of Danish prehistorians the local *Late Neolithic (‘dagger epoch’), c. 2300-1700 cal BC,* was a time of integration of culturally and genetically distinct groups. It was also the time when bronze began to take over in the local production of

weapons. However, elegantly surface flaked daggers in flint were the dominant male burial gift throughout the epoch.

The Danish Late Neolithic is very richly represented by human skeletal material. The majority is derived from bog depositions and burials, including re-used stone chambers of the FBC. Biological anthropologists have noted a clear increase in stature as compared to all previous periods [e.g. 52]. They have also reported a novelty in cranial morphology: a number of skulls, tentatively referred to the period, were described as relatively 'archaic' with large, grossly formed skulls, very thick supraorbital ridges, low forehead and pronounced eyebrows [53,54]. Two of these are included in the present study (NEO735 and NEO737, both from a passage grave by Borreby). We can, therefore, confirm through AMS dates that at least these two individuals are of Late Neolithic date, and can be genetically associated with immigrant populations of the Corded Ware and Yamnaya cultures.

Which environments produce human skeletal remains

Our samples basically derive from three find categories: burials, bog depositions and stray found single skeletal elements. These categories can briefly be presented as follows:

Burials

Nearly all burials known from the Mesolithic are inhumation graves. Apparently, they were intended to be non-monumental. This category is also richly represented throughout the subsequent Neolithic periods.

Monumental architecture first showed up in Denmark and its vicinity with the construction of the earthen long barrows of the Early Neolithic FBC [41]. These rectangular or trapezoid earth mounts cover one or more burials, built of planks and/or small stones. The nature of their construction is not ideal for bone preservation. Consequently relatively few individuals in our study come from such contexts. A somewhat better preservation situation for bones is found in the dolmens, which are monumental burial constructions of earth and large, raised stones (megaliths). Even though their burial chambers are relatively small they often include several skeletons interred consecutively - the last ones often dating as late as the Late Neolithic or Early Bronze Age.

During the FBC period the construction of megalithic burial chambers developed into architecturally more complex and often significantly larger passage graves. Their chambers can be as long as 14 m, and there are examples of original roof-heights up to c. 2.5 m [55]. Their water-proof constructions and thick soil cover have often resulted in fine preservation quality for human DNA.

Such ideal preservation conditions have never been met in the low lumuli, typically of sandy sediment, of the SGC in the western part of the country. At best a dark 'shade' of the skeleton is all there is left. Much better conditions for the preservation of human bones were established during the Late Neolithic in terms of large collective burial cists of large stone slabs, covered in lime-rich soil in eastern parts of the country [53].

Depositions in watery environments

The category of bog skeletons typically represent deliberate depositions of whole bodies in watery environments distant from coeval habitation [34,56,57,cf. 58]. From the content and internal organisation of the best-examined bog skeleton sites it appears they are results of sacrificial deposition. A couple of these individuals were found with ropes around their necks [56], and several reveal traces of fatal physical violence associated with their deposition [e.g. 44]. The tradition of sacrificial deposition of human bodies and items of symbolic importance in the watery elements seems also to have taken place in fjords and open sea (NEO891 Roskilde Fjord; NEO943 Stenderup Hage; NEO898 Svinninge Vejle).

Isolated bones and teeth

Within layers of settlement debris at Mesolithic sites isolated human bones are often found [59]. Likewise, disarticulated human bones are sometimes seen in Neolithic enclosure ditches of ceremonial nature [60]. An example is a fragment of a human jaw (NEO19) from the submerged habitation site of Rønstenen. Here cut marks from a flint knife reveal a deliberate dismembering of the body – be it for venerational and/or cannibalistic reasons [22].

Wet deposits tend to produce the best DNA preservation

We have collected DNA samples from 211 human skeletons from Denmark. The 100 of these that proved of acceptable quality for whole genome analysis and date to the period prior to 1000 cal. BC are dealt with in the present paper. The best preservation quality is generally seen in bones and teeth found in deep sediments that have been permanently water-saturated since their deposition. Most examples presently known within this category derive from previous generations' peat digging in deep bog deposits. With the recent development of underwater archaeology, an increasing number of well-preserved human skeletal remains in terms of burials and stray human bones have come to the light from coastal habitation sites that were abandoned due to rapid inundation by the sea [22].

Eastern Europe and Western Siberia

The development and dispersal of cultivation and husbandry is of prime importance also in this area. However, there are also important changes in technology, economy and social organisation that precede and postdate this transition, and which may or may not have been related to genetic changes. Of early developments we can highlight the repopulation of northern Europe after the glacial maximum, the introduction of pressure blade technique, the dispersal of pottery production, and the general tendency for settlement stability, economic intensification, and probably social complexity within late hunter-gatherer populations.

The earliest of these technological changes is the development and spread of pressure technique for blade production. This is closely connected with the production of composite tools such as slotted bone points. As far as known, the earliest instances of pressure flaked blades and microblades are found in eastern Asia and date back to around 20000 cal BC [61,62]. From this region, the technology seems to have spread both eastwards into America and westwards into Europe. In western Russia and Scandinavia, it is first found in Early Mesolithic assemblages, for instance in the Russian Veretye culture and in the late Maglemose and the Kongemose cultures [24,63]. Some researchers associate the dispersion of this technology with migrations of people belonging to the genetic EHG (Eastern Hunter-Gatherer) group [25].

The emergence of pottery is one of the more significant technological changes in human prehistory. In western European archaeology, the introduction of pottery is largely seen as coupled with the introduction of farming, being part of the Neolithic package. Seen in a wider perspective, this is not the case. At present, it is widely acknowledged that the oldest pottery appears in eastern Asia during the Late Palaeolithic. Kuzmin [64] suggests dates at c. 16000 cal BC for southern China, c. 14700 cal BC for Japan and c. 13900 cal BC for the Russian Far East. From these very early centres, the technology spread gradually towards the west, reaching the area east of Lake Baikal at c. 12000 BC [64]. Here, however, the dispersal seems to have halted for several thousand years.

In western Siberia and the Urals, pottery appears considerably later, at present knowledge c. 6500-6000 cal BC [65]. In the region further to the west, i.e. Ukraine and western Russia, pottery appears slightly later, around or shortly after c. 6000 cal BC [66,67], while the Narva pottery and Comb Ware in the eastern Baltic regions are again somewhat later, from around 5500 cal BC [68]. As the most western outlier, we may consider the Ertebølle pottery found around the southwestern Baltic, from c. 4500 cal BC.

This early pottery has been subdivided into a plethora of cultural groups, mostly based on decoration. For recent overviews, see Jordan & Zvelebil [69] and Piezonka [70]. While often richly

decorated, vessel shapes are less varied and rather simple, consisting mostly of pointed-based or flat-bottomed, rounded bowls. Analyses of lipids, preserved in the clay matrix, conducted in several geographical regions suggest a variety of foods being processed, with a notable presence of aquatic products, i.e. freshwater fish and molluscs, increasing over time [31,70,71]. This is consistent with the human isotope data from the present project.

Thus, a general east-west trend is obvious in the dates of early pottery. Pottery is used to define the division between Mesolithic and Neolithic in these regions, but this does not imply any dramatic change in subsistence economy. Instead, these societies persist as pottery-using hunter-fisher-gatherers for 2-3 millennia. Several scenarios have been proposed to account for the emergence and spread of early pottery, such as continuous spread from east to west [72], or independent innovation in various Eurasian foraging communities [64]. It has also been proposed that eastern pottery traditions met with east Mediterranean “farmer” traditions along a frontier running through eastern Europe [72].

Even if no indications of agriculture are associated with the early pottery, important developments seem to occur both in the economic, social and ritual spheres. Thus, an increasing exploitation of seasonally abundant resources, higher degree of settlement stability, emergence of complex settlements, of enclosed and sometimes fortified settlements, large cemeteries and sacrificial sites in the form of ritual mounds, are features of this period [65,73].

Introduction of agriculture

The eastern regions covered in this project show a very different picture regarding the introduction of domesticates, as these are generally introduced later or much later than in more western regions. The delayed introduction of domesticated plants and animals, at least in the form that ultimately derives from the eastern Mediterranean, may perhaps be related to the highly developed hunter-gatherer societies in these regions, cf. above. It has been suggested that other plants may have been cultivated, such as Buckwheat [74], but this remains uncertain at present.

The earliest agriculture of European type is found in the more southern regions, e.g. Moldavia and western Ukraine, dating to at least before 5000 cal BC [75], and culturally belongs to the LBK and Bug-Dniestr cultures. Some domesticated animals are also found at the large settlements and cemeteries along the Dnepr rapids, after c. 5000 BC. Based on human isotopes, these are thought to play a very minor role in the economy, in favour of the dominance of fishing [76]. A later development is the fully agricultural Trypillia culture (c. 4100-3000 cal BC), characterised by large, highly structured settlements with up to 10-15000

inhabitants [14]. These agricultural groups would have coexisted with hunter-gatherer groups along the Dnepr as well as in the forest belt further north. In the forest belt of western Russia as well as eastern Baltic and Finland, clear indications of agriculture do not appear until well after 3000 cal BC, probably in the context of Corded Ware groups [77,78].

We find throughout much of the region a frontier between Neolithic communities in the southwest and foragers to the northeast, from eastern Europe to the Caucasus [79,80 Fig. 8.1]. These groups defy in certain ways traditional classifications, and some of them reached advanced levels of tribal organisation, in part due to the potential of the environment, steppe/forest steppe, intersected with large, productive rivers and lakes for fishing, that could sustain long-term settlements.

Some of this variation has been summarised by David Anthony [80] as a prelude to the formation of the Yamnaya nomadic lifeway from the mid to later 4th millennium BC [also 81]. Examples of these groups are found in the Dnieper-Donets culture, also including Sredni-Stog. In their cemeteries, we find richly furnished graves with symbols of power, most clearly at Khvalynsk at the Volga. These societies were linked together in far-reaching forms of exchange [11,82].

East of the Urals, in western Siberia, we find little or no indications of cultivation and stock keeping during the period of interest here, i.e. before c. 3000 BC. Only by the mid 3rd millennium BC do we find indications of agro-pastoralism in northern central Asia, and in the Altai and southern Siberia even later [83,84]. The beginning of the Neolithic period dates back to the 7th millennium BC in this area and the end is associated with the first metal tools in the 4th millennium BC. Based on the amount of archaeological sites and the appearance of necropolises, Siberia was densely populated in the Neolithic period. This vast territory is not culturally homogeneous, there are at least 7 large regions: Trans-Urals area, taiga zone, Ob-Irtysh interfluve, Altai, Baikal region, Transbaikalia, Far East. The genesis of Neolithic cultures took place in its own course in each region. In chronological terms, the Neolithic period is also not homogeneous, because there are from two to four development stages distinguished in different regions. Discussion issues are the emergence and development of complexes with flat-bottomed ceramics, the autochthonous or migratory origin of different populations of hunters and fishermen, and their interaction with each other.

Anthropologically, the Neolithic populations of the Baraba forest-steppe, where the samples from the Vengerovo-2A burial ground originate, demonstrate the presence of a northwestern vector of connections [85,86]. In the Late Neolithic period, the influence of the populations of the East European Plain and, indirectly, of the Baikal region was noted [87].

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6) Catalogue of Danish archaeological sites

Edited by Anders Fischer[1,2] and Per Lysdahl[3]

[1]Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

[2]Sealand Archaeology, Gl. Røsnæsvej 27, 4400 Kalundborg, Denmark

[3]Vendsyssel Historical Museum, Museumsgade 3, DK-9800 Hjørring

Aims

Ancient DNA sampling across Denmark has been undertaken with the explicit aim of analysing a comprehensive assemblage of the total population of human skeletal remains from the Mesolithic and the Early Neolithic, curated in public museums. The genomic data produced should, as far as possible, reflect the full variability of the skeletal population in question with regard to chronology, geography and depositional environments. Additionally, a further direct aim was to maximise representation of social diversity as potentially reflected in burial types, sacrificial depositions and stray human bones from mentioned periods. Skeletons believed to belong to the Middle and Late Neolithic have only been sampled in special cases. Individuals of even later date have merely come into the assemblage by chance.

Geographic distribution

Our sampling has involved skeletal remains of 197 humans dating earlier than 1000 cal BC. Of these, 100 were found to have DNA preservation of acceptable quality. Their find locations are shown in Figures S6.1 and S6.2. The uneven geographical distribution across Denmark seen in these figures is largely due to geological factors, as well as research-historical and museological sampling biases. For instance, early prehistoric bones have very little chance of surviving in good preservation quality (if at all) in the lime deficient soils of Western Jutland (Figs. S6.1-2), and this is undoubtedly a dominant reason for the lack of samples of acceptable quality from this region.

The sampled material was found during excavation activities etc. from 1838 onwards - nearly since the birth of archaeology as a scientific discipline [1]. During much of that time the National Museum of Denmark in cooperation with the Zoological Museum of the natural history branch of Copenhagen University were the major proponents in the assembling of

Danish prehistoric human bones. A collection of human skeletal materials at the branch of human health and anatomy of Copenhagen University also received finds directly from activities at various places in the countryside. The latter assemblage developed into the Anthropological Laboratory, which nowadays curates not just its own assemblage of skeletons, but also the majority of prehistoric human skeletal materials formally held by culture-historical museums all over the country. Even though especially the former two of these three institutions had field activities and contacts all over the country [e.g. 2], find sites located in the vicinity of Copenhagen are no doubt overrepresented in their collections – and consequently potentially also in the assemblage sampled by the present study (cf. Figs. S6.1-3). We have benefitted from efficient access to the collections of all three institutions since the initiation of this study in 2008. Likewise, we have had generous access to regional culture-historical museums with especially large collections of prehistoric human skeletal material, located geographically widespread in Hjørring, Rudkøbing and Kalundborg. Additional sampling has taken place in several other public museums (Fig. S6.3).

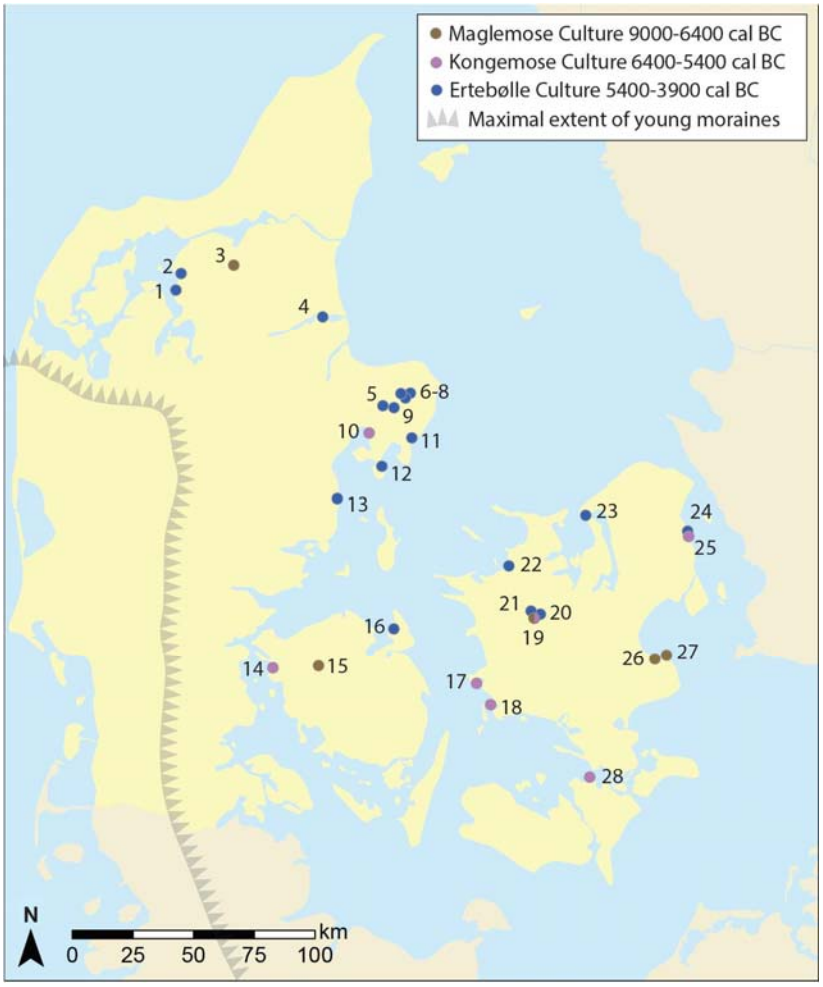

Figure S6.1. The geographic distribution of the study's 38 Mesolithic individuals from Denmark. *All three major chronological groups (Maglemose, Kongemose, Ertebølle) have been sampled to comparable high intensity. The sites in question are: 1 Ertebølle (*locus classicus*), 2 Bjørnsholm, 3 Hedegaard, 4 Havnø, 5 Koed, 6 Nederst, 7-9 Fannerup D, E and F, 10 Rønsten, 11 Holmegård-Djursland, 12 Vængesø II, 13 Norsminde, 14 Tybrind Vig, 15 Koelbjerg, 16 Langø Skaldynge, 17 Korsør Nor, 18 Tudse Hage, 19 Bodal K, 20 Ravnsbjerggård II, 21 Kongemose (*locus classicus*), 22 Dragsholm, 23 Sølager, 24 Henriksholm-Bøgebakken, 25 Vedbæk Boldbaner, 26 Strøby Grøftemark, 27 Køge Sønakke, 28 Orehoved Sejlrende. Map production K-G. Sjögren, Rich Potter and Anders Fischer.*

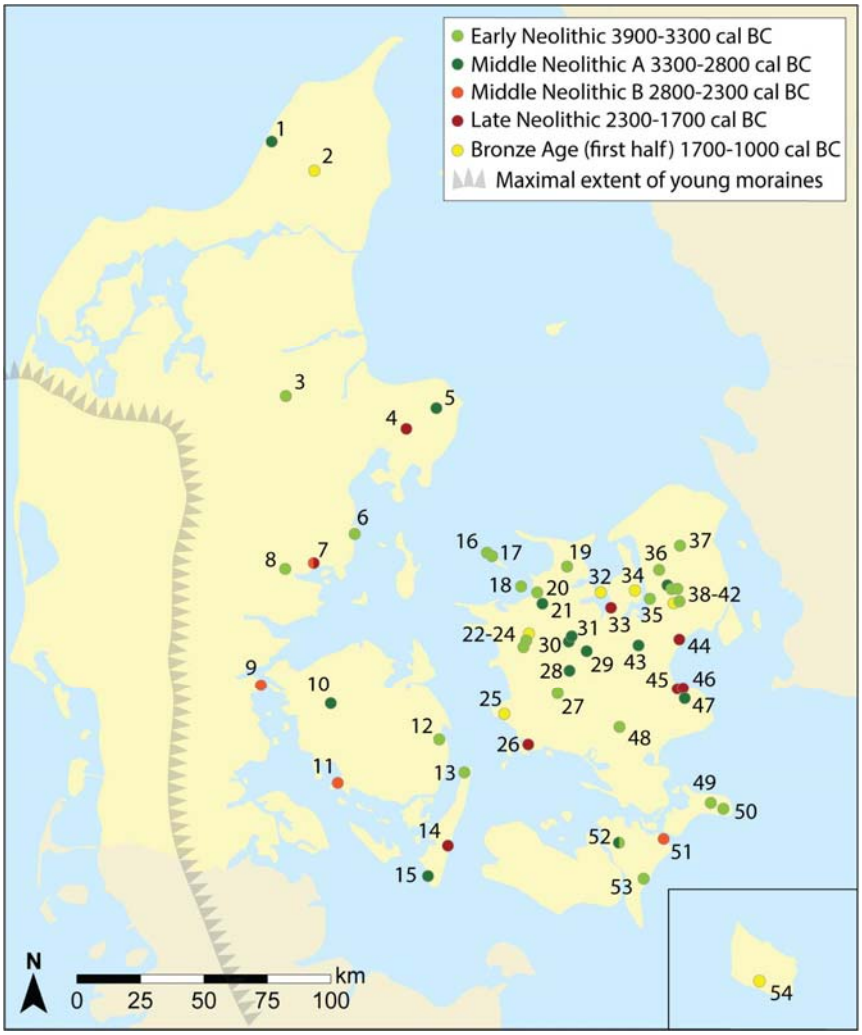

Figure S6.2. Geographical distribution of the find locations for the study's 55 individuals of Neolithic date and 7 individuals dating to the parts of the Bronze Age earlier than 3000 cal BC. *1 Vittrup, 2 Klæstrupholm Mose, 3 Læsten Mose, 4 Kolind, 5 Kainsbakke, 6 Rude, 7 Toftum Mose, 8 Bygholm Nørremark, 9 Stenderup hage, 10 Neverkær Mose, 11 Klokkehøj, 12 Sludegård Sømose, 13 Lohals, 14 Gammellung, 15 Myrebjerg Mose, 16 Rødhals, 17 Sejerby, 18 Pandebjerg, 19 Vig Femhøve, 20 Dragsholm, 21 Svinninge Vejle, 22 Madesø, 23 Jorløse Mose, 24 Tissøe, 25 Magleø, 26 Borreby, 27 Grøfte, 28 Døjringe, 29 Vanløse Mose, 30 Storelyng Eel Picker, 31 Storelyng Fire Lighter, 32 Bybjerg, 33 Kyndeløse, 34 Lollikhuse, 35 Roskilde Fjord, 36 Jørlundegård, 37 Salpetermosen, 38 Sigersdal Mose, 39 Viksø Mose, 40 Sigersdal, 41 Hove Å, 42 Tysmose, 43 Vibygårds Mose, 44 Mosede Mose, 45 Barhøj, 46 Strøby Ladeplads, 47 Avlebjerg, 48 Porsmose, 49 Dalmosegård, 50 Mandemarke, 51 Næs, 52 Lundby-Falster, 53 Elkenøre, 54 Vasagård.*
Map production K-G. Sjögren, Rich Potter and Anders Fischer.

We have undertaken AMS dating and DNA sampling upon a considerable number of skeletons without any archaeological context, found during peat digging. There are several hundred such bog skeletons in Danish museums that remained undated until now. We focused on sampling individuals from Jutland and the islands south of Zealand – areas from which we were generally short of Neolithic material.

Figure. S6.3. Museums where sampling (successful or not) has taken place. *Map production K-G. Sjögren and Rich Potter.*

Chronology

The majority of the previously undated bog skeletons were discovered to be of Early Neolithic date – coinciding with a very high frequency of human sacrifice in wetlands. The remainder were spread throughout subsequent periods, closing with the Roman Iron Age. They display secondary peaks in the Late Neolithic (Fig. S6.4) and in the Early Iron Age (the final centuries BC). The 14 individuals identified as later than 1000 cal BC will be included in other genomic and archaeological studies.

When looking at the number of individuals per cultural epoch, normalised to equal units of time (1000 years), the number continuously rises through the Maglemose, Kongemose and Early Ertebølle periods (Fig. S6.4). This does not necessarily reflect actual changes in population size or density within the present-day Danish (land and sea) territory. To a greater extent it probably reflects the effects of the major sea-level change that took place during these Mesolithic periods. Inland regions generally had a significantly lower population density than coastal zones. Due to the approximately 30 m sea-level rise (see Fig. S5.2) during the periods in question, the later the period of focus; the greater the area of former coastal zones within effective reach of archaeology [3].

The declining incidence of individuals per time unit seen throughout the three stages of the Ertebølle Culture [ex. 4] can hardly be explained from subsequent sea-level conditions. It more likely reflects the realities of the Ertebølle world. An explanation may be looked for in terms of changes in burial practice. Alternatively, the decline could reflect impact from farming societies approaching the Ertebølle territory during this period [5,6] – be it in terms of violence or spread of diseases.

The highly varied numbers of individuals per 1000 years units seen from the arrival of farming (the onset of the Neolithic) onwards most likely reflect a combination of chronological sampling bias and taphonomic factors. Individuals dating to the Early Neolithic have deliberately been sampled more intensely than those of the following periods. Moreover, sampling generally avoided the Middle Neolithic B and later periods.

From Figure S6.4 it can be seen that during the Neolithic there are instances of more than one ancestry group living within the Danish territory at one and the same time. Based on their combinations of absolute date and genetic profile, two individuals from the very earliest of the Neolithic (the Rødhals and Dragsholm males) seem to represent relics of the previous periods' local Ertebølle population. In addition, the individual from Stenderup Hage belongs to the time of the Steppe invasion, although by genetic signature this skeleton clearly connects with the previous period's local Funnel Beaker Culture. The individuals from Vittrup and Svinninge Vejle, who chronologically belong to the epoch of the local Middle Neolithic

Funnel Beaker Culture, genetically relate to Mesolithic and Neolithic (Pitted Ware) individuals from Sweden.

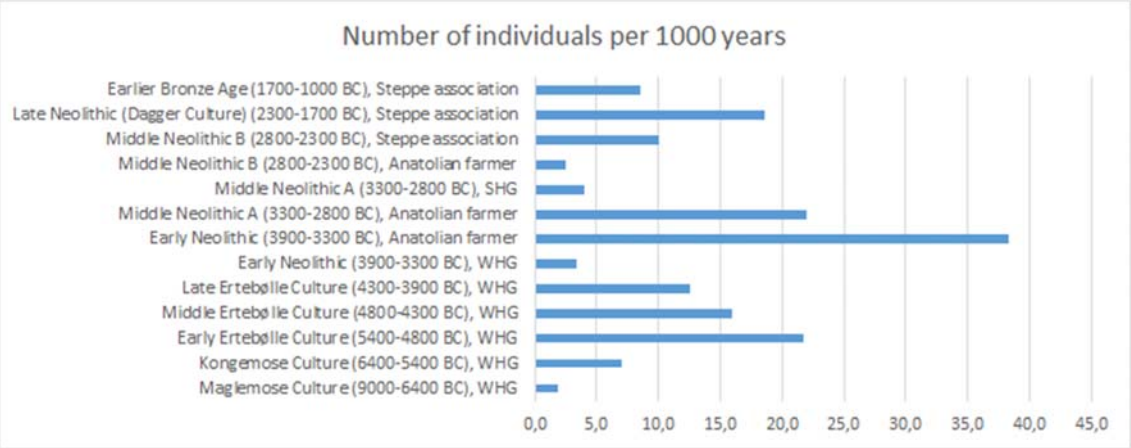

Figure S6.4. The chronological distribution and genetic association of the 100 Danish early prehistoric individuals, represented in the present study, expressed as the number of individuals pr. 1000 years (reservoir corrected, calibrated midpoint dates). *The chronological grouping is based on categories traditionally made use of in Danish archaeology.*

The structure of the catalogue

In the following the sites, from which skeletal material has been sampled, are presented in alphabetical order. Emphasis is put upon topography, chronology, research history and human skeletal remains represented. The headings below begin with the site name – with alternative site names in brackets. Following that comes our project's internal ID number(s) for humans from the site in question, represented in the main text. Then comes the name of the parish in which the site is located and an ID number referring to the national database for archaeological sites, *Fund & Fortidsminder*, housed by the National Agency for Culture and Palaces. Next, reference is made to the major geographic region of the find. Finally comes a brief, generalised culture-historical classification of the site. ^{14}C dates are given as conventional radiocarbon years Before Present (i.e., uncalibrated ^{14}C years before 1950 AD). Matters of reservoir correction of dates are dealt with in Supplementary Note 8, while calibrated and reservoir corrected ages of each individual are listed in Supplementary Table III. The full assemblage of dates and isotopic values is presented in Supplementary Table IV. We also provide reference to the specific publications detailing the history of research at each site, listed at the end of each site description under 'literature'.

Acknowledgements

During the years-long process of selection and sampling of human skeletal materials for the study, many persons working within archaeology, etc. as researchers, museum employees and citizen scientists have assisted importantly in the acquisition of samples, provenance data, etc. A special thank is given to the following (listed alphabetically), who have been involved in our work with the assemblage dealt with in the present paper: Arne Hedegaard Andersen, Pia Bennike, Sophie Bergerbrant, Kirsten Christensen, Kristian Murphy Gregersen, Vaughan Grimes, Erik Johansen, Ole Thirup Kastholm, Kurt Kjaer, Tage Lotz, Erni Lundberg, Jesper Olsen, Knud Rosenlund, and Hugo Hvid Sørensen.

In addition, we acknowledge those, who have been of assistance in the sampling process or the gathering of provenance data on prehistoric human remains that showed up not to have sufficiently well-preserved DNA (although the remains have provided other kinds of interesting data via AMS dating and/or measuring of C, N or Sr isotopes). Among these persons we especially thank the following (site names in brackets): Hans Dahl (Tybrind Vig), Inge Bødker Enghoff (Østenkær), Anne Birgitte Gurlev (Vedbæk Havn), Lars Holten (Aldersro), Niels Nørkjær Johannsen (Stistrup Kær), Lilian Matthes (Knudsgrund/Knudshoved), Klavs Randsborg (Nivå).

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Avlebjerg, NEO961; Strøby 05.06.12-8A, Zealand. Stone cist

Rune Iversen

Aulebjerg is situated on a hill above a pronounced river valley. In 1937 human remains were exposed during gravel digging, after which an archaeologist from the National Museum of Denmark arranged a swift excavation of a NE-SW oriented, irregular stone cist. It was 2.6 m long and 0.85 m wide and contained the skeletal remains of two children placed in opposed crouched positions facing south. The burial goods included tooth and amber beads, two bone tubes, a boar tusk and two boar-tusk ornaments. Except for two amber beads, all the burial goods were associated with skeleton I. In 1939 another grave was excavated 12-15 m NE of the previous one. It was covered by a stone heap, measured 2.2 by 0.5 m and contained the skeletal remains of a c. one-metre-long child (individual III) placed with the head toward the E. The grave contained no burial goods.

DNA samples were taken from the individuals I and III. However, sufficient endogenous DNA was only preserved in skeleton I. A radiocarbon date of this individual gave the result 4510±32 ^{14}C years BP (UBA-40443) corresponding to the early Middle Neolithic TRB (MN I).

Literature: Becker 1951[7]; Iversen 2015[8].

Barhøj, NEO92; Strøby 05.06.12-22, Zealand. Stone cist

Kristoffer Buck Pedersen

Barhøj belongs to a cluster of burial mounds that were erected about half a kilometre from the present-day and contemporaneous coast. This tumulus was situated 10 m above sea-level on a flat piece of cultivated land. Originally it was surrounded by a circle of large stones. These were removed in 1855-1860, and in 1900 the mound was reported over-ploughed. Anyhow, an excavation in 1932-33 revealed several burials, including one measuring 3.1 by 1.4 m, made of large stone slabs. A tooth from an adult human was sampled for DNA, and proved to have sufficient endogenous DNA content. It dates 3803±31 ^{14}C BP (UB-37878), which according to the traditional south Scandinavian chronology says Late Neolithic. Fragments of at least two ceramic vessels are typologically dated to the same period.

Bjørnsholm, NEO751; Ranum 12.07.10-20, North Jutland. Shell midden with inhumation

Anders Fischer

The kitchen midden of Bjørnsholm is one of the largest of its kind known from Denmark. The extent of marine mollusk accumulations along the former sea shore is c. 325 m, while width and thickness are reported to be up to 50 m and 1.2 m, respectively. The shell layers were subject to archaeological investigation in 1931 and 1985-1991 and are well-known in literature, among other reasons, due to their stratigraphically well separated assemblages of flint, pottery and faunal materials dating from the Late Mesolithic and Early Neolithic. It was, however, only apparent through the present project that this site has also provided one of the first intact Mesolithic burials revealed during professional archaeological fieldwork in Denmark. Dated 5792±41 (δ^{13}C -13.5, δ^{15}N 14.1, UB-35718) this inhumation without burial goods can be referred to the last half of the Ertebølle Culture [ex. 4].

Literature: e.g. Andersen 1993[9] (with reference to earlier archaeological presentations); Bratlund 1993[10]; Enghoff 1993[11].

Bodal K (Knoglebo), NEO814; Stenlille 03.03.09-176, Zealand. Settlement and unassociated human remains

Anders Fischer

A rich assemblage of habitation debris derives from ploughed-up wetland sediments over an area >20 m in diameter. It is of transitional Mesolithic-Neolithic typology. Several bones of dog, domesticated cattle and a human tibia are AMS dated to the same narrow time slice. Additionally, there are two unassociated human skeletal remains with a significantly earlier AMS date, even when correcting for marine reservoir effect: a fragmented humerus and a molar (6+). The latter, which has produced a DNA sample of acceptable quality, is dated 6435±44 ^{14}C years BP (δ^{13}C -11.6, δ^{15}N 14.5, UB-38238).

Literature: Fischer & Gotfredsen 2006[12]; Fischer et al. 2007[13].

Borreby, NEO735+737; Magleby 04.04.11-45, Zealand. Passage grave

Anders Fischer, Morten E. Allentoft and Martin Sikora

Originally the Borreby passage grave was covered in a tumulus framed by up to 1¼ m high stones that formed a semicircle 16-18 m in diameter. The oval burial chamber, horizontal dimensions c. 5½ by 2 m, was constructed of eleven upright stones and 3 cap stones. The ESE facing, 5½ m long entrance was constructed from 5 pairs of vertical stones and a pair of door jambs, topped by capstones (Fig. S6.5). When excavated in 1859 the chamber and entrance was full to the roof with human skeletal parts, in between which were scattered

burial gifts of Middle Neolithic and Late Neolithic date. The excavator judged there were remains of at least 60-70 individuals. The Meso-Neo project sampled three of them, characterised by unusually coarse facial characteristics ('Borreby type' according to previous literature) and suspected to represent foreign ancestry (cf. text on the Madesø individual below). The two of these skulls that produced DNA of acceptable quality were AMS dated to the Late Neolithic period.

Our genetic analyses have indeed documented shared ancestry for these two individuals, and for our third Borreby type individual, from Madesø, since they are all of Y-chromosomal haplotype R1b, falling within the earlier cluster of Scandinavian Late Neolithic and Bronze Age individuals. Interestingly the non-Scandinavian individuals of this cluster are generally from Western Europe, and the R1b haplogroups are also more common there. If this points to migration it would likely be from there (cf. main text's chapter: *Fine-scale structure and multiproxy analysis of Danish transect*).

Literature: Bröste et al. 1956, p. 320[14]; Ebbesen 2008, p. 125[15]; Bennike & Alexandersen 2002, p. 297[16]; Hansen 1993, p. 115[17].

Figure S6.5. The Borreby passage grave in its present-day appearance, where the surrounding tumulus and most of the cap stones are missing. *The passage leading to the burial chamber is seen in the foreground. Photo: Cille Krause, ROMU 2020, courtesy the National Agency for Culture and Palaces.*

Bybjerg, NEO563; Orø 03.07.09-34, off Zealand. Stone Age kitchen midden with Bronze Age burials

Anders Fischer

The Bybjerg coastal kitchen midden was recorded while its sediments were queried for field improvement and road fill. It consisted of oyster and snail shells in between which numerous worked flints of Mesolithic character and some stone-set fireplaces were observed. In reports of 1911 to the Danish National Museum the local vicar mentioned two human skeletons interred at the site. The one sampled by the present project, was found below the shell layer, and was framed with a rectangular setting of stones of a size a man could lift. The body had been placed on its back in a stretched out position with the head in WSW. An AMS date relates this skeleton to the Early Bronze Age (3210±32 ^{14}C years BP, UB-38226). The same general date probably applies to the other burial since its bones were stained by verdigris.

Bygholm Nørremark, NEO564; Hatting 17.04.03-128, East Jutland. Earthen long barrow

Poul Otto Nielsen

The earthen long barrow of Bygholm Nørremark was excavated 1977-78. It was oriented approximately E-W and measured c. 60 m in length (Fig. S6.6). Based on a series of radiocarbon dates of samples from below and within the mount, it is dated to an early stage of the south Scandinavian Early Neolithic. Grave A contained badly preserved remains of a young male and grave D contained skeletons of four adult individuals (Fig. S6.7), morphologically determined to be one male and three females. At least one of these was killed by force. The long barrow was extended to a length of 75 m in the early Middle Neolithic, when a megalithic grave chamber was constructed.

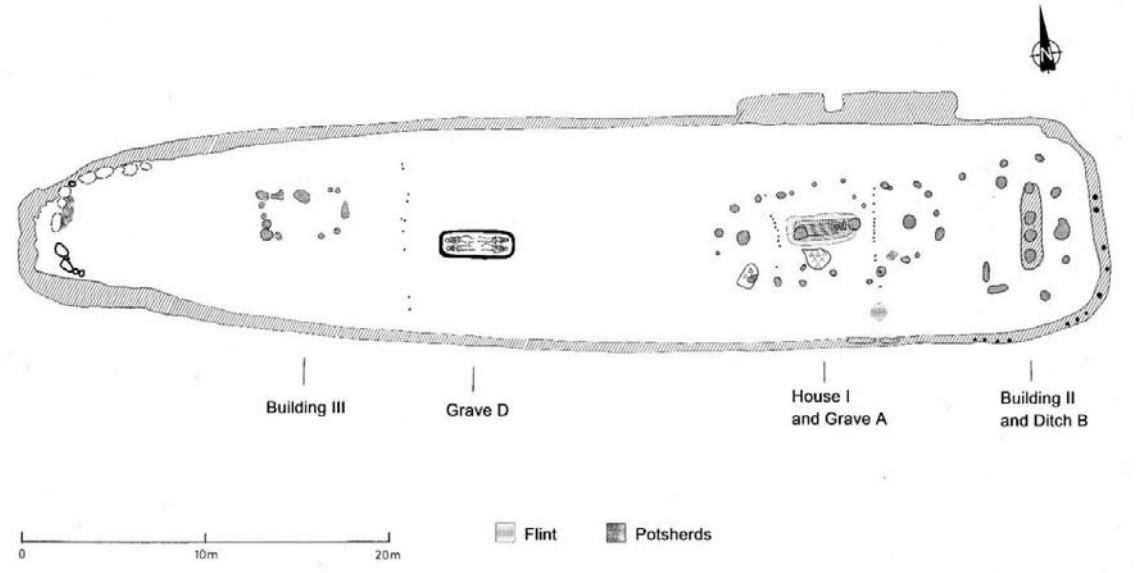

Figure S6.6. Bygholm Nørremark, Early Neolithic stages. *The present genomic study deals with one of the four humans found in grave D, AMS dated 4836±35 ^{14}C BP.*

Figure S6.7. The four humans of Bygholm Nørremark grave D, seen from the north*. It is assumed they were victims of a human sacrifice connected with the primary burial (grave A) elsewhere in the earthen barrow. Photo: Preben Rønne (Danish National Museum) 1978.*

Literature: Rønne 1978[18]; 1979[19]

Dalmosegaard, NEO886; Borre 05.05.02-95, Møen. Bog skeleton

Anders Fischer

During peat digging in a small wetland, a local farmer in 1941 revealed a highly fragmented human skull. Subsequently, a bone of domestic cattle was also salvaged from the bog deposits. Based on parallels to similar finds with better documentation, the find is inferred as the result of sacrificial deposition. Radiocarbon dates the individual to 4774±52 ^{14}C years BP (UB-39141) corresponding to the South Scandinavian Early Neolithic.

Dragsholm, NEO732+733+822+962b; Fårevejle 03.04.03-503, Zealand. Dwelling site with a Mesolithic and a Neolithic burial, and a loose human bone

Erik Brinch Petersen

The location is a small rise in the innermost part of the Lammefjord on the north western coast of Zealand. The former island and the drained fjord are situated just to the south of the Bay of Sejerø. A rescue excavation by the National Museum was initiated here during the early spring of 1973, and this was followed up by a second investigation in the late summer of the same year. A subsequent excavation by the Odsherred Museum and the University of Madison, USA took place between 2002 and 2004. The first two seasons in 1973 produced a single grave each, first a Late Mesolithic Ertebølle burial with ochre and then an Early Neolithic burial, while the later investigation found a single human lower jaw.

The Mesolithic burial is a double burial with two females, while the Neolithic burial contained a single male individual. The two graves were located next to each other near the top of the rise, and this close connection in space as well as in time, has created quite a stir, as well as the spilling of much ink. Both graves have been dug through a former Ertebølle shell midden, though not very deep. The Neolithic male burial is dated around 5100 ^{14}C years BP (AAR-7416, AAR-7416-2). The δ^{13}C value of -19.6‰ shows a non-marine diet, while the δ^{15}N measurement around 10‰ indicates a Neolithic diet. His strontium value, 0.709391, is close to that of a local red deer.

In the Mesolithic double burial was a younger individual of eighteen years of age together with an older female between forty and fifty years at death. The younger was found in a crouched position whereas the older one was in a supine position, and much ochre surrounded the two individuals. Both were well dressed, each with a girdle belt of tooth pendants from red deer teeth. Two exotic teeth, Elk and Aurochs, were found among the red deer teeth in the two belts. The younger female also carried a bone spatula decorated with a human figure.

The radiocarbon dating of the two females has been problematic, involving several laboratories. However, we have a date (prior to reservoir correction) around 6000 BP for the red deer bone dagger, the only item not affected by a marine supplement. Thus, there is at least half a millennium between the Neolithic male and the Mesolithic females. The latter ones have high δ^{13}C values, -10.7‰ for the younger one and -11.7 ‰ for the older one. Their δ^{15}N signatures are as high as 13.3 and 13.7‰.

Literature: Brinch Petersen 1974[20]; Alexandersen 1988[21], 1989[22]; Brinch Petersen & Egebjerg 2009[23]; Price et al. 2007[24].

Døjringe, NEO566; Munke-Bjergby 04.01.08-109, Zealand. Wetland with two bog skeletons

Anders Fischer

During peat digging in the year 1942 remains of two human skeletons were unearthed in the vicinity of each other, about 3 m deep in the sediment. Pollen analysis indicated a nearly identical date within the Early or Middle Neolithic. ^{14}C analyses later on provided nearly identical ages within the Early Neolithic. Individual I: 4629±31 and 4640±90 ^{14}C years BP (UB-40108 and K-3623). Individual II: 4670±90 ^{14}C years BP (K-3624). Both skulls have healed traces of trepanation.

Literature: Bröste et al. 1956, pp. 20-23[14]; Bennike 1985, pp. 69-72[25].

Elkenøre, NEO888; Idestrup 07.02.05-91, Falster. Bog skeleton

Anders Fischer

During peat digging a number of cranial and postcranial human skeletal remains were salvaged. Among these are cranial parts of two individuals, characterised by a dark and a pale patina, respectively. Via AMS dating, the dark one turned out to be from the Early Neolithic (4647±31 ^{14}C years BP; UB-40440), whereas the pale one is from the early Iron Age. Based on parallels to better documented sites, the bone assemblage is inferred to be the result of sacrificial depositions.

Ertebølle, NEO568+569; Strandby 12.02.12-63, North Jutland. Kitchen midden with inhumations and loose human bones

Anders Fischer and Søren H. Andersen

This kitchen midden has given name to the South Scandinavian Late Mesolithic Ertebølle Culture. In the seminal 1900 publication the masses of accumulated shells of marine molluscs were reported to be 1.9 m in height, c. 20 m in width and extending c. 141 metres along the contemporary beach. Excavations 1893-97 and 1979-84 have revealed a rich assemblage of worked flint, pottery, charcoals and bones of fish, birds and mammals. A well-defined stratigraphy (Figure S6.8) is observed, with massive Late Mesolithic (Ertebølle Culture) shell accumulations covered by a less shell-rich culture layer of Early Neolithic date (Funnel Beaker Culture). During the pioneering excavation human skeletal remains were found in five places within the Mesolithic deposits. They represent A) a burial with the skeleton of an adult male; B) skeletal remains of a young child, possibly representing an inhumation that was not noticed during excavation, located right next to the adult individual;

C) three loose human bones. Radiocarbon dates of the two skeletons demonstrate them to be contemporary with the Mesolithic midden accumulation.

Literature: Madsen et al. 1900[2]; Andersen & Johansen 1987[26]; Enghoff 1987[27]; Petersen 1987[28]; Müller et al. 2002[29].

Figure S6.8. Section through the classical Ertebølle kitchen midden. *The whitish (lower) layer, dating to the Late Mesolithic is dominated by oyster shells, while the black-grey top layer of Early Neolithic date is characterised by shells of cockles. To the left in the section is a large pit with several layers of ash. Photo 1983 Jan Sloth-Carlsen.*

Fannerup D, NEO855; Ginnerup 14.01.05-71, East Jutland. Kitchen midden with inhumation

Rikke Maring and Esben Kannegaard

Ruins of a coastal shell midden, excavated 1992-94. Its deposits of marine mollusc shells were accumulated to a height of as much as 0.7 m and contained animal and fish bones, flint tools, ceramics, fish hooks etc. mainly dating to the latest centuries of the Mesolithic (late

Ertebølle Culture). An inhumation burial was revealed in the uppermost shell layers. The site belongs to a cluster of twelve kitchen middens along the shores of the now drained salt water sound Kolindsund.

Literature: Kannegaard 1994[30].

Fannerup E, NEO570; Ginnerup 14.01.05-72, East Jutland. Kitchen midden with inhumation

Anders Fischer

A Mesolithic coastal kitchen midden, where clearly stratified deposits of shell and sand were accumulated to a height of at least 0.7 m. The shells were dominated by oyster, but also included snails [periwinkle], cockle and common mussel. The width of the midden was about 10 m and its length parallel to the coeval shoreline >31m. Archaeological examination in 1888 led to the revealing of an inhumation burial in the uppermost shell layer. A stone paved hearth covered in sod was observed at a stratigraphically lower level. Via AMS dating (5911±43 ^{14}C years BP, UB-35705) the interred, 40-50-year-old individual can be referred to the Late Mesolithic Ertebølle Culture.

Fannerup F, NEO930; Ginnerup 14.01.05-107, East Jutland. Kitchen midden with inhumation

Lutz Klassen

Kitchen midden with a partly disturbed grave dug down into the shell deposits. The deceased was placed in a stretched-out position on its back, and was entirely strewn with red ochre. By means of physical anthropology the well-preserved skeleton is identified as a c. 40-year-old male. It is dated 6377±30 ^{14}C years BP (AAR-19687). The site is part of a large complex of Mesolithic and Neolithic kitchen middens on a peninsula located at the mouth of the Ørum Å river into the Stone Age fjord of Kolindsund.

Literature: Rasmussen 1990[31]; Bennike & Alexandersen 1990[32]; Maring & Riede 2019[33].

Gammellung (Troldebjerg), NEO934; Lindelse 09.03.04-98, Langeland. Ceremonial bog deposition

Otto Uldum

Stray find of a human skull and mandible from a bog extending c. 500 by 300 m. The skull appears to show damages caused by a fatal blow. The find spot is located next to the pronounced hill, Troldebjerg, on which an enclosure site of Middle Neolithic date has been excavated. However, a ^{14}C date produced via the present project tells that the skull belongs to the south Scandinavian Late Neolithic period: 3573±39 ^{14}C years BP (UB-39146).

Literature: Skaarup et al. 1985, pp. 71-72[34].

Grøfte, NEO571; Kindertofte 04.03.06-3, Zealand. Megalithic monument with two dolmen chambers

Anders Fischer

The archaeological site of Grøfte is situated on a low elevation, surrounded by wetlands. Across the small rise in the moraine landscape three long dolmens are located nearly in line. Two small dolmen cists were excavated here in 1946. They were found below an earthen barrow, which measured 9 by at least 80 m and had originally been framed by megalithic stones. At least three individuals were buried in the chambers, furnished with ceramic vessels of Early Neolithic type (Figure S6.9). This date is now confirmed through AMS dating. Expressed in ^{14}C years BP, the results were: 4828±35 (individual from cist A, UB-38228) and 4731±32 (individual from cist B, UB-40437).

Figure S6.9. Grøfte dolmen chamber A. *An intact and a fragmented lugged flask are seen upper right, apparently next to the feet of the two individuals interred in the cist. Photo: Harald Andersen 1946.*

Literature: Bennike 1990[35]; Ebbesen 1990[36]; Sjögren & Fischer (*in prep*).

Havnø, NEO941; Visborg 12.04.13-(45?), North Jutland. Human mandible from a kitchen midden

Anders Fischer

In 1847 a fragmented human mandible was revealed in a kitchen midden by Havnø. It was handed over to an institution, later on termed the National Museum of Denmark. Via a radiocarbon measurement (5947±33 ^{14}C years BP, UB-39153) the find is now dated to the Late Mesolithic Ertebølle Culture. The site in question is probably the one that was subject to systematic excavation in 1894 and was published under the name of Havnø. The latter excavation recorded Mesolithic shell deposits extending c. 100 m along the coeval coastline

and reaching a thickness of up to 0.9 m. In between the shells several human bones were found.

Literature: Madsen et al. 1900, pp. 103-111[2]; Rowley-Conwy 1983[37]; Fischer et al. 2021[38].

Hedegaard, NEO13; Bislev 12.05.01-113, North Jutland. Wetland with human skull

Bjarne Henning Nielsen

The Hedegaard calvarium is a stray find from a cleanup operation in a stream. The skull has some serious but healed traumas in the back and in the front. For many years it was believed to represent an Early Iron Age bog deposition. However, its archaic characteristics led to AMS dating (AAR-4554): 8680±40 BP, which implies Early Mesolithic and makes it one of the earliest human skeletal remains presently known from Denmark.

Literature: Fischer et al. 2007[13]; Nielsen & Adamsen 2013[39].

Henriksholm-Bøgebakken, NEO745+746+747+748+749; Søllerød 02.03.10-157, Zealand. Mesolithic dwelling site with burials

Erik Brinch Petersen

Henriksholm-Bøgebakken lies at the fossil fjord of Vedbæk, along which more than forty Mesolithic sites are recorded. The site was first excavated by the National Museum in 1924, but it was only in 1975 that the burials were detected (Figure S6.10). They include 17 inhumations with 22 individuals. This is not a cemetery, but a settlement with burials. Red deer teeth adorn the richest female, while male persons tend to be equipped with one or two flint blades (Fig. S6.11). Two older individuals were laid to rest on pairs of antlers from red deer, while three males seem to have been buried under parts of dugout canoes.

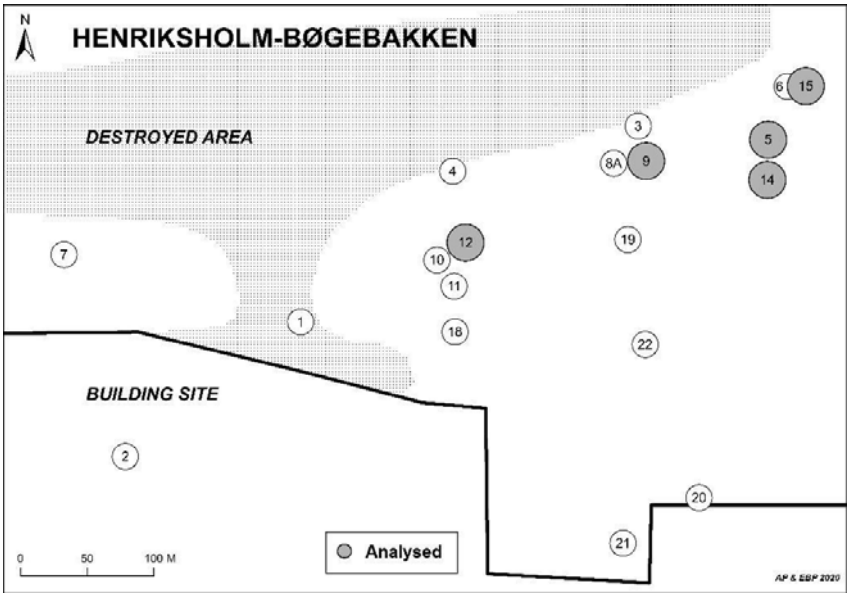

Figure S6.10. Henriksholm-Bøgebakken 1975 with location of inhumations. *Grey fill indicates genetically investigated burials.*

Figure S6.11. Henriksholm-Bøgebakken grave 5, a male burial.

The individuals dated so far, K- and Ua- dates, span the period c. 7100-6100 ^{14}C years BP (not corrected for marine reservoir effect). Their $\delta^{13}C$ and the $\delta^{15}N$ values centre around -15‰ and 15‰, respectively. Five skeletons have been sampled for aDNA, and they were all positive. The selected individuals were adult males from graves 5, 9, 12 and 14 and a female from grave 6/15. The archaeologically most interesting burials were not available for sampling, being presently on exhibition at GI. Holtegård and the National Museum.

Literature: Albrethsen & Brinch Petersen 1975[40], 1977[41]; Newell et al. 1979[42]; Alexandersen 1988[21], 1989[22]; Brinch Petersen 2015[43].

Holmegaard-Djursland, NEO1; Hyllested 14.02.07-24, East Jutland. Kitchen midden with inhumation

Søren H. Andersen

A Late Mesolithic (Ertebølle Culture) kitchen midden from which a rich assemblage of worked flint, pottery, charcoal and bones of fish, birds and mammals is available. The deposit of marine shells, originally located just above the beach, measured c. 20-25 m by 15-20 m and was c. 0.5 m thick. Archaeological excavation has revealed various settlement structures, e. g. hearths of two types, large structural stones, layers of fish bones, a flint-working site and a possible dwelling floor. In 1967 an inhumation burial with a very well-preserved skeleton was found deep in the shell layer. Over the skeleton's legs and feet lay two large stones. Due to the excellent circumstances for observation it can be stated with certainty that no burial gifts were present – and no cranium either. According to physical anthropology the interred individual was a male c. 17-20 years of age. Although only a sample of limb bone was at disposal for the project, it proved possible to extract aDNA of acceptable quality. Radiocarbon dates (K-359, OxA-118, OxA-533) refer the skeleton to the middle phase of the Ertebølle Culture.

Literature: Andersen 2018[44]; cf. Newell et al. 1979[42]; Andersen et al. 1986[45]; Fischer et al. 2007[13].

Hove Å (Gundsømagle Mose), NEO946; Hvedstrup 02.04.06-29, Zealand. Wetland with bog skeletons

Anders Fischer

An ornamented spear head of Early Iron Age type and skeletal remains of two humans were salvaged during peat digging in the 1940s in mire deposits along the Hove River. The individual included in the present study dates to the Bronze Age (2982±44 ^{14}C BP, UB-39154), whereas the other one has previously been dated to the Neolithic.

Literature: Frei et al. 2019[46].

Jorløse Mose (Jordløse Mose), NEO23; Jorløse 03.06.06-192, Zealand. Wetland with bog skeleton

Lisbeth Pedersen

The bog of Jorløse is part of Minor Aamose (in Danish 'Lille Åmose') - a c. 6 km^2 mire with an outstanding concentration of Neolithic sacrificial depositions of pottery and skeletons of humans and cattle. The find in question consists of a stray found cranium, revealed during peat cutting in 1943. According to physical anthropological determination it represents a ≥ 40-50-year-old, probably male individual. Via AMS measurements 4877±32 ^{14}C years BP (UB-39120) and 4706±40 ^{14}C years BP (AAR-11122) it is dated to the South Scandinavian Early Neolithic.

Literature: Fischer & Pedersen 2005[47]; Fischer et al. 2007[13].

Jørlundegård, NEO702; Jørlunde 01.03.06-85, Zealand. Wetland with bog skeleton

Anders Fischer

During peat cutting, several Neolithic to Wiking Age wetland depositions have been salvaged from a c. 40 ha large mire, located in an undulating moraine landscape. Among these are skeletal remains of several humans. One of these was included in the present study. It represents a 2-6 years-old child, dated to the Early Neolithic (4619±41 ^{14}C years BP, UB-35714).

Kainsbakke, NEO25; Ginnerup 14.01.05-118, East Jutland. Ritual pit at coastal settlement

Lutz Klassen

Kainsbakke is the largest settlement of the Pitted Ware Culture known in Denmark and one of the largest Neolithic settlements of this country. It is located on a low elevation, c. 750 x 500 m in size, that was surrounded by a branch of the fjord of Kolindsund on its southern side and by a 200-400 m wide stretch of bogs on all other sides. A number of large pits were located in a row. The most important of these was pit A47, rectangular in horizontal outline, measuring c. 5.7 by 4.5 m and 1 m in depth (Figure S6.12). It had the character of a single ditch of a causewayed enclosure and was filled with marine shells (predominantly oysters), earth, rocks and several tens of thousands of flint artefacts and debris, remains of c. 530 pottery vessels and several thousand animal bones as well a few isolated bones from two humans. The tooth investigated here is from a maxilla of an older individual, directly dated to

4464±29 ^{14}C years BP (AAR-21424). Its stable isotope values indicate a modest intake of marine food. The pit was re-opened on several occasions over a period of several hundred years, and the maxilla may be of an earlier date than the contents of Pitted Ware cultural material.

Literature: Rasmussen 1984[48]; 1991[49]; Wincentz et al. 2020[50]; Philippsen et al. 2020[51]; Makarewicz & Pleuger 2020[52].

Figure S6.12. Cross-section through pit A47 at Kainsbakke. *The human maxilla included in the present study was found in the massive layer of marine shells. Photo: Lisbeth Wincentz (East Jutland Museum), 1982.*

Klokkehøj, NEO580; Horne 09.04.12-2, Funen. Dolmen

Anders Fischer

Klokkehøj is a megalithic burial monument with a partly preserved dolmen chamber (Figure S6.13). During restoration work in 1977 a rich assemblage of human bones was retrieved. They represent repeated Neolithic burial activity over a period of c. a thousand years - from 4847±34 ^{14}C years BP (UB-37888, individual QØ) to 3883±39 ^{14}C years BP (UB-35706, individual RW). Of 17 humans sampled, only one produced aDNA of acceptable preservation quality. That is the individual QK, which is dated 4086±42 ^{14}C years BP (UB-35708), and thus belongs to a relatively early part of the epoch of the Single Grave Culture.

Literature: Thorsen 1981; Sjögren & Fischer (in prep.).

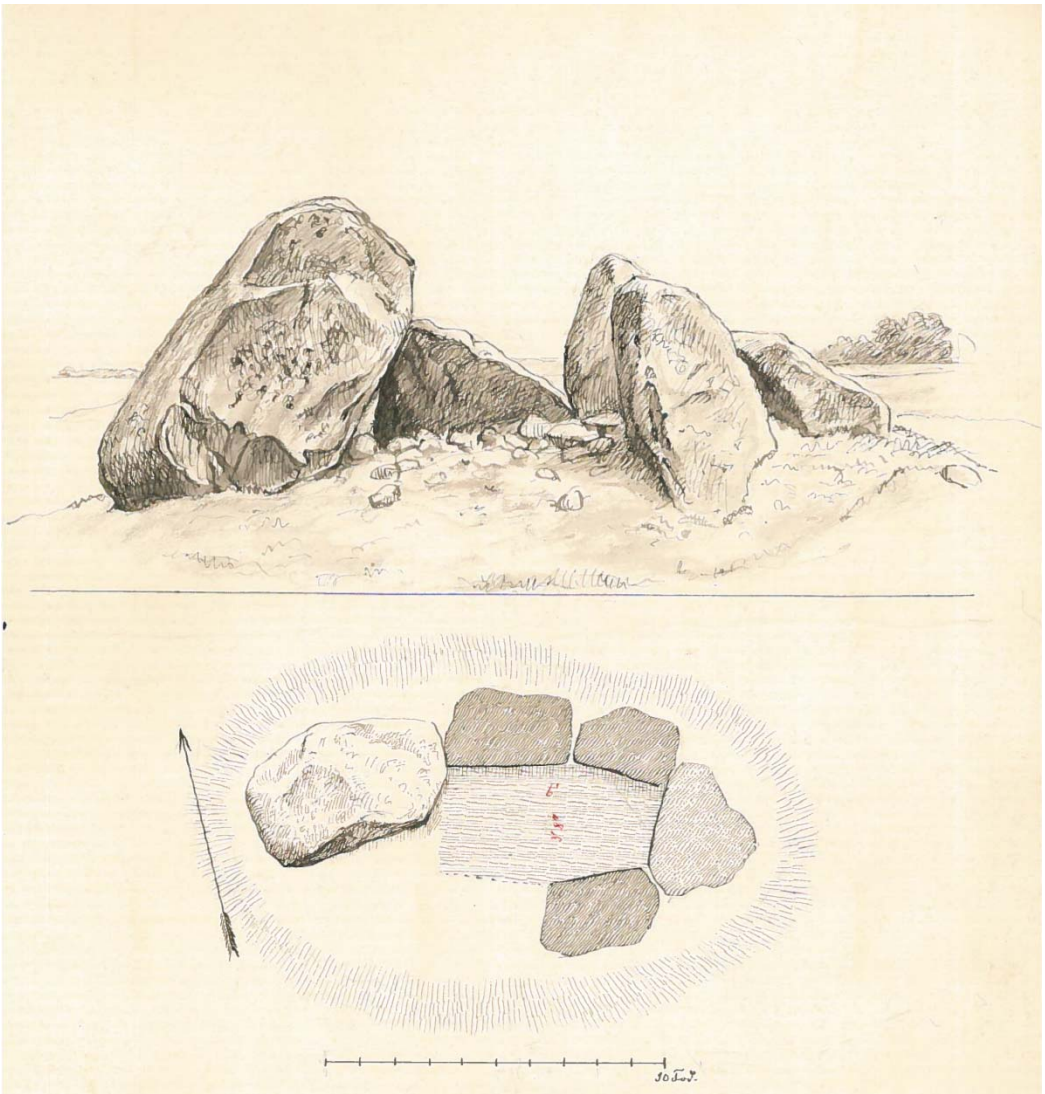

Figure S6.13. The Klokkehøj dolmen chamber. *Although ruined through the activities of a stone mason, a rich assemblage of human skeletal remains, etc. was subsequently salvaged from this monument. It is located on a hill overlooking the sea. Drawing by A. P. Madsen, 1886. 1 Danish foot = 30.5 cm.*

Klæstrupholm Mose, NEO951; Jerslev 10.01.06-269, Vendsyssel. Wetland with bog skeleton

Sidsel Wåhlin

An almost complete human skeleton, unearthed by manual small-scale peat cutting in an alkaline bog situated in a small ice age river valley. Osteologically, it is determined to be an adult, probably male. There are no other prehistoric finds reported from the bog. Based on

the AMS date 3114±54 ^{14}C years BP (UB-39162) it belongs to the Early Bronze Age, according to the South Scandinavian chronology.

Koed, NEO583+586; Koed 14.10.07-37, East Jutland. Kitchen midden and inhumations

Anders Fischer

At the coastal Stone Age settlement of Koed, shell-dominated culture layers made up an about one metre thick deposit. According to a report from 1891 the lower parts of the deposits were dominated by common mussel (*Mytilus edulis*) and periwinkle (*Littorina littoria*), while thin layers of oyster (*Ostrea edulis*) were observed higher up. When the site was removed for road construction in the 1940s a number of human skeletons were observed and partly salvaged from the sand below the midden deposits. Red coloration of the soil around one of the skeletons was reported, and present-day inspections have revealed ochre colour on several of the skulls. According to a physical anthropological report of 1944 there are remains of five individuals. The four of them, which have been radiocarbon dated, belong to an early part of the Ertebølle Culture.

Literature: Rasmussen 1990[31].

Koelbjerg, NEO254; Vissenbjerg 08.04.15-78, Funen. Wetland with bog skeleton

Jesper Hansen

The nearly complete skeleton of a human, estimated in the mid-20s, was found scattered in a bog near Koelbjerg during peat cutting in 1941. Until 2017 it was often referred to as the Koelbjerg Woman but is - due to new physical anthropological studies as well as aDNA analysis - determined as male, approx. 155 cm in height. In the c. 200 by 600 m large bog, two Neolithic flint axes and a Mediaeval sword have also been revealed.

The skeletal remains were preliminary dated to the Mesolithic Maglemosian Culture based on pollen analyses. Subsequently the greater part of the right-side femur was dated to 9250±85 ^{14}C years BP (K-4063). An AMS determination from the same femur has subsequently given an only slightly older age, 9285±50 ^{14}C years BP (AAR-8613). At present, Koelbjerg Man is the oldest human skeletal remains known from the Nordic Countries.

Literature: Bröste & Fischer-Møller 1943[53]; Troels-Smith 1943[54]; Tauber 1986[55]; Fischer et al. 2007[13]; Hansen et al. 2017[56].

Kolind, NEO738+739; Kolind 14.02.08-13, East Jutland. Settlement deposits with stray human bones

Anders Fischer

Stone Age settlement excavated during the 1920s and 1930s. Its habitation remains, accumulated to a thickness of as much as 0.9 m, were dominated by Late Mesolithic coastal kitchen midden layers, topped with deposits from the Neolithic. We have sampled a tooth and a *pars petrosa* from two individuals, aged >15 years and <10 years respectively. AMS dates showed both of them to be of Late Neolithic date (3810±40 ^{14}C BP, AAR-35715; 3691±40 ^{14}C BP, UB-35716).

Literature: Mathiassen et al. 1942, pp. 44-46, pp. 126-127.

Kongemose, NEO587; Stenmagle 04.01.12-232, Zealand. Settlement and stray human skeletal remains

Anders Fischer

The Middle Mesolithic epoch in southern Scandinavia is usually called Kongemose Culture after this site in Zealand's largest peat-filled lowland, the Major Aamose (in Danish 'Store Åmose'). This site, once located at an islet in a large lake, is densely littered with cultural remains of Kongemosian age, such as large rhomboid arrow points of flint. Locally it does, however, also show a far less dense scatter of artefacts of Maglemosian age, such as geometric microliths. From ploughed up parts of the site two teeth and a fragment of a human skull have been picked up by an amateur archaeologist. A physical anthropological inspection indicated they may derive from one and the same individual. This, however, does not accord with two AMS dates. If they can be relied upon, these dates refer to somewhat different parts of the Maglemose period: tooth -6, 8060±65 ^{14}C years BP (AAR-6788) and skull fragment *os parietale*, 8331±49 ^{14}C years BP (AAR-11350), respectively. The reason could be sample contamination from a product based on fossil oil. It is known for sure that the skull fragment was intensely treated with lacquer. Since such material could not be removed effectively through the standard sample pretreatment procedures applied those

days, the AMS date of the skull fragment (and potentially also the tooth) must be suspected to be too old.

Literature: Jørgensen 1956[58].

Korsør Nor (Korsør Glasværk), NEO589+791; off Korsør 401433-17, Zealand. Habitation site with inhumations

Anders Fischer

During harbour construction in the 1940s rich traces of Mesolithic coastal habitation were revealed 2.5-4.0 m below present sea-level in the inlet of Korsør. Reports from the site indicate the presence of dug-out canoes and fish weirs. Among the material handed over to the National Museum were worked items in flint, bone and antler as well as skeletal remains of at least seven humans. Most important is an extraordinarily well-preserved inhumation burial with a middle-aged male surrounded by a packing of hazel sticks and sheets of bark. The skeletal remains tell of a sturdy, about 168 cm high individual with pronounced muscle attachments. Two healed lesions on the skull seem to result from fighting. The scattered finds of human bones from other parts of the locality may derive from burials that were disintegrated during the submergence of the locality. Well-preserved teeth from three individuals were sampled for DNA and came out with positive results.

Literature: Norling-Christensen & Bröste 1945[59]; Bennike 1997[60]; Schilling 1997[61].

Kyndeløse (Møllehøj), NEO878; Kirke Hyllinge 02.06.05-6, Zealand. Passage grave

Anders Fischer

Double passage grave in a tumulus, c. 18 m in diameter, 4 m high. The oval chambers share a wall stone. They both measure c. 3½ by 2¼ m in ground plan and have heights of 1¾ m from floor to roof. Their entrance passages are c. 4 m long. When excavated in 1938 the chamber floors were covered by several decimeters of deposits. In these numerous human bones and burial gifts of Middle Neolithic and Late Neolithic date were revealed. A left *pars petrosa* of one of the most well-preserved skulls (PMD XIII, subadult) was sampled for DNA. Additionally, a tooth (5-) from the same skull was sampled for strontium isotope measurement. Through AMS dating, this individual is referred to the Late Neolithic, 3710±35 ^{14}C BP (UB-39134).

Literature: Bröste et al. 1956, p. 151[14]; Ebbesen 2008, pp. 51-52[15]; Ebbesen 2009, p. 72-149[62].

Køge Sønakke, NEO759; 401379-38, east of Zealand. Human skeleton from the sea floor

Anders Fischer and Kristoffer B. Pedersen

From a submerged beach ridge complex c. 8 m below present sea level, a 'green stone' flat hoe and various human skeletal remains have been revealed during industrial extraction of gravel. When accumulated in the Early Mesolithic this beach formation was located at the entrance to a fjord connected with the Baltic Basin, the waters of which around that time were gradually changing from fresh to saline with the raising of the global sea-level. A human skeleton was brought to the surface in 1951. Morphologically it belonged to an adult, most likely a male. Two radiocarbon dates showed it to be Early Mesolithic and stable isotope measurements indicated a protein diet, which to a large extent derived from marine waters. The topographical characteristics could imply that the skeleton represents a burial at a coastal habitation site. Another human skeleton was pumped up with beach ridge materials from the site in 1943 and donated to a public museum. However, an authoritative physical anthropologist considered it of no interest and discarded it.

Literature: Fischer 1997, pp. 16-17[63]; Fischer et al. 2007[13]; Fischer & Petersen 2018[3]; Fischer & Jensen 2018[64].

Langø skaldynge, NEO853; Stubberup 08.01.12-(51?), Funen. Human skull from shell midden

Anders Fischer

The find consists of a human skull and mandible with the rather scanty provenance data: "found in a shell midden at Langø, flint items above and below it". Based on biological anthropology, it represents an individual aged >45 years at death. Its morphology indicated a Mesolithic date, which would accord with the described context. A large kitchen midden, named Langø, has been known to scientists since the 1880s. Archaeological excavations during the first half of the 1900s had demonstrated it to date primarily from the Late Mesolithic. A *pars petrosa* was sampled for DNA analysis and AMS dating. The latter confirmed the supposed date. It is in fact one of the latest Ertebølle Culture individuals in our

assemblage from Denmark: 5496±57 ^{14}C years BP (c. 4100 reservoir corrected years cal BC; UB-37896; δ^{13}C -10.1, δ^{15}N 14.5).

Literature: Broholm 1928[65].

Lohals, NEO29; Hou 09.02.02-17, Langeland. Shell midden with inhumation

Otto Uldum

None-megalithic grave, discovered during construction work in 1910. It contained two human skeletons in a somewhat degraded state. Via its burial goods it was referred to the south Scandinavian Early Neolithic, a date that was confirmed by AMS dates of both individuals, arranged by the present project: 4843±40 ^{14}C years BP (UB-37900, individual in northern part of the burial) and 4799±43 ^{14}C years BP (UB-39123, southern skeleton). Physical anthropological determination of gender suggests one to be a female of c. 154 cm body height. The other is of indeterminate gender, possibly male, with a suggested body height of 175 cm. The burial was dug into a shell midden with an original extent of c. 16 x 6 m. The shells were primarily of *Ostrea* and *Cardium*.

Literature: Hansen 1917[66]; Johansen 1917[67]; Skaarup et al. 1985, pp. 324-325[68].

Lollikhuse, NEO857; Selsø 01.02.06-77, Zealand. Kitchen midden with stray human remains

Søren Anker Sørensen

Coastal kitchen midden, the accumulation of which took place mostly during the Late Mesolithic Ertebølle Culture. The archaeological excavation of shell deposits at the site produced a few finds of settlement material from the Funnel Beaker Culture as well. A stray human tooth from the shell deposits has provided well-preserved DNA (NEO857) and is AMS dated to c. 3400 ^{14}C years BP (Late Neolithic according to traditional Danish archaeological terminology). It may come from a destroyed burial of that period, as are known from other Danish kitchen middens.

Lundby-Falster, NEO865+866; Brarup 07.01.01-28, Falster. Wetland with bog skeletons

Anders Fischer

During peat digging in 1941 (a time of intense peat digging for fuel) two human skulls were salvaged and donated to the Anthropological Laboratory in Copenhagen. As to their context the scanty archival data only inform of the observation of animal bones. Morphologically, the skulls represent individuals aged approximately 30-35 and 18-20 years at death, respectively. Via AMS dating they can be referred to the Early Neolithic. The date of the former (individual I) is 4688±31 ^{14}C years BP (UB-39128), whereas the latter (individual II) is dated 4743±31 ^{14}C years BP (UB-40439).

Læsten Mose (Volstrup Mose), NEO945; Ålum 13.12.15-(71?) North Jutland. Wetland with bog skeleton

Anders Fischer

Parts of a human skull, found about 1½ m below surface during peat digging, probably in 1943. No further information as to context is available. Via AMS dating, the find can be related to the Early Neolithic: 4674±51 ^{14}C years BP (UB-39151).

Madesø, NEO752; Jorløse 03.06.06-53, Zealand. Wetland with bog skeleton

Anders Fischer and Lisbeth Pedersen

In a peat cutting area in Minor Aamose, next to Lake Madesø, a well-preserved human cranium was found c. 1.75 m below surface. Museums have received several Stone Age items from the same cutting, including two flint daggers of Late Neolithic date. They are all interpreted as the result of sacrificial deposition - cf. text on Jorløse Mose above. According to a physical anthropological inspection of 1945 (K. Bröste unpublished notes, Anthropological Laboratory) the skull represents a male c. 50 years of age. It has healed impact scars on its forehead and is characterised by unusually robust facial characteristics, including ‘nearly ape-like eyebrows [supraorbital ridge]’ (Figure S6.14; cf. comments as to a potential genetic background for these characteristics, mentioned within the above presentation of the Borreby site). Via a radiocarbon date (3523±44 ^{14}C years BP, AAR-8302) it can be dated to the South Scandinavian Late Neolithic.

Literature: Stensager 2003[69].

Figure S6.14. Among the (potentially heritable) archaic traits of the Late Neolithic skull from Madesø are its very pronounced supraorbital ridge. *Photo: Marie Louise Jørkov, Anthropological Laboratory.*

Magleø, NEO590; off Korsør 401433-6, Zealand. Stray Bronze Age skeleton on Mesolithic habitation site

Anders Fischer

Human skeletal remains were found about 1 m below average daily sea-level, in the sea-bed of the inlet of Korsør. Traces of Mesolithic habitation had since long been recorded from the locality, and it was assumed the skeleton represented a burial of coeval age. A radiocarbon measurement, however, dates it to the Early Bronze Age: 3114±30 ^{14}C years BP (UB-38231).

Literature: Pedersen 1997[70].

Mandemarke, NEO896; Magleby 05.05.07-375, Møen. Wetland with bog skeleton

Anders Fischer

During peat digging in 1941 parts of a human skeleton were salvaged and donated to the Zoological Museum in Copenhagen. The donation included bones of sheep and domesticated cattle. No further information is available as to the context of the find. From the well-preserved mandible, a tooth was sampled for DNA analysis and AMS dating. The latter resulted in an Early Neolithic date: 4698±32 ^{14}C years BP (UB-39554).

Mosede Mose (Karlslunde Mose), NEO860+861; Karlslunde 02.05.04-9, Zealand. Wetland with bog skeletons

Anders Fischer

In 1943 peat-diggers salvaged skeletal remains of three humans while working about 2 m below surface in a bog named Mosede Mose. There is no further information available on the context for these finds. Most interest had previously been given to the skull of individual I, which shows signs of trauma. The other two were available for DNA sampling and AMS dating, which resulted in Late Neolithic dates: 3568±51 (individual II, UB-37900) and 3756±29 (individual III, UB-39126) ^{14}C years BP.

Myrebjerg Mose, NEO925; Magleby 09.03.06-78, Langeland. Ceremonial wetland deposition

Otto Uldum and Anders Fischer

The site consisted of a heap of bones, partly covered by a diffuse stone setting. It was located in a mire extending c. 200 by 100 m. The fragmented bones of at least five humans - children aged about 3 and 4 years, an adult woman and two other young adults - were intermixed with skeletal remains of domestic animals, pottery, worked flint, etc. The site is interpreted as a result of ceremonial deposition. Typologically it is – with some reservation - dated to the Funnel Beaker Culture. This chronological position seems confirmed via the ^{14}C date 4640±320 BP (K-3711). The radiometric date should, however, be taken with reservations. This is partly due to its large standard error. Moreover, three bone samples from the present project failed to produce an absolute date for the reason of bad bone collagen preservation quality (UB-37913, UB-40132-1 and UB-40441) – a condition that may also have applied to the dated sample. From the mire there are additional finds of a celt and a belt plate of bronze, both dating to the Late Bronze Age.

Literature: Skaarup 1985, pp. 76-77[68].

Nederst, NEO856; Albøge 14.02.01-49, East Jutland. Settlement with shell middens and inhumations

Esben Kannegaard

During the Late Mesolithic the Nederst site formed an island, measuring a maximum of 400 by 900 m, in a fjord that in the historical period became known as Kolindsund. Archaeological excavations in 1988-92 revealed rich habitation deposits, including three shell middens. In the space between the middens six Early Ertebølle Culture inhumation graves were found. They were characterised by prolific strews of red ochre. Grave 1 was very disturbed by cultivation, and only the back of the skull and part of the jaw were found *in situ*. However, the skeletal remains were in excellent preservation condition, resulting in a tooth sample of acceptable DNA quality for the present project.

Literature: Kannegaard 2016[71].

Neverkær Mose, NEO594; Vissenbjerg 08.04.15-24, Funen. Wetland with bog skeleton

Anders Fischer

The bog named Neverkær measures c. 1½ by 3 km and is rich in archaeological finds. Several of these belong to the Early Neolithic period like the human skeleton dealt with here. According to biological anthropology it is a male aged 40-50 years at death, stature c. 157 cm. His well-preserved bones were revealed during peat cutting in 1944. There are two AMS dates at hand from this individual: 4548±48 (UB-37886) and 4518±33 (UB-38232) ^{14}C years BP.

Norsminde, NEO852; Malling 15.04.05-71, East Jutland. Kitchen midden with burials and loose human bones

Søren H. Andersen

A Late Mesolithic and Early Neolithic coastal kitchen midden below which an inhumation was revealed during archaeological excavation. The grave was oriented NE-SW with the head in SW. Based on physical anthropology it represents a woman 30-40 years of age, live stature c. 153 cm. No grave goods were associated with the burial. Two radiocarbon measurements

of the skeleton (K-5199, 5790±95 ^{14}C years BP; AAR-8556, 5800±35 ^{14}C years BP) indicate it belonged to the younger phase of the Ertebølle Culture. In between the Late Mesolithic and Early Neolithic food and settlement debris of the midden, some stray human bones were found. A second burial that did not produce DNA of acceptable quality is dated to the Late Neolithic.

Literature: Andersen 1991[72]; Fischer et al. 2007[13]; Andersen et al. (in prep)[111].

Næs, NEO792; Aastrup 07.02.14-(45?), Falster. Megalithic tomb

Poul Otto Nielsen

Megalithic tomb, presumably a passage grave, excavated 1838, containing Funnel Beaker pottery and flint objects from the Middle or Late Neolithic (the National Museum of Denmark, inv. no. 4630-31). Among the bones of several individuals was the skull of a man 30-40 years of age with trepanation (Figure S6.15). ^{14}C dated 4020±35 BP (UB-35723), it is one of the very few individuals currently known from the time of the Single Grave Culture in eastern Denmark (MN BII).

Literature: Bröste et al. 1956, pp. 426-27, no. 257[14]; Bennike 1985, p. 84[25].

Figure S6.15. Skull with healed trepanation from Næs, belonging to the period of the Corded Ware Culture influences and genetic impact of steppe ancestry in Denmark. *Photo: Roberto Fortuna / Kira Ursem (National Museum of Denmark).*

Orehoved Sejlrende, NEO122+123; 401651-33, south of Zealand. Submerged settlement with stray human remains

Morten Johansen

The submerged Mesolithic habitation site of Orehoved Sejlrende is located at a water depth of approximately 5 m. In 2015 an area of 94 m^2 of coastal settlement and water deposited dump materials from the Kongemose Culture was excavated. Some 21,000 pieces of worked flint and numerous organic materials including finished tools of bone, antler and wood were uncovered. The material includes three stray human teeth from deposits just off the contemporaneous coastline. Two of these have produced DNA of acceptable quality. Their dates (prior to reservoir correction) are 7505±36 (UB-37880) and 7415±53 (UB-38222) ^{14}C years BP, confirming their Kongemosian age.

Literature: Johansen & Ravn 2018[73]; Donahue et al. 2019[74].

Pandebjerg, NEO595; Føllenslev 03.06.04-76, west of Zealand. Kitchen midden with stray human bones

Anders Fischer

The shell midden at Pandebjerg on the small island of Nekselø was partly excavated in 1916. According to its composition of lithic artefacts it was mainly accumulated during the Late Mesolithic. Stray human bones were found in its upper level. They may be the remains of a disturbed burial. Sampling for DNA, AMS, etc. was conducted on a mandible with six extant teeth. Osteologically, it represents an individual 20-25 years of age, probably a male. Via AMS dating it is referred to the Early Neolithic. Its dietary isotopic signature ($\delta^{13}C$ -18.8, $\delta^{15}N$ 11.5) implies a higher intake of marine food than normal for Neolithic individuals from Denmark.

Literature: Brøndsted 1957, p. 167[75]; Fischer et al. 2007[76].

Porsmose, NEO795; Toksværd 05.04.10-15, Zealand. Wetland with bog bog skeleton

Lasse Sørensen

A nearly complete skeleton of a 35-40-year-old male was revealed in 1946 during excavation of peat within the Porsmose part of a c. 7½ x 2½ km mire, known as Holmegård Bog. His stature is estimated at 166 cm. Two arrows tipped with bone points had struck him, one in the upper jaw and one in the breastbone. The former had penetrated diagonally from above through the right nostril and lodged in the palate (Figure S6.16). The latter would have caused a fatal wound, as the aorta is just behind the breastbone. The skeleton is dated to the Early Neolithic: 4710±90 ^{14}C years BP (K-3748). Stable isotopes tell of a terrestrial diet: δ^{13}C -20.4, δ^{15}N 8.6. Nearby areas are rich in habitation deposits of Mesolithic and Early Neolithic age.

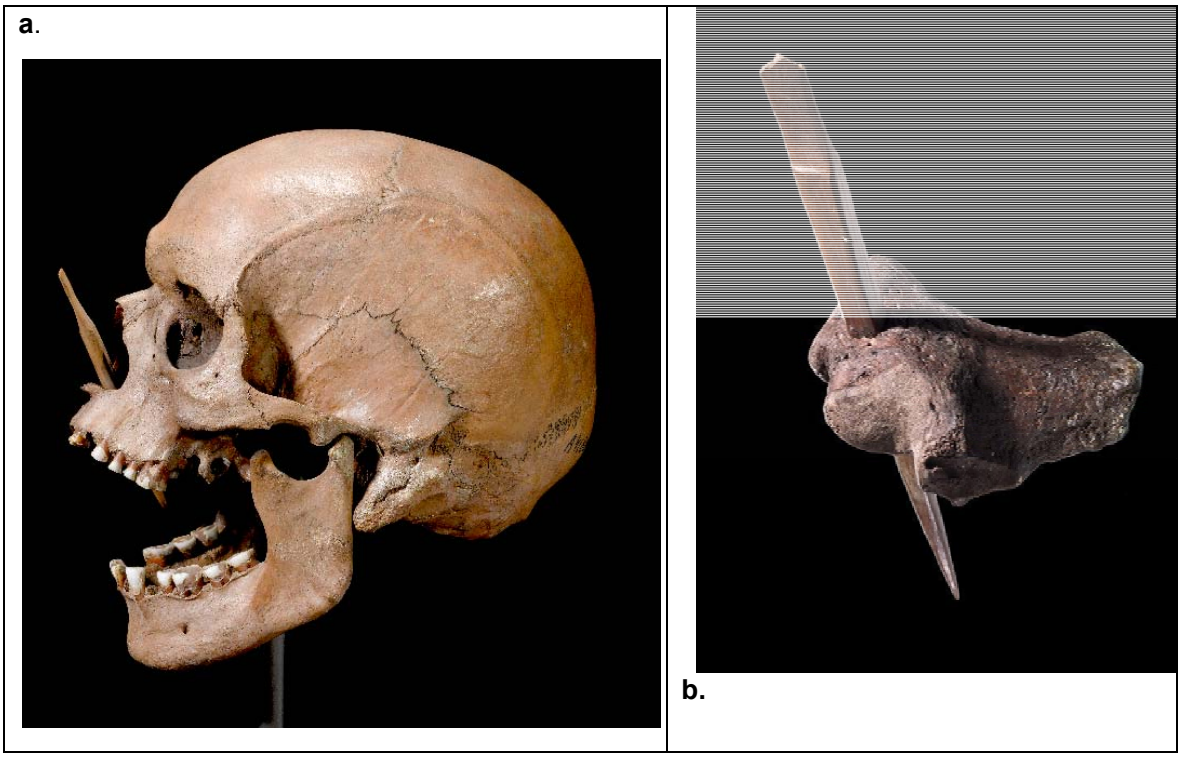

Figure S6.16. The cause of the death of Porsmose Man*: a 10,6 cm long bone point shot at close range in the face (a) and a 12,7 cm bone point struck the breastbone (b). Photos: Roberto Fortuna and Kira Ursem (a) and Arnold Mikkelsen (b), The National Museum of Denmark.*

Literature: Becker 1952[77]; Bennike & Ebbesen 1987, p. 101[78]; Fischer et al. 2007[76].

Ravnsbjerggård II (Rygård), NEO960; Undløse 03.03.18-54, Zealand. Settlement site with bog deposition

Peter Vang Petersen

Human skull found by an amateur archaeologist's private excavation in 1955 of a mixed Late Mesolithic/Early Neolithic (late Ertebølle Culture/early Funnel Beaker Culture) settlement situated on the northern part of a small sandy island in the former lake of Major Aamose ('Store Åmose'). The find situation is unclear, but apparently the skull was found in peat layers, probably a dump zone adjacent to the shore of the island. In the peat zone were also unearthed substantial numbers of flint artefacts, axes and awls of antler and bone as well as ceramic sherds of Ertebølle and funnel beaker pottery including an Early Neolithic lugged jar. Polished flint axes and amber beads have also been found on this site.

Literature: Andersen 1983, p. 113 [79]; Koch 1998, p. 352[80].

Roskilde Fjord (south of Jyllinge), NEO891; 401256-78 off Zealand. Stray human bone from shell bank

Anders Fischer

In 1966 the industrial extraction of fossil oyster shells from the bottom of Roskilde Fjord led to the find of a human mandibula. From the same marine area skeletal remains of red deer and horse were salvaged. Knowing these finds may be of prehistoric age and could be of scientific interest, a local citizen arranged for them to be sent to the Zoological Museum in Copenhagen. Decades later it was realised that sacrificial depositions of precious items and humans frequently took place in Roskilde Fjord during the Neolithic – similarly to what took place in bogs during the same periods. Such ceremonial activity may also be the background of the specimen here dealt with. The present study arranged for its sampling for DNA analysis, AMS dating, etc. This way an Early Neolithic age is established: 4939±45 ^{14}C years BP (UB-37910). Morphologically, it represents an individual >20 years, possibly a female.

Literature: Davidsen 1983[81]; Fischer & Petersen 2018[3].

Rude, NEO41+043; Saksild 15.02.12-6, East Jutland. Long barrow with two stone chambers

Anders Fischer

The long barrow of Rude is 8-9 m wide and at least 58 m long. Within it, two dolmen chambers are seen. They are constructed from slabs of split stone. A copper disc of Early Neolithic type derives from the western chamber. Excavation at the eastern end of the mound has demonstrated the remains of a wooden façade and the presence of votive

pottery. Scattered human skeletal material is available from both cists. At least the ones from the western chamber potentially represent more than one individual, as is also indicated by differences in time and genetic signatures. According to the earliest AMS dates for DNA samples from the stone chambers these were built at an early stage of the local Early Neolithic: 4901±37 (western cist, UB-37877) and 4838±29 (eastern cist, UB-37876) ^{14}C years BP.

Literature: Madsen 1980 [82]; Klassen 2000[6]; Sjögren & Fischer (in prep.).

Rødhals (Sejerø), NEO8; Sejerø 03.06.07-49, off Zealand. Kitchen midden with a burial and a stray human skull

Anders Fischer and Anne Birgitte Gotfredsen

Major parts of the shell midden of Rødhals were accumulated during the last decades of the Mesolithic. The site was located on a tiny island far to sea, and its well-preserved faunal remains reflect a broad-scale exploitation of marine resources including open-sea fowling, deep-water angling and hunting of small whales. For a number of years local amateur archaeologists worked their way through the midden. As a result of this digging activity, faunal material was on several occasions donated to the Zoological Museum in Copenhagen. In 1956 a simple burial was revealed in between the shells. The well-preserved skeleton (Rødhals individual I or 'Rødhals Man') with an intact skull, is included in the present study. It represents an adult male, who dates to the very transition between the Mesolithic and the Neolithic in the region. A recent study has demonstrated the presence of fragments of an additional human skull (Rødhals individual II) among the bones given to the Zoological Museum. The finds from the site also include habitation traces from initial parts of the Early Neolithic, including some of the earliest ^{14}C dated domestic livestock presently known from Denmark.

Literature: Fischer et al. 2005[83]; Fischer et al. 2021[84]; Fischer et al. (in prep).

Rønsten, NEO19; 401275-1, off East Jutland. Settlement with stray human bone

Anders Fischer

The Middle Mesolithic coastal settlement of Rønsten is located below about two metres of marine water. Among local divers it has for decades been known as a site rich in lithic items. Occasionally organic materials have also been exposed in the sea-bed. During a period of

intense sea-floor erosion the Danish authority for cultural heritage regularly inspected the site and salvaged material of scientific importance. Among these finds was a stray right mandible with three extant teeth. It has proven to have well-preserved DNA and is AMS dated to 7542±42 ^{14}C years BP (AAR-11355; δ^{13}C -15.0, δ^{15}N 11.8). Consequently the specimen belongs to the Middle Mesolithic epoch of the Kongemose Culture - in accordance with the typological date of the settlement assemblage.

Literature: Fischer 2007[85]; Fischer & Petersen 2018[3]; Fischer & Jensen 2018[64].

Salpetermose, NEO28; Hillerød 01.03.01-180A, Zealand. Wetland with bog skeleton

Thomas Jørgensen

A nearly complete skeleton of a 25-30-year-old male, was revealed by digging archaeological search trenches in a peat bog. His live height is estimated to be 165 cm. The cause of his death is indicated by an injury in the posterior side of the skull (Figure S6.17). All bones were found in the dug-up soil. An arrowhead of bone was found with the skeleton. No impact marks from the arrowhead were found on the human bones. Two samples from the skeleton have been AMS dated: 4789±25 (AAR-21343) and 4752±29 (AAR-21344) ^{14}C years BP. Nearby areas are rich in habitation deposits of Mesolithic and Early Neolithic age.

Figure S6.17. The possible cause of death of Salpetermose Man*: a 4 cm long impact fracture, probably from a blow with a stone axe. Photo: Esben Aarsleff (Museum Nordsjælland) 2014.*

Literature: Jørgensen & Hagedorn 2015[86].

Sejerby, NEO757; Sejerø 03.06.07-36B, off Zealand. Burial

Anders Fischer

In 1927 the skeleton of an adult human was salvaged right below the bottom of the plough layer, located on even ground at the island of Sejerø. It had been buried on a 2 by ¾ m large paving of small beach-rounded stones, framed with somewhat larger stones. Lacking any kind of burial gift, the grave was – those days - considered not datable. Although of moderate bone preservation, the present study has extracted DNA of acceptable quality and has arranged for an AMS date based on a tooth. This way an Early Neolithic date is established: 4746±45 ^{14}C years BP (UB-35721). Morphologically, the skeleton is determined juvenile or young adult, possibly female, stature c. 1.51 m.

Sigersdal, NEO7; Stenløse 01.06.05-110, Zealand. Wetland with bog skeletons

Anders Fischer

The bog of Sigersdal is located in an undulating moraine landscape where the Neolithic Funnel Beaker Culture erected monumental burials on high ground and sacrificed ceramic vessels, flint axes, domestic animals and human bodies in its watery bottom. Outstanding examples of the latter phenomena are the skeletons of two young individuals, revealed during peat digging in 1949. In literature they are termed Sigersdal individuals A and B, and have called special attention due to the fact that a cord was found around the neck of one of them (the genetically male individual A). This observation was seen as a clear indication that this 18–20-year-old did not meet death in the bog voluntarily. Both skeletons were sampled for DNA, and individual A produced data of acceptable quality. It is dated 4650±140 ^{14}C years BP (K-3744), whereas individual B is dated 4680±75 ^{14}C years BP (K-3745).

Literature: Bennike & Ebbesen 1987[78]; Koch 1998, find site 37[80]; Sparrevohn 2009[87].

Sigersdal Mose, NEO753; Stenløse 01.06.05-99, Zealand. Wetland with bog skeleton

Anders Fischer

The rather fragmentary remains of a human skeleton were found in the peat-infilled tunnel valley some 300 m east of the aforementioned site. They were donated to the Danish National Museum in 1947. As part of the present project an AMS analysis of the individual has been conducted, resulting in an Early Neolithic date: 4853±29 ^{14}C years BP (UB-39125). According to biological anthropology this person was <18 years at death.

Literature: Sparrevohn 2009, Appendix 2, site 31[87].

Sludegaard Sømose, NEO933; Frørup 09.06.06-34A, Funen. Wetland sacrificial site with bog skeletons

Jesper Hansen

Depositions of pottery, flints, wooden objects and bones from the Stone Age were revealed during peat cutting in a mire. The site is located in a small river valley in an undulating moraine landscape and extends c. 600 by 200 m. A pile of at least ten mandibles from wild boar has previously been dated to 5220±90 ^{14}C years BP (K-4632). The present study includes a nearly complete human skeleton of a child app. 2 years of age. It dates to 4688±56 ^{14}C years BP (UBA-39145). Additionally, the assemblage includes two human crania, one of which is morphologically determined male, maturus.

Literature: Albrectsen 1954[88]; Tauber 1987[89]; Noe-Nygaard & Richter 1990[90]; Ebbesen 1996[91].

Stenderup Hage, NEO943; South Jutland 401513c-1. Submerged settlement and stray human bones

Anders Fischer

Since 1946 this site has given rise to finds of prehistoric date from the beach to about 4 m below sea-level. A considerable amount of flint material is of Late Mesolithic date. The same probably applies to faunal remains, nut shells, hazel rods, etc. some of which are observed *in situ* in gyttja formations. In 1971 two fragments of a human skull were picked up from the sea-bed in about 1½ m of water. According to physical anthropology they represent a single individual of around 50-60 years, probably male. The present study has arranged for a

radiocarbon analysis, 4072±61 ^{14}C years BP (UB-39152), which places this individual at the close of the Funnel Beaker Culture or/and the beginning of the Single Grave Culture.

Storelyng Eel Picker (Øgaarde boat III), NEO597; Undløse 03.03.18-331, Zealand. Wetland with bog skeleton

Anders Fischer

The site belongs to a cluster of sacrificial Neolithic depositions in the bog of Major Aamose. It came to the light of day in connection with peat extraction for fuel in 1943. An archaeological investigation demonstrated the presence of a 7 m long log boat of alder wood, fixed to the spot with vertical rods of hazel. Right next to the vessel lay a human skeleton, inferred by the excavator to have originally been buried in the boat – an interpretation that do not conflict with radiocarbon dates of the skeleton and the boat to 4570±60 (K-3746) and 4590±120 (K-1165) ^{14}C years BP, respectively. Morphologically, the individual is determined to be a mature male. Depositions of a second boat of alder wood, a ceramic vessel, a bone knife and a flint item within a distance of 10 m probably also represent sacrificial activity – although not necessarily absolutely contemporaneous.

Literature: Koch 1998, 311-312[80]; Richards & Koch 2001[92]; Pedersen & Fischer 2005, Fig. 5[93]; Fischer et al. 2007[76].

Storelyng Fire Lighter (Østrup homo II), NEO602; Undløse 03.03.18-26B, Zealand. Wetland with bog skeleton

Anders Fischer

Thanks to the presence of a permanently staffed archaeological field station nearby, the present skeleton is one of the exceptions, where scientists were given the chance of investigating a bog skeleton *in situ*. This took place in 1950 in relation to extraction of peat for fuel. Next to the hip of the skeleton lay what was seen as the remains of a long-gone purse holding a ‘strike-a-light’ consisting of pyrite, tinder fungus (*Fomes fomentarius*) and flint. Additionally, this small cluster of items included a further five flint flakes and a small awl made of bird bone. Morphologically, the individual was a male around 30 years old at death. The site is located in Major Aamose, one of the richest areas for Early Neolithic votive deposition in Northern Europe. A death in the context of sacrificial activity may also have

been the fate of this individual. Its Early Neolithic date is established via radiocarbon dating: 4530±90 (K-5741) and 4523±37 (AAR-10248) ^{14}C years BP.

Literature: Koch 1998, pp. 350 & 353[80]; Richards & Koch 2001[92]; Fischer et al. 2007, Table 1 and p. 2143[76].

Strøby Grøftemark, NEO91; Strøby 05.06.12-54, Zealand. Wetland with bog skeleton

Anders Fischer and Kristoffer B. Pedersen

In a mire, extending c. 200 by 100 m in a gently undulating moraine landscape, parts of a human skeleton were revealed during peat cutting in 1943. Morphologically the skeletal remains were judged male and 25-35 years at death. Stratigraphic information indicated a relatively early date, which has been confirmed by two radiocarbon determinations of nearly identical results: 8215±55 (AAR-11311) and 8211±40 (UB-39958) ^{14}C years BP. There are no further observations of the presence of Stone Age humans reported from the site nor from its vicinity within a distance of several hundred metres.

Strøby Ladeplads, NEO93; Strøby 050612-31, Zealand. Stone cist

Kristoffer B. Pedersen

Originally in a large mound measuring at least 25 metres in diameter and 2.5 metres in height, a stone cist was excavated. It is one of several mounds situated close to the present-day and contemporaneous coast. A small excavation in the cist was conducted by professional archaeologists in 1969 to document the circumstances of a previous private excavation.

From the cist, skeletal parts of at least 7 adults were salvaged. At least one of these was a man. Additionally, there were tibiae from a newborn child. Only one of the individuals produced DNA of acceptable quality. An AMS date of the tooth in question says 3512±33 ^{14}C years BP (UB-37879), which implies Late Neolithic according to traditional South Scandinavian terminology.

Svinninge Vejle, NEO898; Svinninge 03.07.12-91, Zealand. Reclaimed fjord with stray human bone

Anders Fischer, Lisbeth Pedersen and Anne Birgitte Gotfredsen

The low-land of Svinninge Vejle was transgressed by the sea during an early part of the Holocene. Around 1850 a decades-long process of land reclaim began. It implied considerable efforts in digging drainage canals etc., a process that attracted the National Geological Survey as well as a locally practising doctor, who enthusiastically collected prehistoric artefacts and ancient skeletal remains to the benefit of museum collections in the nearby town of Kalundborg as well as the Zoological Museum in Copenhagen. In 1924 digging work in the former fjord-bed led to the find of a fragment of a human skull in sediments of presumed prehistoric date. This bone remained undated until the present study arranged an AMS analysis of its *pars petrosa*. It proved to be of Neolithic age: 4539±72 ^{14}C years BP (UB-37912). According to a biological anthropological inspection the individual was an adult, probably a male.

Literature: Fischer et al. (in prep).

Sølager, NEO598; Torup 01.05.09-7, Zealand. Kitchen midden with stray human bones

Anders Fischer

Around 1850 a scientific examination of shell deposits at the Sølager site was conducted with the aim of clarifying if shell deposits observed by scientists in several locations along ancient coastlines of Denmark were the controversially early products of mankind. A human origin was confirmed. Resumed excavations in the early 1900s demonstrated a 1.7 m deep stratigraphy with unpolished flint axes and a coarse style of pottery at its lower levels, and polished flint axes and finer ceramics further up – now known as Late Mesolithic Ertebølle Culture and Early Neolithic Funnel Beaker Culture, respectively. A human mandible from a young adult with an extant tooth was available from the lowermost level. Via an AMS date arranged by the present study, its Late Mesolithic age is demonstrated: 5553±40 ^{14}C years BP (UB-37887). Relatively high δ^{13}C and δ^{15}N values (-10.5, 14.6) tell that marine food took up a considerable proportion of this individual's protein diet, and consequently that a comparably high reservoir effect applies to the radiocarbon date.

Literature: Skaarup 1973[94]; Newell et al. 1979, p. 70-71[42]; Fischer & Kristiansen 2002[1].

Tissøe, NEO942; Buerup 03.02.02-219, Zealand. Lake deposition (?)

Anders Fischer and Lisbeth Pedersen

Human skull from an adult female. It is provenanced 'Tissøe', which is an old-time spelling for Lake Tissø, the name of which refers to the Nordic pagan god of war, Tir. The present-day extent and depth of the lake is 12 km^2 and 13.5 m respectively. It is located in the Aamose-Tissø Valley, the watery landscapes of which served for numerous sacrificial depositions from the Mesolithic and well into the Christian era. Based on the archaeological record the votive activities at Lake Tissø peaked three times: during the Neolithic, the Pre-Roman Iron Age and the Viking Age to Early Medieval epochs. An AMS date 4846±53 ^{14}C years BP (UB-39159) showed the skull to be from the South Scandinavian Early Neolithic.

Literature: Pedersen 2004[95]; Fischer 2004[96].

Toftum Mose, NEO870+872+875+876; Søvind 16.05.08-17, East Jutland. Wetland with bog skeletons

Anders Fischer and Anne Birgitte Gotfredsen

The stores of the Anthropological Laboratory hold skeletal remains of several humans from Toftum Bog, which is a roundish peat filled basin not much more than 100 m in diameter. It is located right at the foot of a hill archaeologically known from a Funnel Beaker Culture causewayed enclosure dating to the transition from the Early to the Middle Neolithic. Our study has produced well-preserved DNA from four of the skeletons. Based on radiocarbon dates two of them can be referred to the close of the Single Grave Culture, while the other two belong to the Late Neolithic. Recordings of finds of skeletal remains from the wetland site date back to 1873. They also inform on the observation of a boat and numerous animal bones, representing wild as well as domesticated species. In addition, the archival materials tell of the finds of two tongued wedges – a type associated with the Single Grave Culture in Denmark and Corded Ware groups in Central and Eastern Europe. A pollen sample from an Aurochs skull is dated to Zone VIII. Its high frequency of *Fraxinus* in combination with presence of *Plantago lanceolata* indicates it is coeval with or later than the arrival of the Single Grave Culture (J. Troels-Smith letter of 1961).

Literature: Degerbøl & Fredskild 1970, pp. 20, 60, 199[97]; Madsen 1978[98]; 2020[99].

Tudse Hage, NEO932; 401441-11, west of Zealand. Submarine settlement site with stray human remains

Per Lotz

Stray human skeletal remains were salvaged during archaeological sea bottom survey of an area rich in cultural material from Mesolithic coastal habitation. Besides a large collection of flint artefacts, the assemblage consists of a variety of weapons, tools and waste products in plant material, wood, bone and antler, dating to the Kongemose and Ertebølle periods. The present genetic study deals with an os temporale with a well-preserved *pars petrosa*. Samples from different parts of this bone are AMS-dated 6794±49 (UB-40929) and 6608±47 (UB-38242) ^{14}C years BP, respectively. The reason for the notable discrepancy in age is most likely differences in degree of sample contamination from a stabilising lacquer ('pioloform'). Since this varnish will have been based on fossil oil it is probable that the younger of the two dates (UB-38242) comes closest to the true age.

Literature: Lotz 2000[100], 2018[101]; Fischer & Pedersen 2018, pp. 78, 139, 140, 180[3].

Tybrind Vig, NEO683; 401521-6, west of Funen. Submerged settlement with burials

Otto Uldum and Anders Fischer

In an area 2-3 m below present sea level, rich remains from Mesolithic coastal habitation have been revealed. Among the archaeologically excavated deposits are two burials, both with skeletal remains of two individuals. DNA samples were taken from three of these skeletons. Only one produced genetic material of acceptable quality. It derives from an inhumation grave excavated in 2008 in about 3 m of water. Its two individuals were placed on their backs, side by side in a communal pit, without any grave goods. Physical anthropological analysis suggests the larger skeleton to be an adult female and the smaller one to be a child aged 9-12 years. Radiocarbon dates of the two individuals confirm their Mesolithic age: 6820±55 (AAR-9341) and 6905±55 (AAR-9342) ^{14}C years BP.

Literature: Fischer et al. 2007[76]; Uldum 2011[102]; Andersen 2013[103].

Tysmose, NEO790; Ledøje 02.02.09-65, Zealand. Wetland with bog skeletons

Anders Fischer and Anne Birgitte Gotfredsen

Two complete human skeletons were revealed in a dense scatter deep in bog sediments of Tysmose. According to biological anthropology, they were c. 10 and c. 8 years at death, respectively. Pollen analysis indicated they belonged to an early stage of the Neolithic. This is now confirmed via AMS analyses arranged by the present study. Expressed in ^{14}C years BP, the former (individual I) dates 4871±32 (UB-39159), whereas the latter (individual II) dates 4959±43 (UB-35722). In the possession of the Zoological Museum is a nearly intact skeleton of a red deer that was also salvaged from this bog in 1940.

Vanløse Mose, NEO599; Stenmagle 04.01.12-418, Zealand. Wetland with bog skeletons

Anders Fischer

Skeletal remains of two humans were found side by side in 1943 in a peat-filled basin extending c. 2.5 by 1 km along the upper reaches of the Aamose River. No other archaeological finds are recorded within a distance of 100 m. A biological anthropological inspection determined the skeletons most likely to be a female and a male. The latter, which was estimated to be <40 years at death, has been analysed for DNA with a positive outcome. According to an AMS date, this individual is Neolithic and can be attributed to the Funnel Beaker Culture. The date is 4485±41 ^{14}C years BP (AAR-10994).

Vasagård, NEO815; Åker 06.02.05-58, Bornholm. Passage grave

Poul Otto Nielsen

Passage grave in a long barrow, whose grave chamber was excavated in 1938, resulting in finds from both the Middle Neolithic and Bronze Age (the National Museum of Denmark inv. no. A38837-40, B13208-10). The passage to the chamber (Figure S6.18) was excavated in 2008 in connection with restoration (National Museum file no. 8333/03-35). In the passage well-preserved bones of an unusually tall (male?) person were found. According to the AMS date: 3248±32 ^{14}C years BP (UB-38239), the individual belongs to the South Scandinavian Early Bronze Age, whereby the passage to the chamber had been modified and re-used as a grave cist.

Literature: Ebbesen 1985, p. 207[104]; Hansen 2014, pp. 48-56[105].

Figure S6.18. The entrance to the Middle Neolithic Vasagård passage grave, in which an Early Bronze Age individual with well-preserved DNA was revealed. *Photo: Martin Stoltze, 2008.*

Vedbæk Boldbaner, NEO600; Søllerød 02.03.10-135, Zealand. Settlement with burials and stray human bones

Anders Fischer

An islet in the former Vedbæk Fjord was inhabited during several hundred years of the Kongemose period. Archaeological excavation took place in the 1940s in connection with construction works. As a result, a large assemblage of flint artefacts was retained, as were faunal remains and items in bone, antler and wood. Among the material discharged in shallow water off the habitation area were some human bones. Two proper burials were found in the sand below the culture layer: an inhumation grave and a cremation grave. The former was characterised by a 20-25 cm deep pit, horizontally extending 1.8 by 0.7 m. In this the skeleton of a mature male lay extended on its back. Based on a radiocarbon date, this individual is firmly established as of Kongemosian age: 7117±55 (Ua-23792). The present study sampled a tooth (-3), which proved to have well-preserved DNA.

Literature: Mathiassen 1946[57]; Bröste et al. 1956, p. 13[14]; Petersen 1977[106]; Newell et al. 1979, pp. 77-79[42]; Brinch Petersen 2015, p. 195[43].

Vibygårds Mose, NEO935; Syv 02.01.10-17, Zealand. Wetland with bog skeleton

Per Lotz

In a mire of c. 1700 by 300 m in a gently undulating moraine landscape, peat cutting has revealed skeletal remains of two humans and a Bronze Age celt. The present study deals

with a cranium of a 35-50-year-old individual, morphologically of male character. AMS dated 4573±33 ^{14}C years BP (UB-39147) it can be referred to the Early Neolithic period. It has marks of a healed trepanation, possibly the earliest of its kind known from Denmark.

Literature: Nielsen 1978[107]; Bennike 1985, pp. 90-91[25].

Vig Femhøve, NEO744; Vig 03.04.12-150, Zealand. Megalithic monument with a dolmen chamber

Anders Fischer

The rectangular monument termed Femhøve ('Five mounds') (Figure S6.19) is surrounded by a frame of megalithic stones and has a dolmen cist approximately in its centre. At the opening of the monument in 1909 the floor of the 1.7 x 0.9 m large chamber was packed with disorderly located skeletal remains of as many as six individuals. Additionally, two ceramic vessels of Early Neolithic type were found in this level. Higher up, and separated by a layer of small stones, the bones of yet another individual were revealed together with burial gifts of Bronze Age date. Teeth from three individuals from the lower layer were chosen for DNA analysis and AMS dating. The latter confirmed the expectation of their Early Neolithic data. Expressed in ^{14}C years BP the results were: 4657±36 (individual 1, UB-37892), 4833±40 (individual 2, UB-40810) and 4709±52 (individual 3, UB-37893).

Literature: Müller 1911, pp. 282-285[108]; Sjögren & Fischer (in prep).

Figure S6.19. The 1½ m high burial chamber of Vig Femhøve, in which a dense deposit of human bones was found. *Prior to its excavation in 1909 this 'Urdolmen' was completely covered in a 3.5 m high mound of crushed flint, a stone packing and a topping of earth. Photo: Anders Fischer 2018.*

Viksø Mose (Rolandsgårdens Mose), NEO601; Veksø 01.06.06-42, Zealand. Wetland with bog skeleton

Anders Fischer

A nearly intact human skeleton was found during peat-digging for fuel in 1946. The location is in the swampy bottom of a tunnel valley, rich in Neolithic votive depositions mainly from the Funnel Beaker Culture. Within a radius of 350 m there are recordings of a stone paving, a ceramic vessel, several flint axes, fragments of a human skull and several skulls of domestic cattle in the bog sediments. The location of the abovementioned bog skeleton of Sigersdal Mose lies round 1½ km further down-stream. The present individual represents an adult/mature female with gracile bones. Her estimated stature was c. 1.52 m. An AMS date on the tooth (3-) sampled for DNA gave the result 5050±15 ^{14}C years BP (UCIA-232706; δ^{13}C -20.9, δ^{15}N 9.5), and four other radiocarbon dates cluster around that value. According to the dietary isotope values this individual had a protein diet typical of Early Neolithic farmers from Denmark. She is currently the earliest radiocarbon dated human with an Anatolian genetic ancestry known from this country.

Literature: Koch 1998, p. 277[80]; Fischer et al. 2007[76]; Sparrevohn 2009[87].

Vittrup, NEO33; Børglum 10.01.02-56, Vendsyssel. Wetland with bog skeleton

Anders Fischer, Per Lysdahl and Sidsel Wåhlin

Deposits of bone, wood and pottery were discovered in 1915 during peat cutting in the valley of a small stream. The present study deals with a skull and a mandible morphologically male and 30-40 years of biological age. The cause of death is indicated by several fractures to the skull, resulting from repeated strikes from a blunt instrument. A wooden club was found within a distance of half a metre. Additionally, a richly decorated Neolithic pottery vessel and skeletal remains of aurochs and domestic cattle were salvaged from the site. Via AMS analysis the human remains are dated to an early part of the South Scandinavian Middle Neolithic (MN A).

Literature: Friis & Lysdahl 1999 [109]; Fischer et al. (in prep.).

Vængesø II, NEO3; Helgenæs 14.05.06-39, East Jutland. Kitchen midden with burials and loose human bones

Søren H. Andersen

A Late Mesolithic and Early Neolithic coastal kitchen midden in which two inhumation graves and a number of scattered human bones have been revealed. Although only a sample of limp bone was at disposal for the project, it proved possible to extract aDNA of acceptable quality from one of these individuals (skeleton BMY). Based on physical anthropology it represents a man 20-35 years of age, stature c. 1.65 m. On the left side of his frontal bone there was a healed lesion, and on the front of the eleventh thoracic vertebra there was a round lesion, probably the mark of an arrow or spear that caused death. Two large stones had been placed over the hip regions. No burial goods were associated with the grave. However, a radiocarbon measurement (5540±65 ^{14}C years BP, K-3921), corrected for a significant quantity of marine protein, dates him to the very latest part of the Late Mesolithic Ertebølle Culture, close to the time of the introduction of domesticated cattle and funnel beaker pottery in the region.

Literature: Andersen 2018[44]; cf. Andersen et al. 1986[45]; Meiklejohn et al. 1998[110]; Fischer et al. 2007[76].

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7) Catalogue of non-Danish archaeological sites

Edited by Fabrice Demeter[1,2] and*se Karl-Göran Sjögren[3]

[1]Lundbeck Foundation Centre for GeoGenetics, Globe Institute, University of Copenhagen.

[2]National Museum of Natural History, Ecoanthropology and Ethnobiology, Musée de l'Homme, Paris.

[3]Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

The format of the following section is similar to the above catalogue of Danish archaeological sites; in each instance a description of the nature of the site and samples is provided, followed by short list of publications on the site, providing a bibliography for each instance.

Armenia

Aknashen, Armavir, Armenia. Settlement and burials.

Ruben Badalyan & Levon Yepiskoposyan

The site of Aknashen-Khatunarkh is located in the Ararat Plain, in the basin of the Sev jur (Metsamor), at an altitude of 838 m, in the province (marz) of Armavir (6 km south of Vagharshapat, on the northeast periphery of the village of Aknashen). The site is an artificial hill (blur), circular in plan, 100 m in diameter (a surface area of about 0.8 hectares), with a flat top rising about 3.5 m above the plain. The excavations of the site have been conducted since 2004 by the Armenian-French joint expedition.

The site belongs to the Late Neolithic "Aratashen-Shulaveri-Shomutepe" culture and dates back to the first half of the VI millennium BC. Human remains occur both from a cultural layer of the synchronous deliberately committed burial (Tr.6, UF 11, F.15) and of household waste (unburied remains of a newborn, Tr.1, UF 8/NEO110), and intrusive burial of the end of Early Bronze - the beginning of the Middle Bronze Age (second half of the III millennium BC; Tr.7, UF 5, F2).

Literature: Badalyan et al. 2010[1]; Chataigner et al. 2014[2]

Czech Republic

Vedrovice, Moravia, Czech Republic. Cemeteries and settlement.

Václav Smrčka

At least three different cemeteries have been found at this Linear Pottery site. Between 1961 and 1974 V. Ondruš investigated 11 graves within the settlement in the tract of land "Široká u lesa" [3]. Funerals H1/1963- H11/1974 and H2/1985 have been found in an area enclosed by a ditch (Erdwerk). North from this densely populated place there is a regular burial ground where the dead had been continually buried since the phase Ib1 of the Linear pottery culture [4]. A total of around 110 burials have been excavated at the site [5].

Besides classical contracted funerals into separate gravel pits (H4,H7 and H10), a settlement pit (H1) or burial in a construction pit (H5), and also cases of discarding (H9) and anthropophagy (H11) were recorded.

One sample was analysed for aDNA: NEO128, grave 10/74. The skeleton of a 40-50 year old male was found in this grave. Orientation of the grave pit was E-W (with head positioned towards the East, feet to the West). The male was positioned lying on his right side (right lateral recumbent). Position of the skull was right temple, unnaturally bent backwards, the rear of the skull touching the spine. View was to NE.

Left humerus was along the body, forming a right angle with forearm and palm in front of mandible, thumb and index in extended position and other fingers flexed. Right hand was stretched along the body and the palm touched the left knee joint. Positioning of the lower extremities was "semi-crouched": the left femur was perpendicular to the body axis and the right knee joint was in the NW corner of the grave pit. Tibiae were crossed with the left tibia behind, right foot covering the left foot.

There was a hoof-shaped wedge in the area of the chest, 2 pcs of products of flaking, pottery fragment under the mandible, and a lump of graphite under the skull.

The male in grave 10/1974 exhibited a high ratio of 87Sr/86Sr in the femur compared with the tooth enamel and with the shell. He may have travelled between distinct environmental localities during his lifetime [6].

Literature: Ondruš V. 1961-1974[3]; Podborský V. (ed.), 2002[4]; Smrčka V. et al. 2005[6]; Richards et al. 2008[7]; Bickle and Whittle 2013[5]; Zvelebil & Pettitt 2013[8].

England

Hetty Pegler's Tump (Uley Barrow), Gloucestershire, England. Long barrow.

Alan K. Outram and Catriona J. McKenzie

Hetty Pegler's Tump, otherwise known as Uley Barrow, is a Neolithic Long Barrow about 8km SW of the modern town of Stroud, Gloucestershire, which was first excavated by Fry in 1821 [9]. It is an early Neolithic chambered tomb of the Cotswold-Severn type [10]. The long barrow is approximately 37 m long with a maximum breadth of 26 m. The entrance passage is at the SE end and originally led to five stone burial chambers, three of which now survive [9]. The early excavations recovered human skeletal material and the teeth and jaws of wild boar from the chambers [9], but in the upper levels there was also a human skeleton buried with Roman coins of the house of Constantine [9,11], showing later re-use of this funerary monument.

The fragmented skeletal material analysed in this study was, according to Gloucester museum records, discovered by a workman digging a fence line around the monument. Given the re-use of the monument and the nature of the discovery, direct dating of the remains was essential and has yielded a determination of 3641-3384 cal BC (95.4%, UBA-40120) confirming Neolithic date. The surviving remains from this discovery comprise four bones: an almost complete mandible (16 tooth sockets with 12 teeth present), an incomplete maxilla (8 tooth sockets with 5 teeth present), a right temporal (part of the squamous portion) and a left temporal (including petrous portion, jugular fossa and the internal auditory meatus). There is no duplication of skeletal elements and so it is possible that these bones may all have come from the same individual.

In terms of sex estimation, the only morphological traits available for analysis are the presence of a slight mental protuberance on the mandible and a pointed rather than squared symphyseal region of the mandible [12]. These two traits indicate that the remains may have come from a female individual. In terms of age at death, three third molars are fully erupted (the fourth was not present for analysis) indicating that this individual was older than 23.5 years of age at time of death [13]. Assessment of dental wear for age estimation following Brothwell [14] suggests that the left mandibular and maxillary molars are from an individual aged between 35-45 years of age, while the right mandibular molars are indicative of an individual older than 45 years of age. Overall, it is most likely that the remains came from an adult woman older than 35 years of age at time of death.

Literature: Brothwell 1981, Williams 1988. [9–14]; Clifford 1966[9]; Thomas 1988[10]; Williams 1998[11]; Brickley 2004[12]; AlQahtani et al. 2010[13].

Estonia

Sope

Sergey V Vasilyev and S. B. Borutskaya

The Corded Ware burial site at Sope is situated on a sandy knoll on the bank of the Sope. The majority of the skeletons were unearthed by farmers at the end of 19th – beginning of 20th century. The available information distinguishes two burial grounds within the larger burial area – Sope A and Sope B.

Sope A was discovered at the end of the 19th century. During the excavation of a cellar a human skeleton in a “sitting position” was unearthed, and in 1924 three accumulations of human remains were visible inside the cellar walls. Thus, this burial ground included at least four inhumations. Sope B was discovered in 1908 when the field was ploughed for the first time and allegedly seven skeletons with some bone and one amber artefact were found). Reportedly, one of the individuals lay on its side, with the lower limbs flexed at the knee. All the recovered bones were reburied nearby. Two more individuals were recovered from the field during archaeological excavations in 1926 [15] and 1933 [16]. Additionally, one skeleton has been found somewhere in the area, but the specific location is unknown.

Excavations revealed sandy soil that contained fragments and spots of charcoal, a small pottery shard and a few animal bones [15]. In the middle of the excavation plot, approximately 35 cm below the present surface in an area of 100×30 cm an accumulation of human and animal bones was found. No evidence of grave structures or above-ground markings were discovered. The body position of the individual was originally interpreted as tightly flexed and it was suggested that the corpse might have been bound prior to burial.

Previously, DNA results from Sope were published by Allentoft et al. [17]. This individual (RISE00, Sope I) was an adult female, probably in a flexed position. In the present project the grave Sope II was sampled, an adult woman buried in contracted position (NEO306). The same individual was analysed by Saag et al. [18]. Both individuals were dated to the Corded Ware period.

Literature: Moora 1926[15]; Indreko 1935[16]; Kriiska et al. 2007[19]; Allentoft et al. 2015[17]; Varul et al. 2019[20]; Saag et al. 2021[18].

France

Grotte Gazel, Aude, France. Double burial.

Patrice Courtaud

This cave (Sallèles-Cabardès, Aude, France) was occupied from the Upper Paleolithic until the historic times with several levels from Mesolithic to late Neolithic. This cave is mainly known by the remains from the Early Neolithic excavated by J. Guilaine between 1963 and 1971. A single burial, Gazel 1 (ERL 12288) 5733 ± 50 BP - 4692-4462 BC (94.5 %) belongs to the Epicardial or early Chasséen [21,22]. The grave sampled here, Gazel 2, was a double grave including a child (around 5 y.) and an adult female (Figure S7.1). The two skeletons are very closely related. The archaeo-thanatological study conducted by H. Duday [23] showed that the two individuals were deposited simultaneously. This discovery is important as there is little funerary evidence from this period in this region of Languedoc and more generally in southern France. One of the questions is the relationship between the two deceased. The age estimation of the female based on the auricular surface of the hip bone [24] suggests a death occurring after the age of 40 years. The adult female in Gazel 2 was dated to (UBA-40111) 5740 ± 32 BP- 4686-4503 BC (95,4%), supporting the contemporaneity of the two burials.

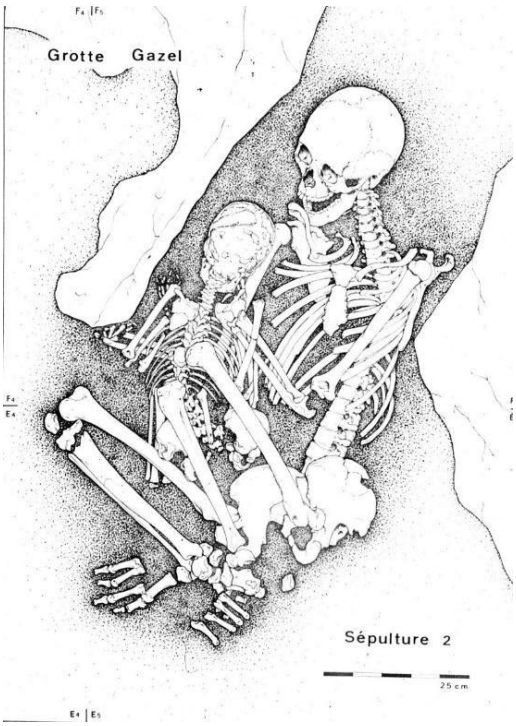

Figure S7.1. The double grave at Grotte Gazel. *From Duday and Guilaine* 1980[23]

Literature: Duday and Guilaine 1980[23]; Guilaine & Manen 1995[21]; 2007[22]; Goude and Fontugne 2016[25].

Grotte Mandrin, Drôme, Rhône-Alpes, France. Rock shelter.

Ludovic Slimak & Laure Metz

Grotte Mandrin is a vaulted rockshelter located in the Middle Rhône valley, in Mediterranean France. The site has been excavated since 1990 and records a long Pleistocene sequence recording a dozen of archaeological layers, from layers J to B, concerning Neanderthal occupations and Early Anatomically modern Humans [26,27]. Recently, a tooth from a modern human was dated to ca 54000 BP, so far the oldest evidence for modern humans in western Europe[298]. The main fossil records of this very rich archaeological sequence concern occupations from MIS 5 to 3. This sequence of Pleistocene successions ends with a single Holocene unit that records several phases of human cremations from the late Neolithic and Bronze age. This Holocene layer layer A was mainly excavated in the 1960's by Gaston Etienne. The archaeological material from layer A is mainly composed of human remains, commonly burned, associated with a rare archaeological material composed of few foliate arrowheads, some pottery fragments and rare Mediterranean pierced shells. Grotte Mandrin was then only used during this Holocene phase for body treatments. This layer A was recently excavated in the entrance of the rockshelter in 2014 and 2015. The material analysed in this study come from both the recent 2015 excavations (human samples Man 15 A 1249 and Man 15 A 101) and from the Gaston Etienne 1960 waste that was screened in 2015 (Man A Déblais Gaston).

Literature: Slimak 2008[26]; 2019[27], Slimak et al. 2022[298].

Georgia

Kotias Klde, Chiatura, Georgia. Cave site.

David Lordkipanidze

The Kotias Klde cave is located in west Georgia, Chiatura region, near the village Sveri on the limestone Mandaeti plateau, in the Sadzalikhevi Gorge, 716 metres above sea level. While at the entrance it is quite spacious (23 metres wide and 8 metres high), most of it comprises a narrow and deep tunnel with the archaeological remains confined to the

entrance area. The cave was discovered in 1968 by the Kvirila basin archaeological expedition headed by David Tushabramishvili, the Georgian State Museum, and assigned to the Neolithic – Early Bronze periods. It was tested in 2003 as part of the international (Georgian-USA-Israeli) project led by Tengiz Meshveliani, the Georgian National Museum. Systematic archaeological excavations were conducted in 2004-2006 and 2010 revealing a sequence of Upper Paleolithic (Layer C), Mesolithic (Layer B) and Neolithic (Layer A) occupations.

A grave was discovered in 2004 containing a complete skeleton of an adult male which was dug from layer A into layer B, almost reaching the stone pavement of sublayer B2. Stones crushing the skull, the knees and lower limbs of the skeleton were placed at the time of the burial. Radiocarbon dating of the tibia provided a date of 9,690-9,540 years cal. BP. DNA from this individual was published by Jones et al. [28] and used to define the genetic group of Caucasian hunter-gatherers.

Literature: Tushabramishvili 1971[29]; Tushabramishvili and Nebieridze 1974[30]; Meshveliani et al. 2006[31]; 2007[32]; 2010[33]; 2013[34]; Bar-Oz et al. 2009[35]; Jones et al. 2015[28].

Hungary

Deszk – Olajkút

Václav Smrčka & Olivér Gábor

This Körös culture site was excavated by Otto Trogmayer [36]. In grave 6 was a gracile skeleton of a 30-35 year old female with a height of 155 cm and with torus palatinus on the palatal plates. An M2 tooth was analysed for aDNA and was dated to 6950±48 uncal BP (UBA-39965).

Literature: Farkas & Marcsik 1988[37]; Lipták 1974[38]; Ottó 1968[39]; Ottó 1984[40]; Whittle et al. 2002[41].

Hödmezövasarhely Kotac

Václav Smrčka & Olivér Gábor

The Körös culture site of Hődmezőváráshely-Kotac is not at this point archaeologically published. The skeletal remains are housed in the University of Szeged. One sample was analysed: NEO137, grave 25/2, no. 132. It was dated to 6728±42 uncal BP (UBA-39966).

Literature: [42,43]

Gorzsa Cukormajor, region Csongrád, Hungary

Václav Smrčka & Olivér Gábor

Hódmezővásárhely-Gorzsa is a settlement of the Tisza culture. The site lies in the environs of Hódmezővásárhely, at the confluence of the Tisza and Maros rivers. However, the archaeological site is not identical with the detached farmstead of Gorzsa shown on road maps; it lies some 10 km to its southwest. The site is marked as Földvár (earthwork fort) on the 18th and 19th century maps. This name has been replaced by names preserving the memory of the former owners (Cukor major). The name Földvár probably coincides with the Mediaeval name of this area given by Slavic settlers. Goruša, the Old Slavic form of Gorzsa, is mound elevation. It is used to denote the entrance to a hillfort in modern Russian. According to an old description the remains of "fortified castle built in olden days“ being surrounded by rivers and marshes on all sides closed to strangers [44].

A total of 50 burials have so far been uncovered. These burials form discrete grave clusters; the preliminary serological analyses indicate that these burials contained the deceased of four successive generations of one genetic unit. These grave clusters appear, moreover, to have been organised according to sex.

The graves were uniformly southeast – northwest oriented. The deceased were buried in contracted positions, with females laid on their left, and males on their right side. About one third of the graves contained vessels that had been deposited beside the skull. Female burials also yielded bone pins, and one male burial contained a marble macehead.

Seven individuals were analysed successfully for aDNA (Table S7.1). They were all dated to a short span of time at 5800-6100 BP uncal.

Sample	**Description**

NEO143, 8999, grave 2	Young person (18-20/22 years old). Deficient and fragmented postcranial skeleton with fragmented mandibula.
NEO147, 9005, grave 10	Adult female with skull in good condition and postcranial skeleton. The neurocranium is medium length, narrow and high mesokran, hypsikran, akrokran, prot. occ. externa 0. The outline of the skull in norma verticalis is pentagonoid. The forehead is narrow and aurymetop. Glabella: 2. graduate. Due to the capacity of skull: aristenkephal. The face is narrow and of medium height., low, leptoprosop mesén, orthognath. Fossa canina 1. graduate. Orbita hypsikonch. Nose: camaerrhin, spina nasalis anterior 2. graduate. Palate brachystaphylin, alveolaris prognathia 1. graduate. On lumbal vertebrae: print of Schmorl's node. Stature: 162 cm. Taxon: gracilis mediterrán—x (m—x) (2. fig.). Literature: MFMÉ 1987
NEO148, 9014, grave 24	Adult with skull in good condition and postcranial skeleton. The neurocranium long, narrow, dolichokran, chamaekran, tapeinokran. The outline of the skull in norma verticalis is pentagonoid, occipitalis externa O. The forehead is narrow and metriometop, glabella 2. grad. Due to the capacity of skull: euenkephal. The face is short orthognath. Fossa canina: 3. graduate. orbita: mesokonch. Nose: hyperchamaerrhin, alveolaris prognathia 3. graduate. Palate: mesostaphylin. In lambrasutures: ossa Wormiana. The first segment of ascrum was not grown together with the following one. On the right humerus: foramen entepicondyloideum. Stature: 157 cm. Taxon: gracilis mediterranean – x(m-x)
NEO140, 9706, grave 27	Banner János: Hódmezővásárhely, Gorzsa-Czukor major. Dolgozatok 1933-34. Bálint Alajos: Hódemezőváráshely, Gorzsa-Czukor major. Dolgozatok 1937. Gazdapusztai Gyula: Jelentés a Hódmezővásárhely-Gorzsa Cukor-majornál végzett ásatásról. RégFüz I/9 (1958) Horváth F: Hódmezővásárhely Gorzsa. ArchÉrt 109 (1982)

NEO142, 9707, grave 28	nd
NEO149, grave 49	nd
NEO145, grave 60	nd

Table S7.1. Details of samples from Gorzsa included in the present study.

Literature: Banner 1934[43]; Bálint 1937[45]; Gazdapusztai 1958[46]; Horváth 1982[44]

Iran

Tepe Guran, Hulailan Valley, Central Zagros, Iran, grave/pit find

Peder Mortensen & Pernille Bangsgaard

The site was excavated in 1963 by the Danish Archaeological Expedition to Iran. It is a classic tell site with remains from the Iron Age, Bronze Age and the Neolithic Periods, with the latter including 18 layers of unbroken habitation (dated to 6700 – 5500 BC. BC). The three samples all come from these Neolithic layers. Two samples originate in area GI. Sample 71 is from level Q, where a tightly flexed female skeleton was found, her age app. 25 years. Sample 75 is from Level V and inside a pit four individuals were found in a disarticulated state, a likely reburial. Sample 75 is the partial skull of an adult around 20-30 years old. From area GIII a pit contained a male skeleton in a tightly flexed position, aged around 35-40 years.

Literature: Meldgaard et al. 1964[47]; Alexandersen et al. 1981[48]; Thrane 2001[49]; Mortensen 2014[50]

Italy

Fontenoce, Recanati, Italy

Gabriele Scorrano, Cristina Martinez-Labarga, Mario Federico Rolfo, Mara Silvestrini, Francesca Radina, Paola Aurino, Mauro Calattini, Lucia Sarti, Enrico Cappellini & Olga Rickards

The archaeological site of Fontenoce di Recanati is located at few kilometres away from the Adriatic coast in Central Italy. The Chalcolithic settlement was excavated under the supervision of Dr. Mara Silvestrini starting in 1984, when an isolated “grotticella” grave was brought to the light. In the subsequent years, several graves associated to Rinaldone culture and trans-Adriatic influence were discovered. All the radiometric dates set Fontenoce di Recanati in the Early Copper Age (3600-3300 cal BC). The sample analysed is a female dated to 4661 ± 30 BP (rib).

The human remains appeared to be in a good level of preservation, and most of the inhumations present complete skeletons, with the bones in anatomical association. There were single and multiple burials, with the inhumations usually lying in a flexed position on the right side, with great variability of the limbs. The exceptional human bone preservation allowed several interdisciplinary studies, such as the occupational markers analysis showing an intense physical activity, such as hunting, while the stable isotope analysis indicated a diet with remarkably high but not exclusive consumption of animal proteins.

Litterature: Silvestrini et al. 1992[51]; 2005[52]; 2011[53]; Cencetti et al. 2005[54]; Dolfini et al. 2010[55]; De Angelis et al. 2019[56].

Gaudo, Paestum, Italy

Gabriele Scorrano, Cristina Martinez-Labarga, Mario Federico Rolfo, Mara Silvestrini, Francesca Radina, Paola Aurino, Mauro Calattini, Lucia Sarti, Enrico Cappellini & Olga Rickards

The excavation and discovery of the Eneolithic necropolis of Gaudo di Paestum, in the locality of Gaudo between the Fiumarello and Contrada Seliano, took place in three important moments:

1. In the autumn of 1943, strictly connected to an exceptional and contingent event, represented by the Second World War, during the works for the construction of a military airport.

In this first stage the excavation took place with mechanical vehicles and the tombs were unfortunately completely damaged; about 50 vases, flint daggers and a copper dagger were recovered.

In June 1944, during the manual extraction of other quantities of tuff, tomb 10 was intercepted leading to the discovery of the culture of Gaudo. The work done by both Lieutenant Morris, who was in charge of the work at the time, and by Lieutenant Brinson, director of the B.P. Mobile Archaeological Unit, in anticipation of any archaeological finds was fundamental.

Lieutenant Brinson carried out the survey of about 9 tombs previously identified by the Allied army and he excavated tomb 10, today known as the Brinson tomb, with great stratigraphic rigor.

The disposition of the human remains indicated that the burials had taken place in succession for a long period of time, and that the ceramics and skeletons had been pushed to the bottom each time and piled on top of each other to make room for the new burials. Furthermore, since the skeletons had the legs collapsed laterally in a squatting position, on the basis of the detached position of the skull, it was possible to assume that the bodies were originally buried curled up on their side or in a sitting position. However, it could not be excluded that these were secondary burials, meaning that the bodies may have been previously exposed elsewhere and the skeletons brought later to their last "home".

2. In 1945, Pellegrino Claudio Sestieri inspected the necropolis of Gaudo and collected materials. Then, two excavation campaigns were carried out in 1945, others between 1946 and 1947 bringing to light a total of 19 tomb contexts whose outfits flowed into the Paestum Museum, which was inaugurated in 1952.

3. The last excavations were conducted by the "Soprintendenza di Salerno" on several occasions since 1962 by Giuseppe Voza who discovered 14 new tombs. Finally, in August 1969 the emergency intervention of the staff of the Paestum museum.

The superimposition of Brinson's planimetric sketch with Voza's planimetry allowed Antonio Salerno and Gianni Bailo Modesti to understand that the tomb 10 excavated by Brinson actually constituted only one of the cells of a bicellular complex digged by Voell in 1962. This second cell was defined as "grave e".

The first cell contained the disconnected remains of about 12 individuals: 10 adults, 1 adolescent and 1 child, while in the second cell were discovered the remains pertinent to about 7 individuals: 5 adults, and 2 sub-adults, still preserved in the Museum of Paestum.

There are some radiocarbon dates from two individuals: individual 5 from tomb IXA: (LTL 13376A) 4593 ± 45 BP, 3520-3310 BC (67.2%, 2σ), 3300-3260 BC (1.5%, 2σ), 3240-3100 BC (26.7%, 2σ); and from individual 13 of the IXB tomb of Paestum: (LTL 3338A) 4478 ± 45 BP, 3360-3010 BC (95.4%, 2σ). The chronology between the middle of the IV millennium and the middle of the III millennium, remains substantially unpublished and mainly derives from the presence in Paestum of tombs with multiple depositions in which there are up to 70 individuals in a single cell.

Literature: Aurino 2011[57], 2013[58].

Grotta delle Mura, Monopoli, Bari, Italy

Gabriele Scorrano, Cristina Martinez-Labarga, Mario Federico Rolfo, Mara Silvestrini, Francesca Radina, Paola Aurino, Mauro Calattini, Lucia Sarti, Enrico Cappellini & Olga Rickards

The archaeological site of Grotta delle Mura is located in the municipality of Monopoli (Apulia), a few metres away from the Adriatic coast in southern Italy. It was discovered by Prof. Anelli in 1952. The excavation has been under the supervision of “Dipartimento di Scienze storiche e dei Beni culturali” of Siena University since 1985.

On the basis of the different artefacts found and some radiocarbon dating performed on charcoal and bone remains, the settlements span from Middle Palaeolithic to the Ancient Neolithic. Several stratigraphic units have been identified, with the most ancient being associated with the Mesolithic and the Final Epigravettian (from SU 125 to SU 130). From SU 130 dated to 11420 ± 100 BP, comes one of the most important Italian Epipaleolithic graves, a child. The sample analysed in the present paper (NEO806) came from SU 123, which is associated with the Ancient Neolithic level. However, the sample was directly dated to the Bronze Age (3014±26 uncal BP, UBA-40109).

Literature: Calattini 2002[59]; Calattini & Tessaro 2016[60]; Calattini et al. 2003[61], 2017[62].

Grotta Nisco, Cassano Murge, Bari, Italy, Cave

Gabriele Scorrano, Cristina Martinez-Labarga, Mario Federico Rolfo, Mara Silvestrini, Francesca Radina, Paola Aurino, Mauro Calattini, Lucia Sarti, Enrico Cappellini & Olga Rickards

The Eneolithic site of Grotta Nisco is a karst cave located in the territory of Cassano Murge (Bari) 380 metres above the sea level, studied by the "Soprintendenza per i Beni Archeologici della Puglia". It was a collective tomb dated between 2,500 and 1,800 BCE.

The very narrow entrance leads, after a drop of more than 1m in a vestibule leading to the central hall around which several irregular rooms are placed on different levels.

In room 1, skeletal remains of 3 disarticulated adults were found, skeletons A and B, both adult males, had a metal stab with nails, flint tools and 3 arrow cusps, the adult female skeleton C, had a clay spindle. In the environment there were other fragments of various small sizes. Large bovid bones were also found, some with clear signs of slaughter.

In room 5, located in the rear part of room 1, the skeletal remains of an individual in a secondary position were recovered, with a kit consisting of a dagger with ogival contour and triangular blade, along with a mug with geometric enterprise decoration.

Overall, a total of 18631 bone fragments were recovered, 4807 of which were properly classified as human (1709, 35.5%) and faunal (3098). The minimum number of individuals was 20: 14 adults, 2 juveniles, 3 infants and, probably a full-term foetus should be added.

The mean stature was about 159 cm, and the males probably were subjected to a greater biomechanical load on the lower limbs, with evidence of running on rough substrates, climbing on rocks, throwing objects and crouching. The general health status was good, only a few cases of malnutrition are evident in the early stages of childhood, but in adulthood, nutrition had to be good based on animal husbandry products and low carbohydrate intake. The frequency of caries is very low, even the loss of ante-mortem teeth and there are no signs attributable to anemias. Based on the analysis of the faunal remains (with 60% of remains attributable to sacrificed *Ovis* or *Capra* and the presence of dog), a pastoral economy based on sheep and goat breeding may be hypothesised.

Literature: Venturo et al. 2011[63]; Radina and Savino 2018[64].

Maddalena di Muccia A, Province of Macerata, Marche Region, Italy. Settlement.

Alfredo Coppa

The Maddalena di Muccia site was discovered and partially investigated in the 1960s by Delia Lollini [65] who had found structures, ceramics and lithic industry dated to the Ancient Neolithic. Since 2001, as part of a larger program, which involved the University of Rome La Sapienza, the area has been systematically investigated, with extensive excavations and regular research campaigns carried out in the years 2001-2003, 2005, 2006 and 2008 [66].

The sample examined (NEO695) comes from the excavations of the 1960s in which only one burial was found (A) of which the skull with mandible, without the splanchnocranium, and various parts of the postcranial skeleton are preserved. The skeleton belongs to an adult female individual, which was determined by the morphology of the skull and hip bone [67,68 a,69 b]. The skeleton was found in the deposits of the ancient Neolithic ceramic impressed with an uncalibrated dating of 6580 ± 75 BP which, calibrated at 2σ, chronologically places the site between 5640 and 5460 BC [70]. To these dating results are added those coming from the new excavations (US114- 6638 ± 59, 6637 ± 83, 6440 ± 50 BP) which confirm the chronology of the site in the 6th millennium BC.

The dental morphological traits of this sample have been employed, together with those of many other Neolithic ruins, in a study as direct indicators of biological affinities among the populations that inhabited the Italian peninsula from the Upper Palaeolithic-Mesolithic to Mediaeval times. The results from the principal component analysis, maximum likelihood, mean measure of divergence, and multidimensional scaling do indicate a net separation of the Paleo-Mesolithic sample from the other groups that is not related to dental reduction. This suggests that the shift in dental morphology was the product of Neolithic populations migrating into the peninsula from other areas. Nonetheless, the Paleo-Mesolithic populations share several discriminative traits with the Neolithic group. The biological relevance of such evidence suggests that, to some minor extent, the spread of agriculture did not occur by total population replacement [71].

Literature: Lollini 1965[65]; Corrain and Capitanio 1968[67]; Alessio et al. 1970[70]; Lollini 1991[68]; 1991[69]; Coppa et al. 2007[71]; Manfredini 2014[66].

Mora Cavorso cave, Jenne, Rome, Italy. Cave.

Gabriele Scorrano, Cristina Martinez-Labarga, Mario Federico Rolfo, Mara Silvestrini, Francesca Radina, Paola Aurino, Mauro Calattini, Lucia Sarti, Enrico Cappellini & Olga Rickards

Grotta Mora Cavorso is a cave with a stratified deposit, located in the inner Apennines in Central Italy. The archaeological deposit spans from Upper Palaeolithic to historical age. The focus of the deposit is the Neolithic level, which holds one of the largest Neolithic burial deposits of central Italy. Multidisciplinary investigations carried out between 2006 and 2018 identified approximately 600 highly fragmented human bones in two little inner rooms (UP and LR) of the carsick complex.

The minimum number of individuals amounts to 28, and the estimation of the age at death indicates: 11 foetus, perinatal and infant (I-II), 1 juvenile, 5 young adults and 11 adults. The majority of human bones were found in one of the two rooms (LR), chaotically piled with no skeletal connection. A smaller number of human bones, still partially articulated, were found in the contiguous room (UR). In this context the human bones were found lying directly on the crust, without any apparent delimitation of the funerary space. Radiometric dating of the Neolithic context are between 6874 ± 45 BP (jaw of a domestic caprine) and 6000±45 BP (charcoal of hearth), and set the Neolithic level in the early phase of the Neolithic period of the Italian peninsula. The archaeological finds in the burial level are scarce, as eleven shell and stone beads, possibly ornaments worn by the dead, were found, together with pottery, a stone polished axe and five flint bladelets as grave goods. Rare and almost exclusively domestic mammals have been identified.

Here we report results from an adult individual (NEO834), dated to 6499±41 uncal BP, UBA-40801.

Literature: Scorrano et al. 2015[72], 2019[73], Rolfo et al. 2016[74], 2017[75], Silvestri et al. 2020[76].

Kazakhstan

Gregorievka 1, Pavlodar, Kazakhstan. Cemetery.

V. K. Merz, translated from Russian by Aija Macane

The Gregorievka 1 flat earth burial ground, grave No. 2, is located 100 m south-east of the grave No. 1, in the village of the same name, on the first terrace above the floodplain on the right bank of the river Irtysh. The grave was discovered on a riverbank bluff, where a dark filling of the grave pit and small bones were recorded. At a depth of 0.6 m, the grave had a square shape 1.5 x 1.6 m in size, oriented to the north with a slight inclination to the east, and with a collapsed southern edge. By the northern and eastern sides of the grave, small pits were recorded. The depth of the grave reached 1 m, and it has been plundered in the past. The red-black filling of the grave contained fragments of charcoal, scattered human bones, as well as bones of cattle and sheep, fragments of ceramics decorated with “stepping” comb stamp impressions (made by rolling), a bone object resembling an awl, and fragments of ochre. At the bottom of the pit, near the eastern wall a spot of ochre was documented [77 b,78].

The postcranial skeleton was studied by the senior researcher of the Physical Anthropology Sector of the Tyumen Scientific Centre of the Siberian Branch of the Russian Academy of Sciences, Candidate of Historical Sciences K.N. Solodovnikov. It belongs to a woman about 18 years old (NEO899). The skull belongs to the dolichocephalic Europioid type with a narrow face, similar to the type of the male population of the Yelunin culture in the Upper Ob region. The skeleton was dated to 3696±20 uncal BP, OxA-39283, similar to the date from burial 1.

Based on peculiarities of the funeral practices and grave inventory, this burial belongs to the Yelunin culture of the early animal herders in the interfluve of the Ob and Irtysh. Despite the fact that the grave had been looted and small material was obtained from it, the burial can still be attributed to the Yelunin culture and reflects the particularity of the development of the Yelunin population in the southern part of the middle reaches of the Irtysh River [79].

A 14C date, UBA-32665, was previously obtained from grave 1, indicating the interval of its construction between 2037–2285 BC [80]. Earlier, before any results of radiocarbon analysis were obtained, this burial was attributed to the Yamnaya cultural type [77,78,81]. However, the obtained radiocarbon date forces us to abandon the original interpretation linking this burial to Yamnaya, confirmed also by the significant difference between the anthropological type of the woman in the grave 1 and the populations of the Yamnaya and Afanasievo cultures. It belongs to the "racial-genetic" stratum of flat-faced Mongoloids settling the sub-taiga zone of the south-western Siberia ([81]; Solodovnikov, 2016: 92, Fig. 4).

Thus, based on these facts, both burials should be considered within the "Klinskaya" sub-group of the burials of Yelunin culture, and reflect the specificity of the burial practices of the Yelunin population in the southern part of the middle reaches of the Irtysh River ([79]). However, it should be noted that the anthropological type of women buried in burial 1 and 2 is very different from each other. That suggests the multicomponent character of the population of Yelunin culture, which has been repeatedly noted by anthropologists ([82]). The Irtysh valley was a contact zone between the populations of the steppe, forest-steppe and sub-taiga zones.

Literature: Tur & Solodovnikov 2003[82]; Merz, V. K. 2007[78]; 2007[77], Merz & Merz 2010[81]; Khokhlov et al. 2016[83]; Merz, I. V. 2017[79]; Damgaard 2018[80].

Shauke settlement, Pavlodarsk, Kazakhstan. Settlement and burial

V. K. Merz, translated from Russian by Aija Macane

The Shauke settlement is located on the first terrace above the floodplain on the right bank of the River Irtysh. It is situated 0.5 km north of the village of the same name, on the site of an old sandpit. The settlement was discovered in 1992 by V.K. Merz. Repeated collection of archaeological material from the Bronze – Early Iron Age (III–I millennium BC) was carried out at the site in 1996, 2001, 2006 and 2011.

NEO901 Shauke settlement, Burial 2: The burial No. 2 was discovered in 1996 by V.K. Merz while surveying parts of settlement which had been subject to wind erosion. The burial was completely preserved, the skeleton lay on the left side with its head to the north. No inventory was documented. Direct dating showed the skeleton to be from the Mediaeval period.

The postcranial skeleton was studied in 2012 by the senior researcher of the Physical Anthropology Sector of the Tyumen Scientific Centre of the Siberian Branch of the Russian Academy of Sciences, Candidate of Historical Sciences K.N. Solodovnikov. It belongs to a woman, 30-40 years old. The skull is gracile, sharply dolichocephal with elongated proportions of the cranial and facial parts of the skull, an Europeoid with sharply wedge-shaped face and slightly protruding nose. No analogous examples can be found among the Neolithic-Bronze Age populations of the interfleuve of Ob and Irtysh rivers.

Literature: Merz 2011[84]; Svyatko et al. 2015[85]; Merz & Svyatko 2016[86].

Shauke 1, Pavlodarsk, Kazakhstan. Cemetery.

V. K. Merz, translated from Russian by Aija Macane

The burial ground Shauke 1 is located on the first terrace above the floodplain on the right bank of the river Irtysh, 1.2 km north of the village of the same name, on the site of a sandpit. The burial ground was discovered in 2010 by V.K. Merz, who discovered accumulations of human bones, ceramics and other objects on the eastern edge of the quarry. The finds were concentrated in several heaps, which received provisional designation as graves in the order of their discovery No. 1–3. While surveying the edges of the quarry, 140 m to the west of the location of the artefacts, the remains of a destroyed grave was discovered. At a depth of 1.7 m from the modern-day surface, a rectangular spot of red and black soil concretion, 1.08x0.3 m in size, was documented. A grave layer or filling, 15 cm thick, was recorded on top of this spot. On this basis it was concluded that the three discovered burials had been transferred by a loader from this very place. The excavations carried out at this site on May 27, 2012, revealed that the spot consists of the north-eastern edge of a rectangular grave pit. No finds were found in the filling (Merz 2011: Fig. 2). Nearby, from the soil fallen down from the quarry walls and from an area newly opened by a bulldozer, fragments of ceramics of the Yelunin

culture were collected and grave No. 4 was discovered. Postcranial skeletons were studied by senior researcher of the Physical Anthropology Sector of the Tyumen Scientific Centre of the Siberian Branch of the Russian Academy of Sciences, Candidate of Historical Sciences K.N. Solodovnikov.

To study the reservoir effect in the region, paired samples were taken from burials No. 1–4 (1 human bone, 1 animal bone) in 2014. The following dates were obtained from grave No. 2:

UBA-268929, human bone: 3772±33 uncal BP, 2293–2047 cal BC

UBA-268939, sheep bone: 3706±36 uncal BP, 2202–1980 cal BC

The following dates were obtained from grave No. 3:

UBA-268949, human bone: 3782±33 uncal BP, 2334–2050 cal BC

UBA-268959, sheep bone: 3761±40 uncal BP, 2292–2036 cal BC

Archaeological material accompanying the bone remains indicates that the burials of the Shauke 1 burial ground belong to the Yelunin archaeological culture, based on four AMS dates. Burial No. 2 is dated to the XXIII–XX centuries BC, burial No. 3 to the XXIII–XXI centuries BC [85,86].

All in all, the radiocarbon and isotopic studies carried out on objects of the Early Bronze Age in the southern part of the Middle Irtysh region revealed the existence of a freshwater reservoir effect in the region. That means that 14C-dates, especially of human bones, turn out to be much older. For the middle reaches of the Irtysh, within the Pavlodar region, the reservoir effect is ≈ 157–224 years ([85]).

NEO900 Shauke 1 Burial 2

Burial No. 2 contained an open, jar-shaped vessel, decorated with a “stepping” comb stamp (made by rolling). A piece of a stone crucible and a tanged arrowhead, and bones of sheep and calf were found nearby. Skeletal remains belonged to a man, 40–50 years old. The skull is dolichocephalic, Europeoid with a narrow face, similar to the type of male population of the Yelunin culture of the Upper Ob region. The sample was dated to 3831±20 uncal BP, OxA-39284.

NEO902 Shauke 1 Burial 3

Burial No. 3 contained two wall sherds of a clay vessel, one of which had a raised cordon decorated with comb stamp impressions. A fragment of an astragalus of a small ruminant covered with green oxides from non-ferrous metal, a fragment of a metal object and 37 animal astragali (cattle – 2 pcs, sheep – 35 pcs), as well as horse and sheep bones were

found nearby. Bone remains belonged to an adolescent, presumably male, 14–16 years old. The skull is dolichocephalic, probably Europeoid with somewhat softened Europeoid features. Possibly similar to the type of population of the Yelunin and Krotovo cultures in the interfluve of the Ob and Irtysh. The NEO902 sample was dated to the Iron Age, 2337±18 uncal BP, OxA-39286. This sample therefore most likely comes from another individual, and the bone assemblage may be considered as mixed, probably in connection with the gravel extraction.

Literature: Merz 2011[84]; Svyatko et al. 2015[85]; Merz & Svyatko 2016[86].

Sjiderty 10, Pavlodarsk, Kazakhstan. Barrows.

V. K. Merz, translated from Russian by Aija Macane

The Sjiderty 10 burial ground is located 5.5 km to the south of the Sjiderty station, in a valley formed by the high right bank of the Sjiderty river and the hills. Two burial mounds (at a distance of 5 m from each other) are situated at the lowest part of the valley, near the confluence of a temporary watercourse and the river. The burial ground was discovered in 2001 by V.K. Merz. In 2001 V.K. Merz investigated the mound No. 1, and in 2002 mound No. 2. Both of them have been plundered earlier. The mounds were stone-and-earth-mixed barrows in the form of an irregular circle, with a diameter of 8x9 and 9x7.6 m, and a height of 0.45 and 0.15 m.

Square settings built of large stones were discovered under the barrows. In the middle of them, earth graves with oval pits contained collective burials of adults and children, placed in crouched positions on their backs, with their heads oriented to the north-west. The walls of the graves were burnt and charcoal was noted in the fill, while concretions of burnt soil and ochre were present in the graves.

The burial inventory is represented by fragments of pottery, decorated with a “stepping” comb stamp (made by rolling), mollusc shells (Unio sp.), flint chips and flakes, fragments of arrowheads and a bronze knife and a turquoise bead. Also bones of horse, cattle and small ruminants were discovered with the burials, interpreted as remains of sacrificial food. A shrine was discovered in the north-eastern sector of the mound No.1, and contained, in addition to the above-mentioned categories of objects, a grinding stone and a bone awl.

The postcranial skeletons were studied by the head of the anthropological department of the Altai State University, Candidate of Historical Sciences S.S. Tur, and the senior researcher of

the Physical Anthropology Sector of the Tyumen Scientific Centre of the Siberian Branch of the Russian Academy of Sciences, Candidate of Historical Sciences K.N. Solodovnikov.

A 14C date (COAH – 4860, 3835 ± 90 uncal BP) was obtained from a charcoal sample from the grave in mound No. 1, and suggests that the object was constructed in the interval between 2563–2031 BC [79,86 Fig. 2,87,88].

The burial ground belongs to the Sjiderian variant of the Yelunin culture, and illustrates the specific development of the Yelunin population in the north-eastern Saryarka (Merz, 2017: 20). Particular aspects of the funerary practice and inventory suggest cultural influences from eastern Europe (Merz, 2018: 138).

Mound No. 2 had an irregularly shaped flat stone-earth barrow 9x7.6 m in size and 0.15 m high. A square setting of large stones was discovered underneath it. Horse bones and a stone ball were found in the filling of the mound. In the centre, there was a heavily destroyed oval pit, 2.4x1.6 m in size, dug 1.39 m deep into the ground, and oriented in WNW-ESE. An accumulation of charcoal was found by the eastern wall, at a depth of 0.8 m, and at the bottom of the pit a concretion of soil with a diameter of 0.33 m. Remains of three people were found, sprinkled with ochre: 1) a woman of mature (?) age; 2) a neonatus or a foetus in perinatal period; 3) a child about 5 ± 1 years old (NEO904). Fragments of horse, cattle and sheep bones were found among the human bones. A turquoise bead was found in the grave filling (Merz, 2003). The radiocarbon date UBA-39933 was obtained from the teeth of the five year old child.

Literature: Merz, V. K. 2002[87], 2003[88], Merz & Svyatko 2016[86]; Merz, I. V. 2017[I.V. 79], 2018[I.V. 89].

Bestamak, Kazakhstan. Cemetery.

I. V. Shevnina & A. V. Logvin

The burial ground Bestamak is located on the right bank of the river Buruktal (Kostanay region, Northern Kazakhstan) The site was investigated by the Turgai archaeological expedition in 1991-2013. The necropolis functioned in antiquity for a long period of time: the Stone Age - the Bronze Age - the Early Iron Age - the Middle Ages. Most of the burials belong to the Sintashta period of the Bronze Age. Pit No. 117 is rounded in shape, 1.15 m in diameter, 0.9 m deep. In the burial, a skeleton of a woman of 50-60 years old was found in a sitting position, facing the pit wall. The whole skeleton is abundantly sprinkled with ocher. Behind the buried back was a stone ball with a diameter of 15 mm and a flake without

retouching (Logvin, Shevnina, 2009, p. 104-110; Logvin, Shevnina, 2009, p. 142-151; Logvin, Shevnina, 2013, p. 231-244).

Literature: Logvin & Shevnina 2009[90]; 2013[91 2013]; Logvin et al. 2009[92].

Latvia

Zvejnieki, Latvia. Cemetery and settlement.

Elizaveta V. Veselovskaya & Sergey Vasilyev

Zvejnieki is a large Mesolithic and Neolithic burial ground and settlement, located in Northern Latvia at the Ruja River head by lake Burtnieks. Excavations of the 1964-1971 expeditions of the Institute of History of Latvia Academy of Sciences were conducted under the guidance of F.A. Zagorskis. 302 Mesolithic and Neolithic burials were discovered. The cemetery has a long period of use, from ca 7500 to 2600 cal BC. According to the inventory, it belongs to the Kunda Mesolithic culture, which was distributed in the territory of Latvia and Estonia from the 8th to 5th millennium BC [93]. The Comb Ware and Corded Ware cultures are also represented. Most burials are single burials in supine position, with variable orientation and covered with ochre. Several graves were excavated by Lars Larsson [e.g. 94]. The total number of burials is at least 348.

Two anthropological variants are represented [95]. One is Caucasoid, sharply dolichocranial with a medium-wide, high, significantly profiled face and protruding nose. The other is dolicho-mesocranial with a wider and flattened face. There are sculptural reconstructions made on the skulls of representatives of both types by G.V. Lebedinsky.

Dietary isotopes were analysed by Eriksson [96]. Previous aDNA analyses were published by Jones et al. [97] and Mathieson et al. [98], suggesting the presence of Western Hunter-Gatherer ancestry.

In the present project one individual is reported (NEO307), dated to the Mesolithic. A further sampled individual (NEO308) from burial 57 was dated to the Mediaeval period and is not included here. Since grave 57 was previously dated to the Mesolithic, the sample is probably intrusive or mislabeled. The two skulls were sent to Moscow for facial reconstruction by Lebedinsky [99].

NEO307 is a male adult, 30-40 years old, from burial 2. The skeleton was buried in a supine position, sprayed with ochre but without artefacts. It was dated to the Middle Mesolithic,

7313±49 uncal BP, UBA-40033. A previously published date, 6900±65 uncal BP, Ua-3638, is considered less reliable.

Literature: Denisova 1973[95]; Zagorskis & Zagorska 1973[93]; Eriksson 2003[96]; Zagorskis 2004[99];Jones et al. 2017[97]; Larsson et al. 2017[94]; Mathieson et al. 2018[98].

Norway

Hummervikholmen, Søgne, Agder, Norway. Submarine find.

Per Persson

In 1994 the landowner dredged the small harbour on the island Hummervikholmen. He then found a human skull that later was radiocarbon dated to the Mesolithic. The find spot was at c. 1 m depth in the sea. In the following years, divers from the Norwegian Maritime Museum documented the site and collected more human bones [100]. In 2013 the remaining part of the undisturbed sediment in the harbour was excavated in a joint project between the Norwegian Maritime Museum and the Museum of Cultural History [101]. In total about 20 human bones were collected. There are skulls/-fragments from at least three individuals. No artefacts were found at the site. Trial pits have been excavated on the island with negative results. There are in total 11 radiocarbon dates on human bones from the site, except for one outlier they are in the range c. 8400-8850 uncal. BP. An investigation on diet from stable isotopes shows an extreme marine diet; average δC13 was -13.7 and δN15 was 19.8 [102]. From the stratigraphy there are 9 radiocarbon dates on natural wood both above and below the skeletal remains, dating the bones to c. 7500-7000 cal BC. These datings in combination with nearby dating of shoreline displacement, show that the find spot was dry land between c. 8000 and 7000 cal BC and that it was up to c. 5 m above the contemporary sea level. Most likely these individuals have been buried on dry land and the graves destroyed by the sea when the site was transgressed and covered by marine sediments. Two other individuals from Hummervikholmen were investigated for ancient DNA by Günther et al. [103].

One sample was successfully analysed for DNA (NEO017). This is a tooth (X82) found close to a cranium (X90) of a male aged 33-45 years.

Literature: Sellevold & Skar 1999[100]; Eggen & Nymoen 2014[101]; Skar et al. 2016[102]; Günther et al. 2018[103]

Poland

Słonowice, Kazimierza Wielka district, site 5, Poland. Cemetery (long barrows)

Krzysztof Tunia & Piotr Włodarczak

A cemetery of the Funnel Beaker culture was excavated in 1979-2012 by Krzysztof Tunia (Institute of Archaeology and Ethnology, Polish Academy of Sciences). The research included the lower part of the southern slope of the upland gently descending to the Małoszówka river. There were discovered 10 tombs (megaxylons, known also as tombs of Niedźwiedź type, corresponding to earthen long barrows in west European terms), as well as a ceremonial square. The singular and (occasionally) double burials were recorded within and outside wooden constructions of tombs. Based on singular radiocarbon dates and typochronological studies, the cemetery is dated to c. 3600-3300 BC. At present, Słonowice is the largest cemetery from the middle Eneolithic period in south-eastern Poland. Two samples were analysed from this site.

NEO640, Feature (grave) No. 12/II. A 2.2 x 0.8 m rectangular grave pit, with a longer axis located in the W-E direction. 1.45 m deep (from the modern surface of the earth). A feature spatially connected with megaxylon No. I - dug into the ditch, from which the soil was taken for the tomb embankment, thus chronologically younger than it. At the bottom of the grave was a skeleton located along the W-E axis. The deceased has been situated in an upright position with arms placed along the torso, head to the west.

NEO641, Feature (grave) No. 10/XXIV. A 2.7 x 1.3 m rectangular grave pit, with a longer axis located in the W-E direction. 1.05 m deep (from the modern surface of the earth). A feature spatially connected with megaxylon No. IV- located about 1 m to the N from its northern edge. Grave equipment - 1 flint flake from the Volhynian flint. At the bottom of the grave was a skeleton located along the W-E axis. The deceased has been situated in an upright position, head to the west. Skeleton partially damaged.

Literature: Tunia 2006[104]; Przybyła & Tunia 2013[105].

Portugal

Gruta do Caldeirão, Tomar, Portugal. Cave site.

João Zilhão

The samples analysed come from Horizon NA2 of Gruta do Caldeirão. This archaeological horizon comprises non-articulated human remains, sheep bones, Cardial-decorated ceramics and other impressed wares intruded into Upper Magdalenian layer Eb, which, due to a post-Pleistocene sedimentation hiatus, formed the cave floor at the time of Early Neolithic funerary activity. Coupled with the analysis of spatial distributions, the physical anthropological study concluded that the set of human remains assigned to NA2 represented four adults and a child, with the dental remains suggesting the possibility of a fifth adult being present. Available dating results indicate that this NA2 ensemble includes individuals buried in at least two different moments, c. 5200-5300 cal BC, and c. 5350-5450 cal BC; the direct dating of the samples analysed here shows that the right temporal R11-8 belongs to the earlier phase and the left temporal Q12-186 to the later phase. Stable isotope analysis of these remains shows that they had a terrestrial diet with no measurable input of aquatic foods, in marked contrast with coeval Late Mesolithic individuals buried in the Muge shell-middens of the Tagus valley, ~60 km downstream. Previous analysis of the mitochondrial DNA preserved in twelve dental samples assigned Gruta do Caldeirão's Early Neolithic humans to haplogroups H (six), H/U (three), U* (two) and V (one), and suggested genetic discontinuity with the region's Mesolithic hunter-gatherer populations (Chandler et al 2005).

Literature: Zilhão 1992; Jackes and Lubell 1992; Zilhão 1993, 2000; Lubell et al. 1994; Chandler et al. 2005; Isern et al. 2017 [106–111].

São Paulo II, Almada, Lissabon, Portugal. Hypogeum.

Ana Maria Silva

In 1989 during repairs in the churchyard of the Old Dominican Convent of São Paulo at Almada (Lisboa, Portugal), a rock cut cave tomb hewn into the limestone was discovered. This hypogeum structure, named São Paulo 2, was used as a collective burial place from the end of the Neolithic until the beginning of the Bronze Age according to the recovered archaeological artefacts. Radiocarbon dating of two human bones indicated a Late Neolithic chronology: 2905–1950 cal BC (UBAR-629) and 2553–2137 cal BC (UBAR-630) with a 95% confidence level [112,113]. The uncovered human remains corresponded to a minimum of 254 individuals (both sexes), 131 adults (>15 years) and 123 non-adults [112,113]. Apart from one non-adult skeleton, all other elements were found disarticulated, due to the burial practice and post-mortem activities that took place inside the cave. Among the more relevant data are the detection of developmental abnormalities in tarsal bones [114] and three adult skulls with evidence of complete trepanation. These were performed by scraping method, and two of

them, with signs of remodelling [115]. The detailed osteological study of this sample has been published by Silva [112,113].

Literature: Silva 2002, 2011, 2012 [112,113,115]

Romania

Schela Cladovei, Danube Gorges, Romania. Settlement with burials.

Dušan Borić

Schela Cladovei, in Romania, is a large, open-air site on an Early Holocene terrace adjacent to the River Danube, c. 67 km downriver from Vlasac. It is situated 7 km below the Iron Gates I dam of the Danube Gorges/Iron Gates area. Discovered in 1964, the first excavations were undertaken by the Romanian archaeologist Vasile Boroneanţ. An area of 127 m long strip was excavated along the riverbank up to 1989. From 1992 onward, a joint Romanian-British research project was co-directed by V. Boroneanţ and C. Bonsall. More recently, A. Boroneanţ has joined as the Romanian project partner. The site covers the Late Mesolithic and Early Neolithic occupation mainly. A large series of AMS 14C dates on animal and human remains places the Late Mesolithic occupation between c. 7200 and 6300 cal BCE, and the Early Neolithic occupation between 6000 and 5600 cal BCE. At least 75 burials, containing the remains of over a hundred individuals, have been excavated from the Schela Cladovei, most of them dating to the Late Mesolithic.

We report genetic data from two individuals with no further stratigraphic details.

Literature: Boroneanţ, V. et al. 1999 [116]; Bonsall 2008[117]; Boroneanţ, A. et al. 2014[118].

Băile Herculane – Peştera Hoţilar, Banat, Romania. Cave.

Dušan Borić

Băile Herculane (The Bath of Hercules), also known as Peştera Hoţilar (The Cave of Thieves), is situated deeper in the hinterland of the Danube Gorges area on the Romanian side, in the Banat region. The site was excavated in 1954–1955, and more intensively in 1960–1961, 1965, 1968–1970, and 1972. It is situated on the cliffs above the Cerna River, one of the Danube tributaries. The deposits of this cave encompass a sequence with Mousterian, Upper Palaeolithic, and Epipalaeolithic/Mesolithic levels (Dinan 1996; Nicolâescu et al. 1957; Mogoşanu 1978). Lithic typology is similar to the site of Cuina Turcului I-II found on the banks of the Danube in the Danube Gorges, with a small assemblage of only c. 100 artefacts. Among the raw materials used were grey radiolarite,

which dominates, followed by red radiolarite, with a presence of several pieces of the Balkan (yellow-spotted) flint. The absence of quartz is notable and among formal tools there are only several microliths (backed bladelet, trapeze, burin). There are numerous fish and mollusc remains, and mammal remains include bear, red deer, and beaver. A cooler environment has been modelled for the Early Holocene occupation phase in the cave on the basis of the presence of rodents and some floral remains. One charcoal measurement (Gr-16978) from Early Holocene levels provides a Mesolithic date: 11,490±75 BP.

We report genetic data from one individual with no further stratigraphic detail, dated to the Neolithic.

Literature: Nicolăescu-Plopșor et al. 1957[119]; Mogoşanu 1978[120]; Dinan 1996[121]; Boroneanţ 2011[122].

Russia

Afontova Gora, Krasnoyarsk, Southern Siberia, Russia. Flat grave.

Mikhail Sablin

Afontova Gora is a complex of archaeological sites located on the left bank of the Yenisei River near the city of Krasnoyarsk, Russia. The complex was first excavated in 1884 by the Russian archaeologist I.T. Savenkov. There are many burial sites from different epochs. Dating of the human bone SR-8482 around 5.3 kya uncal BP, corresponding to the Kuznetsk-Altai culture, Late Neolithic in the Siberian chronology. The sample was personally found by I. T. Savenkov in 1884. Previous aDNA analyses were published by Raghavan et al. [123] and Allentoft et al. ([17], RISE553 and RISE554).

One new sample was analysed: NEO102, SR-8482, dated to 5280±30 uncal BP (UCIAMS-14767).

Literature: Raghavan et al. 2014[123]; Allentoft et al. 2015[17].

Bazaiha village, Krasnoyarsk district, Southern Siberia, Russia. Cemetery.

Mikhail Sablin

Bazaiha Late Bronze Age cemetery is located on the right bank of the Yenisei River near the village of Bazaiha, Russia. As early as 1883-1885 Russian archaeologist I.T. Savenkov excavated a few flat graves at that cemetery. In one of them, a bronze Celt was discovered. Dating of the human tooth SR-8461 around 2.9 kya BP, corresponding to the Karasuk

culture, Late Bronze Age in the Siberian chronology. The sample was personally found by I.T. Savenkov. The material has not been published before.

One sample was analysed successfully, NEO070, SR-8461, individual 4, dated to the Late Bronze Age.

Borovyanka XVII, Omsk region, Russia. Cemetery.

Olga Poshekhonova

The Borovyanka XVII burial ground is located on the bank of Batakovo Lake on the left side of the Irtysh River near the Borovyanka village, Bol'sherechinsk district, Omsk region. The landscape zone is Northern forest-steppe. The site was excavated by L.I. Pogodin in 1999-2001. While description of several burials was published no dedicated publication has been made so far. The site consists of burials dated from the Eneolithic to the Middle Ages. The most numerous are Late Bronze burials which are attributed to Chernozerye culture type [124,125]. About 20 burials which are supposed to be a single Eneolithic complex were dated by the middle of 3rd millennium BC [126]. Most of the burials are single but a few double and collective (up to 8 skeletons) ones were also excavated. The skeletons lay stretched on their back with bent legs and their heads oriented to the North or more rarely to the North-East.

Burials of non-complete skeletons or single skulls as well as a few cases of partly burned skeletons were reported. It was argued that high variability of burial traditions in Borovyanka XVII resulted from multi-ethnicity of Eneolithic society related to the. Based on characteristic artifacts found in graves including the ceramics similar to those of the Ekaterininskaya culture, the Keltiminar fish-like and petal-like pendants, and arrow points the closest analogies can be found in the Khutor Bor IV and Okunevo V-VII burial grounds from the Irtysh region and the burial ground on the Bol'shoy Andreevsky Lake from Tobol region. Three samples are reported here:

NEO080 – grave 83, skeleton E, museum number IPDN 78-19. Morphologically female of 55+ years old. The skeleton was found in a collective grave which consists of 8 or 9 individuals. Only the skull, femurs, left tibia and partially the bones of the foot have survived. Under the skull, pelvis and ankle bones ochre layers up to 3 cm were recorded. The skeleton lay stretched on its back with its head to northeast. An Eneolithic dating was argued and is supported by the 14C date of the skeleton.

NEO081 - grave 69, museum number IPDN 78-52. Morphologically male of 55+ years old. The skeleton was found in a single disturbed burial. The postcranial bones and mandible lay

in the southwest part of the grave while the skull lay separately in the northeast part. A fragment of non-ferrous metal plate was found near the skull and fragments of the Chernozerye and Ekateriniskaya ceramics were found in the grave filling. The grave was dated to the Bronze Age and attributed to Chernozerye culture [126]. The direct dating of the sample (3588±29, UBA-39953) supports a Bronze Age date.

NEO083 - grave 36, Skeleton B, museum number IPDN 78-29. Morphologically male 55+ years old. The burial was found beneath the burial of a child of 7-9 years old (skeleton A). Both skeletons lay stretched on their backs with their heads oriented to the northeast. The long bones and the skull of the child and the adult were partly burned. Also in the child burial the fragmented and partly burned bones of an adult (possibly female) were found. The similarity in funeral ritual of the burials and shell beads found in the graves suggests that all burials belong to the same Eneolithic population and were done in a short period of time [126]. The 14C date of the adult male was UBA-39955, 5433±37 uncal BP, supporting a Neolithic date.

Literature: Khvostov 2001[126]; Polevodov & Shestobitova 2006[124]; Shestobitova 2007[125]

Dolgoe Ozero (Long lake), Krasnoyarsk, Russia. Settlement and graves.

Veselovskaya Elizaveta V. and Vasilyev Sergey

The ancient settlement near the Long Lake is located on the western outskirts of the Kansk city, Krasnoyarsk Territory. From the end of the XIX century and until the beginning of the 1960's, the sand dune in which the burial ground was discovered served as a quarry for the extraction of sand, as a result of which the archaeological site was not completely preserved.

The first archaeological surveys at the Long Lake were carried out in 1909-1910 by the archaeologists of Kazan University, E.A. Popov and A.E. Ermolaev, who collected material here and dated the site to the Early Bronze Age - Iron Age.

In September 1958, in the settlement near the Long Lake, stationary excavations were carried out by the Leningrad archaeologist G.A. Maksimenkov [127]. Two single graves and one double were discovered in the northwestern part of the quarry, which Maksimenkov dated to the early Neolithic, approximately the Isakovo-Serovo period. The graves are located in parallel, forming one continuous row. The skeletons are oriented with their feet towards the lake, not corresponding to the cardinal points. Judging by the surviving remains of the buried, the burial ground has a generic nature, rather than a family one. A piece of ochre was found

by the foot bones of one of the skeletons; a flake was inserted into the hand of another buried. No other archaeological finds were found in the graves.

The main archaeological material from the locality was obtained as a result of collections on its surface, mainly in the northern part of the site:

• 1. Up to eleven types of stone arrowheads.

• 2. Scrapers on flakes of random shapes.

• 3. Two micro chisels.

The nature of archaeological material finds analogies with Western regions, largely repeating the finds in the areas of the Krasnoyarsk district.

In anthropological terms, the population that left the burial ground was characterised by a combination of Caucasoid and Mongoloid traits. The only whole skull (sampled here as NEO 292) is massive, with a very high and wide flattened face. Zygomatic bones are very large, canine fosses are very weakly expressed. The lower jaw is massive with expanded rami. The skull was determined to belong to an adult male, ca 40-45 years old. It was dated to 5448±41 uncal BP, UBA-40027.

Literature: Maksimenkov 1964[127]

Fofonovo, Baikal region, Russia. Cemetery.

Vasilyev Sergey & S. B. Borutskaya

For the first time, skulls from the Fofonovsky burial ground were published by G.F. Debets [128]. At his disposal were only 4 skulls from the excavations of M.M. Gerasimov of 1934 and 1936, which discovered over 40 burials of the Eneolithic and developed bronze. Studies of the Fofonovsky burial ground were continued by A.P. Okladnikov, who headed the Buryat-Mongolian expedition in 1948 - 1952. In 1959, M.M. Gerasimov, as part of the Irkutsk expedition under the leadership of M.P. Gryaznov, the excavations of the Fofonovsky burial ground were resumed.

The continuous excavation in the eastern part of the burial ground made it possible to open 41 burials belonging to three stages or cultural complexes. These excavations made it possible to make valuable stratigraphic observations, which contributed to the fact that all burials, regardless of the availability of accompanying dating equipment, could be divided into three stratigraphic and chronological groups - Kitoysky, Glazkovsky and, possibly, Shiversky.

The most interesting materials were given by the burials of Kitoyan association - jewellery made of shells and teeth of wild boar and maral, bone daggers with silicone inserts, various stone and bone tools found in the grave usually in a bundle or in heaps. Burials are characterised by abundant backfilling with ochre. In 1988, at the Fofonovsky burial ground, excavations by archaeologist V.P. Konev. For one of the burials, a radiocarbon age of 6600 ± 100 years is given. Already in our time, the excavations of EA Zhambaltarova in 2007 - 2008 provided paleoanthropological material from several other Kitoyan burials.

Three individuals are reported here, all dated to the Early Neolithic, ca 6800-7000 uncal BP (osteological determinations are not available):

NEO199, burial 10

NEO200, burial 2(2)

NEO201, burial 7(5)

Literature: Alekseev and Gokhman 1984[129]; Gerasimova 1992[130], Vasilyev et al. 2010[131].

Golubaya Krinitsa, Middle Don, Russia. Cemetery.

A.M. Skorobogatov

The site was discovered in 2011 by Valery Berezutsky [132]. The burial ground is located on the right bank of the Black Kalitva River (a tributary of the Don River), near its mouth. Excavations were carried out in 2015-2016 under the leadership of Andrey Skorobogatov. A total of 18 burials were studied (single, paired and collective).

The burials were in rectangular pits, characterised by orientation to the south - southeast and southeast. The position of the buried is stretched out on the back, with arms located along the body. The bones are sprinkled with red ochre.

The burials were accompanied by inventory: fossil sea shells, Unio shells and products from their wings, bone decorations (wild boar fangs, beaver teeth and groundhogs), bone tools, a copper product, flint tips, flint knives, and ceramics.

The complex finds analogies in the Mariupol-type burial grounds widespread in the territory of modern Ukraine (Mariupol, Nikolsky, Lysogorsky, Yasinovatsky burial grounds), and can date back to the 6th millennium BC.

Six samples were analysed, with datings ranging ca 6400-6700 uncal BP, corresponding to c. 5000-5400 cal BC:

NEO113, kurgan 10, burial 10

NEO204, burial 4

NEO207, burial 7 skeleton 2

NEO209, burial 7 skeleton 4

NEO210, burial 8

NEO212, burial 10

Literature: Berezutsky et al. 2011[132].

Itkul (Bol'shoy Mys), Altai region, Russia. Cemetery.

Marina Rykun & Vyacheslav Moiseyev

The Itkul' burial ground is located in the Altai lowland area between Pleshkovo and Vershinino villages, Zonalnoe district, Altai region. The site is situated on the top of the Bol'shoy Mys (Big Cape) of Itkul' Lake. In the Neolithic-Eneolithic times the cape would be separated by water from the mainland.

16 burials arranged in 3 rows were excavated by B.Kh. Kadikov in 1962. Earlier one or four skeletons were excavated by a local amateur. All buried lay stretched on their back, heads oriented to North-East. The burial inventory is scarce and found mostly in the male burials. Few pendants made of animal teeth were found in both male and female burials. No ceramics were found. At present time the burial ground is attributed to Bol'shoy Mys Eneolithic culture [133].

NEO063 - burial 2, morphologically male of 30-35 years old [134]. Burial inventory included a stone axe, flake and polished bar. Several deer and bear teeth were found in the neck zone of the skeleton. It was dated to 6656±34 uncal BP, UBA-39940.

NEO064 - burial 8 (doubled with burial 7), morphologically female of 25-35 years old [134]. Burial inventory included stone rod of the fishing hook, several beaver and marmot teeth and pendants made of deer and roe deer, two gypsum «roses». The skeleton was dated to 5744±41 cal BP, UBA-39941.

Literature: Dremov 1980[134]; Kiryushin et al. 2000[135]; Kiryushin 2002[133].

Karavaikha, Vologda region, Russia. Cemetery.

Alexandra Buzhilova

The site of Karavaikha was located on the right bank of the Eloma River, which flows into the Lake Vozhe from the west (Kirillovsky District, Vologda Region). Since 1938, during seven field seasons, this site was excavated by Bryusov [136]. A total of 38 burials were opened. Now bone remains from the excavations of 1938 and 1939 are housed in the Museum of Anthropology of Moscow State University (22 burials).

The burials discovered in 1938 were mostly destroyed. Nevertheless, it was possible to establish that there were remains of adult individuals only, most of them buried on their backs with the head oriented to the south. In one burial (No. 7, #8623), the remains were in a sitting position. All burials were single, except for grave No. 2, in which there were remains of two individuals. Part of the skeletons was covered by ochre (No. 2-7, 9-11).

Excavations of 1939 gave a greater number of burial options. So, in addition to human remains on the back (No. 12, 15-18), there was a person lying on the right side (No. 21) and one individuals was in a sitting position (No. 13, #8761). The bodies of the buried were oriented with their heads to different parts of the world (to the south, north and west). In addition to adults, a teenager (No. 17) and two children (No. 15, 18) were buried. Some of the skeletons were covered by ochre (No. 12, 14, 15, 18 and 22).

Bryusov stressed that burials 1 (#8624), 3 and 11 (#8625) could be the earliest in this part of the excavation; and the rest of the burials were from later time. In the early years of the excavation, Bryusov established the chronological difference in the burial complex of Karavaikha, dating it from the late Mesolithic to the Eneolithic [136]. This was partially confirmed by attempts of radiocarbon analysis (#8624 burial 1 - 8200 ± 50 GIN-7173, #8622 burial 6 - 4420 ± 50 GIN-7172 and #8623 burial No. 7 - 6880 ± 90 GIN-7176) [137]. In the present project, the datings were concentrated to around 7700-7500 uncal BP. This applies also to burial 6, which was redated (Supplementary Table IV).

Anthropological studies have shown the heterogeneity of the series, which could be associated with use of the burial complex for a long time; researchers also note a mixture of craniological complexes [138,139].

Sampled individuals:

NEO559: 8622 – burial 6, M, Adultus

NEO556: 8623 – burial 7, M?, Adultus2-Maturus, healed skull trauma

NEO555: 8624 – burial 1, M, Maturus2-Senilis

NEO557: 8625 – burial 11, M, Maturus2-Senilis, healed skull trauma

NEO558: 8761 – burial 13, M, Adultus 1

NEO560: 8762 – burial 20, M?, Maturus 2, healed skull trauma

NEO561: 8763 – burial ?, F?, Maturus 2- Senilis

Literature: Akimova 1953[138]; Gerasimov 1955[139]; Bryusov 1961[136]; Utkin & Kostyleva 2001[137].

Kostenkova Izbushka, Altai region, Russia. Cemetery.

Marina Rykun & Vyacheslav Moiseyev

The Kostenkova Izbushka burial ground is located on the opposite shore to the Itkul' site of Itkul' Lake. The site was excavated by Y.F. Kiryushin in 1981. Two of three excavated burials were attributed to the Eneolithic Bol'shoy Mys culture.

NEO065 - burial 5, morphologically male of 30-40 years old. The individual was killed by an arrow shot from a close distance. The bone arrow found at the head base destroyed several frontal teeth, went through the larynx and stuck at the cervical vertebrae. The burial inventory included fragments of ceramic vessels and two beaver maxillas. The skeleton was dated to 4516±33 uncal BP, UBA-39942.

Literature: Kiryushin et al. 2000[135].

Kumyshanskaya cave, Ural, Russia

Pavel Kosintsev and Yu. Serikov

This karst cave is located on the bank of the Kumysh River in the Middle Urals (57.58 N 58.20 E). The entrance to the cave measuring 3 x 4 m is located at an altitude of 4 m from the river level. The length of the cave is 9 m, the width is 2 m, and the height is up to 5 m. Excavations were carried out in 1998-2000. The excavation area is 17 m2.

The cave deposits consist of 4 layers (from top to bottom): a layer of humus, a layer of black sandy loam, a layer of brown loam, a layer of brown clay. In layers 2 and 3, artefacts from

the Middle Ages, Iron Age, Bronze Age, Eneolithic, Neolithic and Mesolithic were found. Upper Palaeolithic artefacts have been found in the upper horizon of layer 4. In layers 1, 2 and 3, bones of a mountain hare (*Lepus timidus*), squirrel (*Sciurus vulgaris*), beaver (*Castor fiber*), wolf (*Canis lupus*), marten (*Martes martes*), brown bear (*Ursus arctos*), elk (*Alces alces*), reindeer (*Rangifer tarandus*) (about 2000 specimens) were found. In layer 4, bones of mountain hare (*Lepus timidus*), bobak (*Marmota bobak*), wolf (*Canis lupus*), arctic fox (*Vulpes lagopus*), mammoth (*Mammuthus primigenius*), horse (*Equus ferus*), woolly rhinoceros (*Coelodonta antiquitatis*), reindeer (*Rangifer tarandus*), bison (*Bison priscus*), saiga (*Saiga tatarica*)(more than 500 specimens) were found.

A radiocarbon date of 12,430±260, SOAN-4846, was obtained from the mammoth bone from the upper horizon of layer 4, and a radiocarbon date of 33,670±300, OxA-10929 was obtained from the lower horizon of layer 4 from the woolly rhinoceros bone.

In the part of the cave farthest from the entrance, at a depth of -0.3 -0.4 m, there was a cluster of human bones (more than 100 specimens). It had an oval shape measuring 0.3 – 0.6 m x 2.0 m. The bones were covered with ochre. Bones of 2 foetuses 7 – 9 months old, 2 newborn individuals (skull bones, pelvis, ribs, tibia, femur, humerus and radius bones) and bones of 3 adult individuals (skull fragments, ribs, metapodia, phalanges), probably women: 2 adults (over 30 years old) and one young (20 – 25 years old) were found. A radiocarbon date of 4 635±85 uncal BP, SOAN-5155, was obtained from the bones of adult individuals.

In this project, one sample was analysed for DNA: NEO687, 910/2456, Kumyshanskaya 2. This is a cranial fragment from a small child (inf I). It was dated to 4922±47 uncal BP, UBA-40107.

Literature: Serikov 2004[140], 2013[141].

Ksizovo 6, Lipetsk, Russia. Settlement and burial ground.

R.V. Smolyaninov & S.B. Borutskaya

The archaeological complex of Ksizovo 6 was investigated by R.V. Smolyaninov in 2004-2005, two excavations with a total area of 253 sqm [142]. It combines the features of a settlement and a burial ground of the Neolithic-Bronze Age periods. Located near the village of Ksizovo, Zadonsky district, Lipetsk region at the confluence of the river Don with its right tributary river Snova. The site is located on a flat surface with a height of about 5.5-6.0 m above the river edge at the foot of a steep ledge of the root bank of the Don River with a height of 20-25 m.

As a result of the excavations, a ceramic collection was obtained from several hundred vessels of the Neolithic-Bronze Age epochs dating from the second half of the VI - II millennium BC. The site has cultural strata varying from 1 to 2 metres thick. In both excavations, burials were revealed. In total, the remains of 17 individuals from 15 burials were studied from them: 6 men, 5 women, and 6 children. Anthropological definitions made by S.V. Vasilyev and S.B. Borutskaya [143].

Based on the analysis of the studied burials, we believe that the flat burials were left by the population of three archaeological cultures. Elongated burials with a northern and northeastern orientation date back to the Neolithic era and to the first quarter of the VI millennium cal BC. The Srednestogovskoy culture of the Eneolithic era includes elongated and shortened burials, which date to the 1st half of the 5th millennium BC (cal. BC). To the Catacomb culture of the Bronze Age, middle of III millennium BC, one crouched burial 3 from excavation site 2 belongs.

Four samples from three burials were analysed:

NEO172, burial 4. Neolithic, dated to 6181±47 uncal BP, UBA-39984.

NEO173, burial 2 skeleton 1. Sredny culture, dated to 5789±34 uncal BP, UBA-39985.

NEO174, burial 2 skeleton 2. Sredny culture, dated to 4865±33 uncal BP, UBA-39986.

NEO175, burial 3. Catacomb culture, dated to 4032±34 uncal BP, UBA-39987.

Literature: Lavrushin et al. 2009[142]; Vasilyev et al. 2018[143].

Mergen' 6, Tumen region, Russia. Settlement

Olga Poshekhonova & Svetlana Skochina & Dmitri Enshin

The Mergen' 6 multilayer settlement is located on the bank of Mergen' Ishim district, Tumen region, Russia. The landscape zone is defined as the forest-steppe of West Siberia. The site was excavated by V.A.Zakh in 1990; in 2002, 2004 and 2013 by S.N. Skochina and D.N. Enshin. The Neolithic settlement consists of 13 buildings arranged in a semi-circular complex adjusted to the cape form [144]. Based on dating of different materials including (animal horn and bone, human bone, ceramics of Boborykino and Koshkino types, and ceramic soot) the dating of the settlement was defined as the last quarter of the 7 millennium BC (Piezonka et al, 2020) which corresponds to the Early Neolithic period.

NEO072 (museum number IPDN 116-1) - morphologically female of 30-45 years old. A fragment of the female skull was found in hut 15 near a hearth together with a tool for making

bast shoes, and several crushed animal bones. On the opposite side of the hearth a skull of a dog was found. This finding was identified as the evidence of ‘building sacrifice’, which is characteristic to Koshkino and Boborikino cultural traditions [144]. The earlier obtained dating OxA-33489 7355±40 BP, 6361-6086 cal BCE (δ15N+15.3‰, δ13C -20.15‰) is close to the dating of based on animal bones and ceramic soot found in the hut; (Poz-94074 7060±50 BP and Poz-98334 7270 ± 50 BP) [145].

NEO073 (museum number IPDN 116-2) - a child up to 1 year old (genetically female). The burial of the child was found in hut 21. The pit grave (0,55×0,25×0,1 m) was dug into the pit floor of the house by 0.1 m. The skeleton of good preservation lay on its stomach with the arms stretched along the body oriented from North to South. No artefacts were found in the grave. The sample was dated to 7317±62 uncal BP,

Both samples have been genetically studied earlier [146].

Literature: Enshin 2012[147]; 2014[144]; Piezonka et al. 2020[145]; Narasimhan et al. 2019[146].

Minino I and II, Vologda region, Russia. Cemetery.

Alexandra Buzhilova

Minino I and Minino II are two Mesolithic-Neolithic burial complexes, which were excavated on the bank of Kubenskoe Lake during a few seasons from 1996 by an archaeological expedition of the Institute of Archaeology, RAS. The Kubenskoe Lake is a large water-pool of glacier origin situated to the south from latitude 60° North in European Russia (Vologda region). Around 170 archaeological sites have been registered in the area (from the Mesolithic to Early Mediaeval time). There were not too many convenient places to settle near the marshy sides of the lake; therefore, those suiting habitation were settled repeatedly. The Mesolithic materials originate from 10 sites and 4 of them are from the archaeological complex Minino, which was represented both by artefacts and 2 of them represented by human remains [148].

The burials are located on the elevated edge of the modern floodplain terrace. The distance between the excavations of these two sites is 230 m. The orientation of the graves prevails along the edge of the terrace, along the southeast-northwest line, parallel to the shore of a lake.

Minino I and Minino II burials were revealed in the Mesolithic cultural deposit. These are several groups of asynchronous burials (among them 22 single burials, 5 paired burials and 2 triple ones) [149]. Some burial goods point toward parallels to the local Veret’e and Butovo

archaeological cultures. However, the majority of objects and a radiocarbon analysis suggest a wide chronological span from the Mesolithic until the Early Neolithic [150,151].

The anthropological materials (39 individuals), which were studied in bioarchaeological context, provided the basis for a detailed reconstruction of lifestyles. The indicators of physical activity demonstrate the general picture of occupational stress matched to known cases of hunter-gatherers. A series of male skulls from Minino indicates undoubted analogies with the synchronous population of the nearest territories of northern-eastern Europe and partly represented anthropological complexes of Late Palaeolithic and Early Mesolithic hunters. In the early stages of the development of the region, the population demonstrates high life expectancy; and the mean age at death decreases in the final chronological period [152]. Isotopic analysis of human bones gives the data of diet changing over time [153]. These data could well mirror some biological and cultural changes over time.

Four samples were analysed, three of which dated to the Mesolithic and one to the Late Bronze Age:

NEO536, Minino II, burial 2 skeleton 2. Adult female?, dated to the Mesolithic

NEO537, Minino I, burial 3. Adult male, dated to the Mesolithic

NEO538, Minino I, burial 16. Adult male, dated to the late Bronze Age

NEO539, Minino I, burial 20, Adult male, dated to the Mesolithic

Literature: Makarov 2001[148]; Suvorov & Buzhilova 2004[149]; Wood 2006[153]; Suvorov 2007[150]; Wood et al. 2013[154]; Buzhilova 2016[152].

Okunevo 5 and 7, Omsk region, Russia. Cemetery.

Olga Poshekhonova

The Okunevo 5 and 7 burial grounds are located on a narrow cape formed by the Tara and Irtysh rivers; Murmantsevo district, Omsk region, Russia. In terms of the landscape, the territory belongs to the subtaiga zone of Western Siberia. Only ground graves and ritual places but no settlements were found in the vicinity.

The multi-layer site of Okunevo 5 consists of a sacrificial place and a cemetery. The site was found by V.A. Mogilnikov and was excavated by B.A. Konnikov, V.A. Mogilnikov and V.I. Matyushchenko in 1976, 1981 and 1987-1989 respectively. The cultural layers date from the Neolithic to the Middle Ages.

The Okunevo 7 burial ground directly adjoins the Okunevo 5 site. It was excavated by A.I.Petrov, V.I. Matyushchenko and V.A. Mogil'nikov in 1980's and 1990's. Burials dating from Neolithic to the Middle Ages were studied at the site.

For genetic analysis, Eneolithic-Early Iron Age samples (the end of the 3rd – first part of the 2nd millennium BP) from both sites have been taken. The close location of these graves suggests that all of them belong to a single cemetery which was artificially divided by its excavators in two sites. The graves were arranged in rows divided by at least six deep ditches of uncertain dating. All samples belong to the first (earliest) group of burials but their cultural attribution was not fully defined. At least a part of the graves of this group of burials belongs to the Ekaterininskaya culture [155,156]. Because most artefacts were found between graves they can obviously be defined as funeral offerings.

Three samples were analysed, all dated to the Eneolithic, ca 4500-4700 uncal BP:

NEO068 - burial 62, morphologically male 20-21 years old. Grave size is 170x75 cm, oriented from North to South. The artefacts found in the grave include 40 horn beads, a bronze pendant and a piercer, and a ceramic tetrahedral flat-bottomed vessel, decorated by comb ornament [155].

NEO077 - burial 66, morphologically male, 40-45 years old. Grave size 160x80 cm, the skeleton oriented from North to South lay stretched. The skull lay on a sand "pillow" 8-10 cm high. Ochre spots were found near the skull and between the femurs. In the North-East part of the grave a fragment of a wooden cylindrical item with a diameter of 5 mm and a length of 3 cm was found [155].

NEO079 - burial 69, morphologically female, 18-20 years old. The grave pit was traced along a spot of humus soil. It had a rectangular shape, 220x90 cm and a depth of 80 cm. The skeleton was covered with wooden chopped blocks. Their thickness varied from 25 cm to 10-15 cm, the width was 10-20 cm. A thin layer of ocher was poured over the entire area occupied by the bones. A poorly preserved skeleton of a newborn child lay between the tibias of the adult. A large quartzite scraper was found near the right arm of the adult, a scraper-knife of the same material was on the left. A ceramic ball and two fragments of ceramics are also found here [155].

Literature: Matyushchenko & Polevodov 1994 [155]; Petrov 2014[156].

Omskaya Stoyanka (Omsk settlement), Russia. Settlements and cemeteries.

Olga Poshekhonova

The complex of archaeological sites usually referred to as the ‘Omsk settlement’ is located in the city of Omsk on the left bank of the Irtysh River, Russia. In the Neolithic the site was on a small island. From the landscape point of view this is the forest-steppe zone of Western Siberia. The site includes several settlements and burial grounds. The burial complexes are dated to the Neolithic and Bronze Age.

The site was discovered in 1918 by C.A. Kovler. Since then a number of excavations have been done [157]. In 1998 B.A. Konnikov excavated five burials. Three of them were severely destroyed while two were not disturbed. These grave pits partly overlapped each other.

NEO075 - (grave pit1, skeleton 2) morphologically female of 20-25 years old. Few artefacts including two wolverine drilled canines, two small stone knives, and a flake were found in the grave. Direct carbon dating has been done earlier - 6656±50 BP (UBA-23603). A new date was almost identical, 6654±40 uncal BP, UBA-39947.

NEO078 - (pit grave 2, skeleton 3) morphologically male of 25-30 years old. The pit grave was 10 cm deeper than grave 1 and partly overlapped it. No artefacts were found in the grave. Direct dating was 6560±49 uncal BP, UBA-39950, i.e. slightly younger than NEO075.

Both skeletons lay stretched in anatomical order with their heads oriented to the Irtysh River from South to North or North-East. Archaeologically the burials were dated to the 4th millennium BC [158]. Albeit no cultural attribution has been proved for these burials, some similarity with Sopka 2 was nevertheless declared [159].

Literature: Metel’ 2016[157], Konnikov 1998[158], 2013[159].

Ostrov 2, Tumen region, Russia. Cemetery.

Olga Poshekhonova & Svetlana Skochina

The Ostrov 2 Eneolithic sanctuary is located in the Iset’ River basin (Tobol tributary); Yalutorovo district, Tumen region, Russia. The site was excavated by A.V. Matveev in 1995. The sanctuary consists of several clusters of pits. In two pits human remains were found (pits 3 and 4). The site is attributed to the Eneolithic comb ceramics of Shapkul' culture of local South Ural origin [160].

NEO076 – child, 7-8 years old. The child skeleton was found in an oval pit 3 (3x0,98 m) which is one of the central pits of the sanctuary. Close to the child remains a mandible fragment of a female, 18-20 years old, and fragments of femur and tibia which possibly belong to the same individual were also excavated. The only artefacts found in the grave are

a scraper made of pink flint and a jasper blade [160]. The sample was dated to 4225±29 uncal BP, UBA-39948.

Literature: Matveev et al. 2015[160].

Pad' Tokui, Krasnochikoysky region, Russia. Cemetery.

S. V. Vasilyev & S. B. Borutskaya

The Neolithic burial grounds of Zjindo and Pad' Tokui are located on the territory of the Krasnochikoysky region of Western Transbaikalia, in the Chikoi river basin (the eastern part of the Selenga river basin and Lake Baikal). Now mountain taiga biotopes are common there. Excavations were carried out mainly in 2004-2005 by the Chikoy archaeological expedition of the Trans-Baikal State University under the direction of M.V. Konstantinov [161].

Pad' Tokui burial ground is located in the Daur Highlands on the left bank of the Menza River, 7 km south-west of the village. Menza on a gentle slope of a hill, on the site of an old abandoned arable land. This place rises more than 900 m above sea level. The monument is a flat burial ground. In 2005, two burials were discovered and excavated.

One sample was analysed, from burial 2 (Zhindo 6/NEO116). It was dated to 7378±72 uncal BP, UBA-33757.

Literature: Konstantinov et al. 2005[161]; Vasilyev et al. 2018[143].

Peschanitsa, Archangelsk region, Russia. Burial(s).

S. V. Vasilyev & S. B. Borutskaya

In 1986, during archaeological research of the Mesolithic site in the Peschanitsa area, located 800 m from the modern shore of Lake Lacha (Kargopolsky district of the Arkhangelsk region), S.V. Oshibkina discovered the skeletal remains of an ancient person. In a quarry that destroyed the site, a skull was discovered (object 1). Near this location, in the excavation, bones of the thoracic region, pelvis and fragments of bones of the upper extremities were found. At a distance of 1.5-3 m, at a depth of 60 cm from the modern-day surface, a pit with only leg bones was found (object 2). The bones lay on a thin layer of white clay and were abundantly covered with red ochre. They were accompanied by fragmented animal bones and three flint flakes. Small coals are marked in the clay layer.

All this, according to the author of the excavation, suggests that the burial of the legs was not accidental. The skull and the other bones may possibly belong to one and the same person.

The appearance of the material remains of the Peschanitsa site and the features of the funeral rite make it possible to attribute it to the Mesolithic culture of Veretye, as well as the Popovo burial ground, and several settlements located near Lacha and Vozhe lakes.

The skull, sampled here as NEO202, was previously dated to 10728±50 BP uncal, UBA-41633, and the leg bones to 9890±120, GIN-4858 [18]. A new dating of the skull resulted in the date 10030±56 uncal BP, UBA-40011. This makes it more likely that the skull and leg bones are contemporary.

Literature: Oshibkina 1997[162]; 1998[163]; 2017[164]; Mamonova 1995[165]; Saag et al. 2021[18].

Pogostishche I, Vologda region, Russia. Cemetery.

Alexandra Buzhilova

The site was discovered by A. Ya. Bryusov in 1938. A scientific paper was published in 1951, in which the author mentions that the site of Pogostishche 1 is located opposite the confluence of the Ukhtomka River and the Modlona River near the village of Pogostishche, Charozersky district, Vologda region [166]. Only one skull of a juvenil woman is stored in the Museum of Anthropology, Moscow State University.

Modern researchers note that the site is located on the floodplain terrace – a relatively high and dry place. There are very few such places in the basin of Lake Vozhe, which explains the high density of archaeological sites in the area. Nowadays, almost two dozen archaeological sites are known. They were discovered and partially explored in different years by A. Ya. Bryusov, S. V. Oshibkina, N. A. Makarov, and N. V. Kosorukova. Since 2002, the Stone Age sites have been systematically studied by the archaeological expedition of the Cherepovets State University [167].

Information about the site of Pogostishche 1, presented by Bryusov, is extremely fragmentary. There is no information about the methodology of excavation; only a schematic plan of the location of the excavation is presented, subsequently published by Oshibkina [168]. Bryusov notes that the artefacts were in the sand. Oshibkina, who checked the stratigraphy of the site, writes about the same. Bryusov reports that the findings were not numerous: in the excavation there were found tools made of bone and stone, including 6 scrapers from large flakes, a fragment of a leaf-like flint tip of a dart, a fragment of a knife-like plate, 2 flint retouchers, 4 nucleuses, half of the stone disc-shaped top of the club with a hole in the middle, a bone awl 16.5 cm long, a fragment of the second awl, a fragment of a bone

harpoon, a fragmented horn clutch of an axe, a bone arrowhead with a biconical head [166]. Also animal bones, flakes and fragments of flint, slate and quartz were found.

Bryusov suggested that the site of Pogostishche 1 should be dated no later than the end of the 4th millennium BC. According to Oshibkina, the site of the Pogostishche I can be compared with the site of Lower Veretie I (to the conditions of the cultural layer, as well as by the characteristics of the finds), and should be dated to the Boreal period [169]. According to Makarov, the site does not represent a pure Mesolithic complex, since pit-comb ceramics and smooth-wall ceramics of the Iron Age were found in the pits in the upper layer [170].

A sample from the single skull (NEO554) was analysed here. The skull was determined as belonging to a young female individual. It was dated to 7472±42 uncal BP, UBA-40069.

Literature: Bryusov 1951[166]; Oshibkina 1983[169]; Makarov et al. 2001[148]; Oshibkina 2006[168]; Kosorukova 2012[167].

Protoka, Novosibirsk region, Russia. Cemetery.

Veselovskaya Elizaveta V. & Vasilyev Sergey

The Protoka burial ground is located in the Kyshtovsky district of the Novosibirsk region. Under one of the 9 mounds from the Early Iron Age, 14 Neolithic burials were revealed, in which 26 people were buried.

According to the state of the bones in the Neolithic part of the burial ground, scientists conclude that the burials are secondary. Apparently, the dead were first kept in an open place, possibly in the winter. This may explain the absence of some bones that animals could pull apart. Then the dead were reburied in groups of up to 8 people, laying everyone with their heads to the northwest.

N.V. Polosmak, the excavator of the Protoka burial ground, attributed its Neolithic part to the Middle Irtysh culture. Later V.I. Molodin attributed it to Verchne-Obskaya Neolithic culture.

The study of craniological material shows the presence of Mongoloid complex features.

One individual was sampled (NEO309, burial n19).It was dated to 5575±36 uncal BP, UBA-40035. Data for morphological age and sex is lacking from this individual.

Literature: Troitskaya & Novikov 2004[171]

Sakhtysh, Ivanovo region, Russia. Settlements and cemeteries.

Veselovskaya Elizaveta, Vasilyev Sergey & Kostyleva Elena

Sakhtysh, a unique complex of 15 archaeological settlement and cemetery sites, is located in the centre of the Russian Plain in the Teykovsky District of the Ivanovo Region at the source of the Koyki (Kiyki) River from the Sakhtysh Paleolake. Chronological range of the multilayer settlements: early Mesolithic - Middle Ages; burial grounds: Neolithic - Eneolithic.

Burials of that time were found at the Sakhtysh I, II, IIa, VII and VIII sites. They were inhumated into the ground.

Neolithic burials belong to the Lyalovo archaeological culture (Middle Neolithic). People who came from Northern Europe (Karelia, Finland) took part in the formation of this culture. This is confirmed by specific features of material culture and anthropological type of sculls (Kostyleva, Utkin. 2019). Burials of the Eneolithic epoch belong to two phases of the Volosovo culture. Burials of the early phase possess some links with Eastern Baltic region, such as numerous amber decorations from the area of Lake Lubanos (now in Latvia) in the male burials, as well as the anthropological type of people characteristic of the Baltic zone. In the burials belonging to the late phase of the Volosovo culture, the eastern direction of cultural connections may be traced, in particular, the presence of serpentine stone ornaments in female burials, deposits of which are known near the South Urals. Perhaps this is due to exogamous marriages [172–174].

The dating of the Ljalovo burials is about 5000 years BC, the earliest Volosovo is c. 4000 BC, and the latest c. 3500 years BC [175,176].

Sakhtysh II

The archaeological site Sakhtysh II was discovered by Prof. D.A. Krainov in 1962. Excavations of the Sakhtysh II site were carried out during 14 field seasons (1962-1964, 1966, 1978-1982, 1984-1987, 2001). During this period, 23 burials were excavated, located on an area of 1500 square metres. The burials are clearly subdivided into two cultural and chronological groups: Lyalovo (4 burials) and late Volosovo ones (19 burials).

The Lyalovo burials have a North-South orientation with slight deviations. The burial ground of the Volosovo culture does not have a clear structure; the orientation of the burials is different. Single burials prevail, but there are also some group burials: in two graves there were 4 people each and in another one - 18. In a number of burials, traces of violent death were noticed.

Most of the ornaments found in the Volosovo burials at the Sakhtysh II site were made of bone. The second largest type of ornaments is pendants made from animal teeth. They were

mostly from dog teeth. Amber ornaments are scarce. Basically, these are pendants, several buttons and rings. There are also stone pendants in burials.

In addition to human burials, three burials of dogs were discovered. Burials of dogs are chronologically linked to the Volosovo layer. There is reason to consider dog burials as a kind of ritual.

Three samples were analysed from this site:

NEO158, burial 4; Burial 4 (excavation of 1963) was collective: it contained three males (skeletons # 2, 3, 4) and one female (skeleton # 1). The male skeletons had no skulls, while the female skeleton had a skull. Thus, a tooth for analysis could only be taken from a woman's skull. The woman was determined to be 16-18 years old [172 Table 2]. Determination of sex and age was carried by Prof. G.V. Lebedinskaya, who personally participated in the excavations. The burial belongs to the late Volosovo culture. However, it was genetically determined as a male (SI table I).

NEO178, burial 12. Adult male (late phase of Volosovo culture)

NEO192, burial 19. Adult male (Lyalovo culture).

NEO192 was dated to ca 6200 BP uncal. while the three others were c. one millennium later.

Sakhtysh IIA

The archaeological site Sakhtysh IIA was opened by D.A. Krajnov and E. Kostyleva in 1986. Excavations at the site continued intermittently for 11 years (1987 - 1994, 1999, 2004, 2015), six of which D.A. Krainov personally supervised [177].

As a result of excavations on an area of 824 m2, 72 burial sites were discovered: 57 classed as Volosovo and 15 classed as Lyalovo [172].

An analysis of the planigraphy of burials revealed the structure of both burial grounds and the sequence of burials. Representatives of Lyalovo culture buried their dead in the north-south direction, parallel to the river in a position stretched out on their backs, less often on their stomachs. Representatives of Volosovo culture oriented the dead with their heads toward the river (to the south-west), in a position stretched out on their backs. A study of the stratigraphy of the Volosovo graves and the decorations made it possible to divide the burials into early and late. Early phase male burials were accompanied by amber ornamentation from the Eastern Baltic region (Lake Lubanos area) and lay at a greater depth (30-50 cm from the present surface). Late burials were located less deep (15-30 cm from the present surface) and were accompanied by decorations made from animal teeth, bone and stone.

Serpentine stone decorations were found in female burials of this phase. This allows us to propose the eastern direction of communications - up to the Ural Mountains.

Anthropological studies of the materials were carried out by G.V. Lebedinskaya, T.I. Alekseeva, V.N. Fedosova (Philbert), M.V. Dobrovolskaya (Kozlovskaya). Sex-age determinations and craniological measurements were made, the chemical composition of bones was studied, and nutritional preferences were revealed. G.V. Lebedinskaya performed a number of graphic and sculptural reconstructions of the external appearance of the bearers of the Ljalovo and Volosovo cultures, which clearly demonstrated their differences [178,179].

It is worth paying attention to burial # 11. The date of burial makes it possible to reconsider its cultural affiliation. It clearly "drops out" from the dating of the Lyalovo burials from Sakhtysh IIa (burials # 40 and 42) and Sakhtysh II (burial # 19). The funeral ritual is also unusual: a young woman is buried in a strongly crouched position on her left side, with her head facing east (with a slight deviation). Its attribution to the Lyalovo culture was based only on the position of the skeleton below the level of the cultural layer in the natural soil ortsands [172]. The funeral ritual noted in burial 11 is characteristic of the cultures of the Bronze Age, including the Fatyanovo culture, which replaced Volosovo on the territory of this culture. Women of this culture were buried on their left side with their heads pointing east [180]. The dates of the Fatyanovo culture available in modern literature determine the time of its existence between ~2880 (2750) and 2500 (2300) CalBC, pre-Fatyanovo refers to ~3000–2550 CalBC [181,182]. However the absence of any burial inventory in the grave gives the ability to accurately determine its cultural identity. It is obvious that this burial does not belong to the Lyalovo culture.

14 samples were analysed successfully, detailed in Table S7.2.

Sample no	**Context**	**Material**	**Labno**	**BP uncal**	**1s**	**Sex**	**Age**
NEO179	Grave 13 skel 2	tooth	UBA-39991	4919	30	female	50-60
NEO180	Grave 36 (lower)	tooth	UBA-39992	5314	34	male	20-25
NEO181	Grave 58	tooth	UBA-39993	5328	39	female	40-45
NEO182	Grave 46	tooth	UBA-39994	4767	35	female	20-25
NEO183	Grave 33	tooth	UBA-39995	5011	35	male	50-55

NEO185	Grave 40	tooth	UBA-39997	6393	39	male	50-60
NEO186	Grave 42	tooth	UBA-39998	6317	91	male	20-25
NEO187	Grave 11	tooth	UBA-39999	4616	38	female	20-25
NEO188	Grave 9	tooth	UBA-40000	4916	35	male	50-55
NEO189	Grave 39	tooth	UBA-40001	5157	35	male	30-35
NEO193	Grave32	tooth	UBA-40004	4981	37	male	40-45
NEO194	Grave 34	tooth	UBA-40005	5143	34	male	50-55
NEO195	Grave 35	tooth	UBA-40006	5118	59	male	35-40
NEO197	Grave 36 (upper)	tooth	UBA-40007	4827	34	male	40-45

Table S7.2. Details of samples from Sakhtysh analysed in this study.

The dates of burials No. 40 and 42 of the Lyalovo culture to a certain extent agree with the dates obtained earlier in the laboratories of Aarhus and the Geological Institute of the Russian Academy of Sciences [175].

NEO179, burial 13 skeleton 2. This was originally recorded as belonging to Skakhtysh II, but burial # 13 from the Sakhtysh II site (excavation of 1978) was a solitary one and belonged to a teenager [172 Table 2]. Double (paired burial) # 13 was at the Sakhtysh IIa site (excavation of 1988). Skeleton 2 belonged to a 50-60-year-old man identified by G.V. Lebedinskaya, T.I. Alekseeva and M.V. Kozlovskaya (Dobrovolskaya) by stratigraphy and artefacts from the late Volosovo culture.

Sakhtysh VIII

The archaeological site Sakhtysh VIII was opened by D.A. Krainov in 1964.
Excavations at the Sakhtysh VIII site were carried out for 11 seasons (1965, 1970, 1971, 1973-1978, 1995, 2021). The excavation area is 1448 sq.m. 39 burials were identified. One burial belonged to the Lyalovo culture, 38 to the Volosovo culture. Most of them were destroyed.

The burial of the Lyalovo culture was oriented with its head to the north. The grave pit was located parallel to the river. The buried of the Volosovo culture, most often, lay stretched out on their backs with their heads toward the river (to the east). Many ornaments were found in the burials: pendants, beads, rings and buttons-plaques made of stone, bone and amber. Serpentines and slate were the main materials for making stone ornaments. They were found in burials of the late phase of the Volosovo culture. Burials of the early phase contained amber ornaments.
One sample is reported here: NEO184, from the burial of the Volosovo culture, a tooth of an adult female 40-45 years old. It was dated to 5014±36 BP uncal (UBA-39996).

Literature: Krajnov 1972[180]; Krajnov et al. 1994[177]; Alekseeva et al. 1997[178]; Kostyleva & Utkin 2010[172]; Piezonka et al. 2013[175]; Engovatova et al. 2015[179]; Kostyleva & Macane 2018[173]; Kostyleva et al. 2018[174]; Krenke 2019[181]; Macane et al. 2019[176]; Utkin & Kostyleva 2019[183]; Nordqvist & Heyd 2020[182].

Sosnovyi Mys, Angara valley, Russia. Settlement and cemetery.

Nikolai A. Saveliev, Aleksey A. Timoshenko & Andrey Gromov

The settlement and burial ground of Sosnovyi Mys are located in the Angara valley, Northern Angara region, on the lower end of the Sosnovyi Island, between the Kata and Yodarma River mouths.

The site was discovered by Nikolay I. Drozdov in 1974. Large-scale archaeological rescue work was performed in 2011-2012. The burial ground, where 8 burials were found, is located in the eastern part of the Sosnovyi Island, on the periphery of the settlement.

NEO841, Burial 4 was discovered on a base of the cultural horizon 3 which is attributed to the Neolithic period. The skeleton of a child of 5-7 years old was placed between large stones put in a rectangular construction. The burial was severely destroyed by a tree root system. Only hands, spinal column, and several ribs were found in an anatomical order while fragmented skull bones lay in separate compact clusters.

The grave inventory consists of two pendants made of split wild boar fangs with the holes at the ends. They lay around the neck vertebrae in the form of a circle with a diameter of 14 cm. Fragments of the upper and lower jaw of the child, and separately lying teeth are found inside of this circle. The skeleton was dated to 6781±35 uncal BP, UBA-40116.

NEO843, Burial 7 is a double burial. It was discovered in the cultural horizon 3. The burial pit was not traced, the grave constructions are absent. Skeleton 1 (sampled as NEO843): A male 20-30 years old lay on his back (along the East-West line), his head tilted to his left

shoulder, facing South-West. The skull is crushed. This skeleton was dated to 6678±37 uncal BP, UBA-40117.

A bone tip with a bevelled base is found in the grave's upper part, at the level of the skull. Two musk deer fangs were placed at the east side of the skull. At the southeastern side of the skull 8 musk deer fangs and 2 pear-shaped pendants made from maral (Caspian red deer) teeth were found.

A comparative analysis of the burial tradition and inventory allows us to attribute the Sosnovyi Mys site to the Kitoy culture. At present time the site is the most northwestern point of the Kitoy people dispersion.

Literature: Okladnikov 1976[184]; Drozdov & Privalikhin 2003[185]; Saveliev et al. 2011[186]; Timoshchenko 2012[187].

Ural River, Orenburg region, Cis-Urals, Russia. River beach find.

Mikhail Sablin

A partly destroyed human skull was personally found on the Ural River beach in the Orenburg region by the Russian palaeontologist N.K. Vereshchagin in 1956. Dating of the human bone NEO100, SR-8457 around 9.1 kya 14C BP corresponds to the Romanov-Il'murzin culture, Mesolithic in the Cis-Urals chronology. The material has not been published before.

Ust'-Isha, Altai region, Russia. Cemetery.

Marina Rykun & Vyacheslav Moiseyev

The Ust'-Isha Neolithic burial ground is located near Ust'-Isha village (Krasnogorsk district, Altai region), close to Isha River mouth in the zone of low mountains of Altai. The site was excavated by B.Kh. Kadikov in 1961. 11 Neolithic burials were found below an Iron Age cultural layer dating 500-100 BC [135]. Several burials were damaged by Iron Age storage pits. Archaeologically the burial ground is attributed to Kuznetsk-Altai Neolithic culture.

The male burials inventory included stone and bone daggers, stone knives, arrows and darts heads, bone harpoon and others while female burials had few artefacts.

NEO067 - burial 7, morphologically female of 20-30 years old [134]. Several pendants made of elk and deer teeth were found in the neck zone of the skeleton. The sample was dated to 6640±55 uncal BP, UBA-39943.

Literature: Dremov 1980[134]; Kiryushin et al. 2000[135].

Vasilyevsky Cordon 17, Lipetsk, Russia. Settlement and burial ground

R. V. Smolyaninov

The archaeological complex Vasilyevsky Cordon 17 was investigated by R. V. Smolyaninov and A. A. Sviridov in 2012-2015 with a total area of 348 sq.m. It combines the features of a settlement and a burial ground of the Neolithic-Eneolithic eras. Located near the village Preobrazhenovka Dobrovsky district of the Lipetsk region in the floodplain of the river Voronezh (left tributary of the Don river).

As a result of the excavations, six foundation pits were investigated, a large number of bones, stones, and ceramic collection tools were obtained from several hundred vessels, mainly from the Srednestogovskaya culture of the Eneolithic era, dating from the first half of the 4th millennium BC.

The excavation revealed 28 burials. They are divided into three groups: wrinkled on the back, wrinkled on the side and elongated on the back. Based on the analysis of the studied burials, we believe that this soil repository was abandoned mainly by the population of the Srednestogovskaya culture of the Eneolithic era in the first quarter of the 4th millennium BC.

Nine human samples are reported here (see SI sample table).

Literature: Sviridonov 2013[188]; Smolyaninov 2013[189].

Vengerovo-2A, Novosibirsk Region, Russia

V.I. Molodin, D. V. Pozdnyakov, L. N. Mylnikova, M. S. Nesterova, translated from Russian by Aija Macane

The Vengerovo-2A burial ground is located on the edge of the second terrace above the floodplain on the left bank of the river Tartas (Vengerovsky District, Novosibirsk Region, Western Siberia).

Two collective burials of the late Neolithic period have been investigated. The mounds consisted of complex architectural structures, including a central burial pit and a ditch

surrounding it, which in ancient times were covered with a barrow. The minimum number of individuals in the central grave consisted of 8 and 19 individuals, respectively. Various methods of the body disposal were recorded (inhumation, cremation, secondary and partial burials) and the dead were buried in different positions.

Analysis of the accompanying inventory demonstrates a pronounced north-west vector of parallels. In addition to those artefacts, with extremely wide territorial and chronological distribution (polished axes, adzes, teardrop-shaped pendants from bone and stone, tubular beads, artefacts made from incisors and canines of animals, shells), the rest of the items are, in one way or another, associated with the Neolithic materials from the taiga zone of the Western Siberia, the forested Trans-Urals, the Baltic states and Karelia.

Two burials from the complex No. 1 provided radiocarbon dates (skeleton 1: COAH-8738, 6250 ± 70 uncal BP and skeleton 2: COAH-8739, 6220 ± 80 uncal BP). According to them the usage of the site dates back to the end of the 7th millennium BC [190]. The new datings on these skeletons gave somewhat different results, see Supplementary Table IV. From complex 2, two individuals were dated: MAMS-29411 - 6322 ± 23 (Complex 2, sk. 17) and NSKA-02199 - 6368 ± 89 (Complex 2, sk. 18).

Cranially, Vengerovo people display the Northern Eurasian trait combination. This fact along, with skeletal and paleogenetic findings, places them within what can be described as the Uralian and Western Siberian Neolithic community.

First of all, it can be stated that all currently known craniological material from the Barabinsk forest-steppe belongs to the typological structure of the second level of racial differentiation - the north Eurasian anthropological formation. We can also talk about two components that formed the basis of the Vengerovo 2A paleopopulation. One of them is of the autochthonous origin and is close to people buried at the Sopka-2/1 and Protoka sites. The second component has its origins in the Volga-Ural interfluve. This component had the greatest impact on the male part of the population, while the female part of the population retained a certain local identity [191].

Eleven samples were analysed from this site, of which one was dated to the Mesolithic, eight to the Neolithic, one to the Chalcolithic and one to the Bronze Age. Details of the samples are found in the SI sample table. While most of these dates are comparable to the earlier datings, two individuals (NEO910 and NEO921) gave datings later than expected. We have no explanation for this discrepancy.

Literature: Chikisheva et al. 2015[191]; Molodin et al. 2016[190].

Zamostje 2, Sergiev-Posad district, Moscow region, Russia. Settlement.

Olga V. Lozovskaya & Vyacheslav Moiseyev

Zamostje 2 is a multilayer Late Mesolithic – Early and Middle Neolithic wetland settlement located at the Volga-Oka region, Sergiev-Posad district, Moscow region, Russia. The site is cut by the Dubna River. The archaeological layers are below modern water level.

According to archaeological data the groups of hunter-fisher-gatherers appeared on the shore of a vast post glacial lake along with the retreat of the water. Fluctuations in water levels continued for all 7th mil. cal BC [192]. The economy of Zamostje 2 people included hunting for elk and beaver, wetland and waterfowl, active and passive fishing (pike, perch, cyprinids), gathering berries, roots, and seeds [193,194].

No burials were found on the site. A number of human bones were probably brought to the site by its inhabitants while deciduous teeth might be lost by children naturally. Archaeological layers dates are: LM LL c.6600–6400 cal BC, LM UL (c. 6300–5900 cal BC), Final Mesolithic (c. 5900–5750 cal BC), Early Neolithic (c.5700–5300 cal BC) and Middle Neolithic (c. 4900–4300 cal BC). The ceramics were found in the Neolithic layers with no evidence of agriculture.

The results of the analysis of the metric characteristics of the permanent molars from Zamostje 2 suggest that the inhabitants of the site might have had common origins with the Onega culture population from Yuzhny Oleny Island [195]. More generally, the studied dental sample shows similarities to a wide range of Eastern European populations collectively referred to in paleogenetics as Eastern hunter-gatherers.

NEO087, sample 8, is a molar taken from the fragmented mandible of a young female of 18-20 years old. The sample was excavated in 1990 by Vladimir Lozovski in the dark grey sandy sapropel (gyttja) among hundreds of other artefacts made of bone, stone, and wood without burial context in the Late Mesolithic Upper layer (LM UL, square B3). The 14C dating of the sample is 7663±44 BP (KIA-51435) (6600–6440 cal BC) and can be slightly older than the surrounding layer.

NEO088, sample 9, is an incisor taken from the right half of the maxilla of an adult 20–30 years old. The sample together with few archaeological finds was found in 1998 by Vladimir Lozovski without burial context in a drainage trench in dark grey sapropel (gyttja) with shells between Upper and Lower Late Mesolithic layers (LM UL/LL). A 14C dating of the sample is 7581±41 BP (KIA-53296) (6500–6380 cal BC). A new dating gave a similar result, 7533±38 uncal BP, UBA-39957.

A detailed discussion of dating and results of stable isotope analysis of samples 8 and 9 is published by Meadows et al. [196]. The morphological description of dentition is in Zubova et al. [195].

Literature: Lozovski et al. (eds.) 2013[193]; Lozovski et al. 2014[192]; Lozovskaya (ed.) 2018[194]; Zubova et al. 2019[195]; Meadows et al. 2020[196].

Zjindo, Krasnochikoysky region, Russia. Cemetery.

S. V. Vasilyev and S. B. Borutskaya

The Neolithic burial ground of Zjindo is located on the territory of the Krasnochikoysky region of Western Transbaikalia, in the Chikoi river basin (the eastern part of the Selenga river basin and Lake Baikal). Now mountain taiga biotopes are common there. Excavations were carried out mainly in 2004-2005 by the Chikoy archaeological expedition of the Trans-Baikal State University under the direction of M.V. Konstantinov [161].

The Zjindo burial ground is located on the right bank of the river Chikoi on the lower part of the elevated slope, which is part of the system of spurs of the Malkhan Range. 2 km downstream of the river, the left bank of Chikoya already belongs to Mongolia. The elevation is about 680 m. The height above the river is 10-25 m. An artificial erosion ditch located across the slope surface has developed into a powerful ravine. In the ravine zone, from its top to the mouth, within 600 m, there is a burial ground consisting of a series of soil burials. It has been studied since 2005. 7 burials of varying degrees of conservation have been identified.

Two individuals were sampled:

NEO115, Zhindo # 7, burial N2, skeleton 1a. Dated to 6943±51 uncal BP, UBA-33756.

NEO117, Zhindo # 9, burial no.2, skeleton 2. Dated to 7964±63 uncal BP, UBA-33758.

Literature: Konstantinov et al. 2005[161]; Vasilyev et al. 2018[143].

Scotland

Banks Chambered Tomb, South Ronaldsay, Orkney, Scotland

Nick Card

Two phases of partial excavation were conducted by the University of the Highlands and Islands in 2010 and 2011 on a newly discovered chambered tomb. The area was disturbed during development work, but the heart of the monument was largely intact. The tomb consists of a linear central chamber, aligned E–W and c5m long, leading to five burial cells sealed by large capstones. The original ridge-like mound would have been up to 80m long, 20m wide and 2.5m high, but was truncated to the level of the capstones. The central area is partly subterranean and constructed in a quarried area into bedrock. The entrance passage is to the N. There are two larger cells at the W and E end of the central chamber, a single cell to the N and two cells to the S.

The N and E cells were partly excavated during Phase 1 and were found to contain human bones that formed closing deposits. These had been placed upon a layer of slabs, which is presumed to seal the lower unexcavated burial deposits. Six fragments of bone, predominantly cranium, were found in each cell, and a whole cranium had been placed in the E cell as if in a final gesture. The remains of the upper chamber backfill deposits were excavated during Phase 2. Further deposits of cranium and long bone were found within the SE cell above the slab layer.

In Phase 2 the damaged W cell was fully excavated. Above the floor were several layers of disarticulated human bone within soft semi-waterlogged silts. The evidence indicates that there were several phases of use within the cell, with distinct concentrations of bones. All the samples submitted came from the W cell. The other cells remain unexcavated and are preserved in situ.

Literature: Lee 2011a[197], 2011b[198].

Serbia

Vlasac, Danube Gorges, Serbia. Settlement with burials.

Dušan Borić

The site of Vlasac contains Early and Late Mesolithic and Early Neolithic deposits. Vlasac is situated in the Lady's Whirlpool Gorge of the Danube Gorges/Iron Gates area, on the right (Serbian) bank of the river 3 km downstream from the site of Lepenski Vir. The site was investigated in 1970–1971 by D. Srejović and Z. Letica examined an area of 640 m2 along the riverbank below 70 m a.s.l., which was subsequently submerged beneath the reservoir created by the Iron Gates I dam. More recent excavations were undertaken between 2006–9 by D. Borić, who examined a further 326 m2 upslope of the area excavated in 1970–1. The

two excavation periods produced over a hundred burials of primarily or exclusively Mesolithic date, comprising primary inhumations and secondary inhumations and cremations [199–203]. A total of 68 AMS 14C dates on human and animal remains and charcoal from Vlasac range (after fresh water reservoir correction) between c. 9300–6000 cal BCE.

We report genetic data from three individuals, all of which were found in the period 1970–1971:

NEO655, burial 32 represents a fully articulated extended supine inhumation found in the vicinity of dwelling 2, immediately beneath burial 31 that was directly AMS dated by AA-57777 to 8196±69 BP (7756±82 BP after the correction for the reservoir effect was applied), with this date representing a terminus ante quem for burial 32.

NEO677, burial 41 represents a disarticulated skull found at the bottom of the stratigraphic sequence, on bedrock in quad. D/I.

NEO657, burial 83a represents a disarticulated human mandible found on the shoulder of an articulated supine burial marked as 83, which was directly AMS-dated by OxA-5826 to 7760 ±100 BP (7756±82 BP after the correction for the reservoir effect was applied).

Literature: Srejović & Letica 1978[199]; Borić et al. 2008[200]; 2009[201]; 2014[202]; Borić and Griffiths 2015[203].

Lepenski Vir, Danube Gorges, Serbia. Settlement with burials.

Dušan Borić

Lepenski Vir is one of the best-known archaeological sites in Europe, covering the Mesolithic and Early Neolithic periods. The site was discovered in the 1960s during archaeological surveys in advance of the construction of the Iron Gates I dam. Excavations between 1965–70 led by Dragoslav Srejović examined an area of c. 2500 m2 where an unprecedented array of archaeological features and artefacts relating to repeated use of the site over thousands of years was found [204–207]. These included the remains of around 70 buildings with trapezoidal bases and (often) furnished with lime plaster floors and stone-lined hearths, over 200 burial contexts [204], and exceptional numbers of stone and bone artworks and body ornaments. A revised chronological framework recognizes three main phases of site occupation of the site: Early–Middle Mesolithic, c. 9500–7300 cal BCE (‘Proto-Lepenski Vir’), Mesolithic-Neolithic Transition, c. 6150–5950 cal BCE (‘Lepenski Vir I–II’), Early Neolithic, 5950–5500 cal BCE (‘Lepenski Vir III’) (Borić 2019; Borić et al. 2018). Based on a total of 108 AMS 14C dates

that cover Mesolithic and Early Neolithic contexts, no evidence of a Late Mesolithic (7300–6200 cal BCE) occupation has been identified at Lepenski Vir.

We report genetic data from two individuals:

NEO669, burial 126. Burial 126 is a disarticulated mandible, possibly of an Early/Middle Mesolithic date, found beneath a large trapezoidal base building structure of the Mesolithic/Neolithic transition phase I-II. Previously obtained genomic information on this individual has been reported in Mathieson et al. 2018.

NEO658, Burial 88: This sample was probably mislabeled as coming from Vlasac, but since no burial 88 exists at Vlasac, it more likely is from Lepenski Vir. If this is correct, it is the grave of an older adult, probably female. Burial 88 at Lepenski Vir was previously dated to 7130±90 uncal BP (OxA-5831, Boric 2019).

Literature: Srejovic 1972[207]; Radovanovic 1996[206]; Borić 2016[204]; Borić et al. 2018[208]; Mathieson et al. 2018[98]; Borić 2019[205].

Spain

Camino de las Yeseras, San Fernando de Henares, Madrid, Spain. Chalcolithic Tomb, Área 15, El-08-I

Corina Liesau, Patricia Ríos, Concepción Blasco, Jorge Vega & Roberto Menduiña

Camino de Las Yeseras is a large, third millennium BC ditched enclosure covering more than 22 ha, strategically located on a terrace near the confluence of the Henares and Jarama rivers. More than 8500 structures were documented after the area was mechanically cleared during the 2006/2007 campaign. Circa 1200 features (pits, hut structures, tombs, structured depositions) were excavated by Argea Consultores, S.L. archaeological company in collaboration with the research team of Camino de las Yeseras from the Autonomous University of Madrid.

The analysed sample (individual 2) comes from a skeleton of an 18-20-year-old female from a tomb excavated in 2006 by Argea S.L. company. The tomb is a pit with dimensions of 1.60 m in diameter and 0.86 m in depth. In the bottom of the pit, 4 primary inhumations have been located, two infantile buried nearby, but not in physical contact, covered partially by two adult females in a crouched position, a 26-31-year-old female (individual 3) and at least by a younger female (individual 2) superposing the latter one, the body of individual 3. Several grave goods have been recovered in the centre of the pit, a granite mill, a plain bowl upside

down, and a necklace bead. Intermingled with the human remains some cranial and appendicular bones of a lamb or kid have been recovered.

This tomb located in the south area of the site beneath the enclosure 4, is until yet one of the oldest ones documented in Camino de las Yeseras. The 14C dating of the individual number 2 is 4021 ± 30 BP, 2620-2471 cal BC 2σ (Ua-39308). The 14C dating of the female individual 4 gave the result 3990 ± 40 BP, 2621-2350 cal BC 2σ (Ua- 35016), evidencing contemporaneity, as well as the close contact of the skeletons, indicates a multiple burial in a filled space. The structure was half-filled with sediment and sealed by a compact clay layer. Remarkable, and until now as a unique case in this site, is the fact that several centuries later, another female (individual 1) was buried in a crouched position in an upper level of the tomb. The C14 dating of this adult female (individual 1), less than 27-year-old gave the result 3590 ± 30BP; 2028-1884 cal BC 2σ (Ua-35015). This led us to propose that probably this burial exhibit during a long period, some visual external markers to be located and respected.

The tomb is in close contact with enclosure 4, well documented by surface characterization up to 60m (of which 42m of them have been excavated). The enclosure is generally U-shaped, 1.35–3m in width, and with depths ranging between 0.45m and 1.40m. Another interesting aspect to highlight is that the tomb was so close to the enclosure 4, that when the circular trajectory of the enclosure was designed, it was deviated outside to avoid the destruction of the tomb. Once excavated the enclosure and still in use, some erosional processes took place, probably torrential rains, that affected the wall of the enclosure near the tomb. To avoid the destruction of the tomb the inhabitants of Camino de las Yeseras intentionally protected this zone around the tomb with an inner buttress of a compact earth step inside the enclosure.

Literature: Liesau et al. 2008[209]; Vega et al. 2009[210]; Blasco et al 2011[211]; Ríos 2011[212]; Gómez et al. 2011[213]; Ríos et al. 2014[214]; Liesau 2017[215]; Arteaga et al. 2017[216].

El Toral III, Andrín, Asturias, Spain. Rock shelter.

Igor Gutiérrez-Zugasti

The rockshelter of El Toral III was almost completely dug by María Noval and a team of the Institute of Prehistory (IIIPC – University of Cantabria) in 2009 as part of a rescue excavation. The site contained a huge Mesolithic shell midden that was heavily eroded by environmental and anthropogenic causes throughout the Holocene, although some intact stratigraphic units were still preserved at the time of excavation. Radiocarbon dates placed the Mesolithic occupation of the site between ~9500 and 7300 cal BP. Shell midden units

were mainly composed of shells, lithics, and fish and mammal bone remains. Three post-holes were identified in unit 8. A partially disarticulated skeleton was found inside the mesolithic shell midden, in units 21 and 22. Apart from the Mesolithic evidence, the presence of pottery and human remains from disturbed units evidenced that the site was also visited by human populations between the Neolithic and the Bronze Age. Radiocarbon dates placed those visits in two different periods: 5600-5400 cal BP and 4300-3600 cal BP. Despite the heavy erosion that affected the site, an empty funerary cist was found. Anthropological and isotopic analysis of the human remains are still in progress as part of the PhD of Borja González-Rabanal.

Literature: Noval 2013[217]; Bello-Alonso et al. 2015[218]; Rigaud & Gutiérrez-Zugasti 2016[219].

El Mazo, Andrín, Asturias, Spain. Rock shelter.

Igor Gutiérrez-Zugasti, David Cuenca Solana, Manuel González-Morales

The inner test pit at the rockshelter of El Mazo was excavated in 2009-2012 by a team of the Institute of Prehistory (IIIPC – University of Cantabria). This is one of the most well-documented shell midden sites in northern Iberia. Although significant parts of the site have suffered from heavy erosion throughout the Holocene, part of the deposit was well preserved in the inner part of the rockshelter, close to the walls. Excavation of the inner test pit produced 27 mesolithic stratigraphic units dated between ~9000 and 7300 cal BP, providing an almost continuous record of occupations at the site. Microstratigraphic investigations have demonstrated the existence of several subunits inside some of the units identified during the excavation. The shell midden units were mainly composed of shells, with lesser presence of lithics and fish and mammal bone remains. Several in-situ hearths were also identified. Four human teeth were found across the stratigraphic sequence. The excavation of three additional test pits in other parts of the site have allowed to establish the formation and erosion processes at the site, as well as the presence of stratigraphic units belonging to the Bronze Age. Some isolated human remains (three teeth and a bone) were found in the outer test pit. Anthropological and isotopic analysis of the human remains are still in progress as part of the PhD of Borja González-Rabanal.

Literature: Gutiérrez Zugasti & González Morales 2013[220]; Gutiérrez-Zugasti et al. 2013[221]; 2014[222]; García-Escárzaga et al. 2015[223]; Rigaud and Gutiérrez-Zugasti 2016[219]; Gutiérrez-Zugasti et al. 2016[224]; Gutiérrez Zugasti et al. 2018[225]; García-Escárzaga et al. 2019[226].

Coves de Santa Maira, Castell de Castells, Alacant, Spain. Cave.

Carles Lalueza-Fox, J. Emili Aura Tortosa, Domingo C. Salazar-García

Coves de Santa Maira is a site situated c. 600 m.a.s.l., in a Mediterranean middle-mountain environment. Archaeological excavations were performed in two sectors: West (= SM-W) and East (= SM-CG). Archaeological materials used for this study were recovered from the site in 2009, during excavations carried out by the Universitat de València [227].

The dental piece analysed in this study comes from SM-CG, where short human occupations have been reported during the Late Glacial Maximum (23 – 19 kyr cal BP), the Tardiglacial (11.5 kyr BP) and the Neolithic (5,7 kyr BP). The tooth appeared in the upper levels of the Pleistocene package, where several non-articulated human remains were recovered over a surface of c. 1 m2 under a pit. Two AMS radiocarbon dates were performed on this assemblage: on a human bone (Beta-261220: 8540 ± 50) and on a *Quercus* charcoal (Beta-313425: 8540 ± 50) [228]. The dental piece used for this study appeared only 30 cms away from the directly dated human bone.

The above-mentioned assemblage is intrusive, appears in Late Upper Palaeolithic levels but comes from a Holocene Mesolithic context. In SM-W there is evidence of Mesolithic layers with a similar chronology. From this other sector come human remains from 3 individuals with evidence of anthropic processing (cutmarks, bite marks, fractures and thermoalterations) [229]. Isotopic data show a wide variety of resource exploitation and suggest a connection with the coast, 30 km away [230].

Literature: Aura Tortosa 2014[227]; Salazar-García et al. 2014[230]; Verdasco Cebrián 2016[231]; Morales-Pérez et al. 2017[229]; Carrión Marco et al. 2018[228], Aura Tortosa et al., 2020a[299], Aura Tortosa et al., 2020b[300]

Sweden

Bredgården, RAÄ 113 Marbäck sn, Västergötland, Sweden. Wetland find. SHM 33241.

Maria Vretemark

The remains of a nearly complete human skeleton were found in 1994 when some trenches were dug in gyttja layers in a former lake. A total of 18 well preserved bones from the skeleton were found at a depth of 1.2 metres, dislocated over a relatively large area. The

body is supposed to have been deposited or buried in a small lake. The bones had been disarticulated during decomposition in the bottom sediments. According to C14 dating, the human skeleton is Mesolithic, around 7800 BC. Observations on the bones reveal that this was an adult male with stature around 174 cm. He had lost some teeth ante mortem and the still present ones were heavily worn. There was also clear evidence of inflammatory processes in the jaws due to apical lesions. The age at death was estimated to be 45+ years. A tooth was sampled for DNA (NEO027).

Literature: Borrman et al. 1996[232]; Jonsson and Gerdin 1997[233].

Dösemarken, Scania, Sweden. Grave and settlement.

Yvonne Magnusson

The area (Limhamn 155:355) is located in the south-west of Malmö, directly east of the limestone quarry in Limhamn and was excavated in 2006 by Malmö Kulturmiljö.

This was a coastal area made up of arable land and the eastern part consisted of a former wetland, Hyllie mosse. The marshland has been fairly extensive but has since long been dried out and cultivated.

The area is part of what is known as Dösemarken, and there is information about the remains of a stone chamber grave nearby, possibly a dolmen (Hyllie sn., RAA no. 25:1), but its exact location is unknown. The existence of one or more stone chamber graves in the surroundings is indicated by the place names of the fields, Stora and Lilla Döse.

In Area A, a well-preserved skeleton grave was found (grave 1671, MK 321), along with a large number of settlement remains in the form of houses, pits, pit systems, hearths, a well, an oven, and postholes.

The tomb was rectangular, 1.9 x 1.2 m and 0.5 m deep, placed in a north-south direction and surrounded by a frame with large, evenly laid stones. The main end was marked especially with horizontally laid longer stones and with a circular shaped stone in between each long stone. In addition to the nearly intact skeleton, fragments of ceramics, flint flakes, and a bone awl was found at the foot end.

The body had been placed on the left side with its lower extremities bent, the upper arms along the body and forearms bent to the torso, with hands originally by the head. The position of the skeleton was in a north-south direction with its face directed to the east. The skeleton was very brittle and fell apart when touched.

This was the remains of a young woman who died at the age of 15 - 18. The size of the leg bones shows that the woman was relatively short, about 155 cm. Enamel hypoplasia occurs on several teeth, which have been formed at the age of 5–8 years and show that during this period the individual was subjected to physiological stress in the form of, for example, illness or malnutrition. The shape of the femur and tibia indicates that they have been subjected to some stress and can be seen as an indication that the buried woman has been relatively physically active during her short life.

Based on 14C analysis of a tooth, the grave can be dated to 2470 - 2230 BC. The design and location of the grave show similarities to graves from Battle Axe Culture and pieces of ceramic which were found confirm this hypothesis.

The orientation of some bones indicates that the grave was disturbed relatively shortly after the burial, about 2 or 3 years. The lack of grave goods, apart from a bone awl, could also be a sign that the grave has been looted.

The closeness of Neolithic house remains suggests that this can be interpreted as part of a burial ground belonging to one of the houses. A total of twelve house remains were found. Together with other remains of buildings, this indicates an intensive and varied settlement activity. The buildings have an assumed continuity from the Late Early Neolithic to the Late Neolithic/Early Bronze Age. One tooth was sampled from A1671, NEO044.

Literature: Magnell 2006[234]; Ifverson 2007[235].

Evensås, Skaftö 85, Bohuslän, Sweden. Flat graves.

Karl-Göran Sjögren

Human bones were found in 1930 during gravel digging in a late glacial shell bank. The find was investigated by Johan Alin later the same year. According to Alin the remains were from a single individual buried in supine position with the head towards the west. No artefacts accompanied the skeleton, but flint finds indicated a settlement at the site. Later osteological determinations by Gejvall and Ahlström showed the presence of two individuals. Individual A was a juvenile and individual B was a male, c. 25-30 years old. It is unclear if they had been buried in the same grave or not.

Several datings and isotopic analyses have been made, showing a very high intake of marine protein in both individuals. Datings range ca 5000-5200 BP, i.e. late Mesolithic, but after reservoir correction both must be regarded as early Neolithic in date, although no

indication of Neolithic diet is seen in the isotope values. An upper right first molar from the adult male was sampled for DNA, NEO260.

Literature: Niklasson 1932[236]; Johansson 1974 nr 3[237]; Nordqvist 2000[238]; Liden et al. 2004[239]; Ahlström & Sjögren 2007[240]; Sjögren et al. 2009[241].

Fredriksberg, Falköping stad 5, Västergötland, Sweden. Gallery grave.

Malou Blank

The gallery grave at Fredriksberg in Falbygden, western Sweden, was excavated and restored by Västergötlands museum in 1973. The slightly trapezoid chamber measured 5.3×2 m and was oriented NNE-SSW. It was constructed of limestone slabs and consisted of a chamber and an ante-chamber covered by a collapsed roof. During the excavation a pottery sherd, a flint dagger (Lomborg type IIB), flint flakes, amber pendants, a slate whetter, a bone bead, bone needles, a bone awl, a bone cylinder, a few animal bones and commingled human remains were recovered. The number of buried individuals are estimated to be at least 28 to 30, both males and females, adults and children. Dating of the skeletons range from c. 2200 to 1650 BC, corresponding to the Late Neolithic and the beginning of the Early Bronze Age period I in the Scandinavian chronology. In addition to the aDNA data presented in this study, other scientific analyses were conducted, including Sr isotopes and stable isotopes. Most of the sampled individuals (12/21) exhibit childhood Sr isotope ratios which can be expected outside the local area of Falbygden. The stable isotopes indicate a terrestrial diet with a rather high intake of plant foods.

16 samples were analysed from this site, eight of which yielded usable DNA, presented in Table S7.3.

Sample id	**Context**	**Material**	**Description**	**Sex**	**Ageclass**	**Age**
NEO220	F115II:2	tooth	PM1 dxt	M	juv/adult	15-20
NEO221	F83III:1	tooth	canine sin	M?	adult	>30
NEO223	F98III:2	tooth	dpm1 dxt		inf I	3
NEO224	F121	tooth	PM2 sin	F	adult	>35

NEO225	F123	tooth	PM2 dxt	F?	adult	>40
NEO226	F90	tooth	dc dxt		inf I	3-4
NEO227	F122	tooth	canine sin	M?	mat	40-50
NEO228	F108IV:3	tooth	PM1 dxt	M?	mat	45-55

Table S7.3. Details of samples from Fredriksberg in the present study.

Literature: Weiler 1977[242]; Blank et al. 2018[243], 2020[244].

Frälsegården, Gökhem 94, Västergötland, Sweden. Passage grave.

Karl-Göran Sjögren

The passage grave at Frälsegården in Falbygden, western Sweden, was excavated in 1999-2001 by Gothenburg University. In spite of damage and ploughing, this constitutes the most well-documented bone material from a Scandinavian megalithic tomb. The grave had been a ca 10 m long and 2 m wide chamber of limestone slabs, with a passage towards the east, also ca 10m long. The presence of a number of whole or partially articulated skeletons was one of the most significant results of the excavation. These range from almost complete skeletons to partial articulations. In addition, there is a mass of disarticulated bones but also some bones that seem to have been treated differently, such as a skull group and a couple of bone packages. The number of buried individuals are estimated to be at least 51, but more likely ca 78-80. Datings of the skeletons range mainly ca 3100-2900 BC, corresponding to the late Funnel Beaker Culture, period MN A in the Scandinavian chronology. A large number of scientific analyses have been made, including aDNA, dietary isotopes, Sr isotopes. Two individuals tested positive for plague infection, so far the oldest identified cases. Sr isotopes suggest that some 25% of the individuals were born outside the local area.

One sample was analysed in this project, NEO259 (ID120033, bone ID3644, Tooth ID 318), a lower left PM4 tooth.

Literature: Ahlström 2009[245], Skoglund et al. 2014[246]; Sjögren 2008[247], 2015[248], 2017[249]; Sjögren et al. 2009[241]; Rascovan et al. 2019[250].

Hanaskede, N Ving sn, Västergötland, Sweden. Wetland find. VGM 106100.

Maria Vretemark

In autumn 1990 a single human cranium was found during drainage of a small kettle hole near lake Hornborgasjön in Västergötland. No other parts of the skeleton were found despite thorough search around the find spot, nor any artefacts. The cranium was C14 dated to the Mesolithic period, around 8000 BC. At that time the lake Hornborgasjön was larger than today and there were lots of Mesolithic settlements on the shores. When it decomposed the separate skeletal parts were scattered around and eventually embedded in the bottom sediments of the kettle hole. The cranium was from a male with an age at death estimated to 40+ years. Some of his teeth had been lost in life due to severe dental wear. An apical infection was noted in the upper right lateral incisor. He also had a scar from a healed injury in his frontal bone, just above the right eye. Dietary isotopes from two teeth and a cranial sample were published by Eriksson [96].

One tooth sample was analysed, NEO018.

Literature: Vretemark 1996[251]; Eriksson 2003[96]

Hindby mosse, MHM 1505, Scania, Sweden. Central place.

Yvonne Magnusson

The archaeological excavations of Hindby Mosse were carried out by Malmö Museum between 1967 and 1974. Today, the site is beneath a motorway, Inre Ringvägen, which transverses the site and it is located about 600 m southwest of Hindby junction in the southern part of Malmö.

In prehistoric time the site was located on a fairly flat isthmus between two shallow bays in a lake which today is Hindby mosse. Just south of the settlement, a stream debouched into the lake. In the vicinity there are several neolithic settlements and a long dolmen.

Hindby mosse is an unusually large settlement and is an example of a central place dating to the Middle Neolithic period and the Funnel Beaker culture. In the area several remains of buildings have been found. The almost circular cultural layer covers 1.5 hectares and in the middle is an 80 x 60 m large featureless area surrounded by two semi-circular activity areas, one in the north and one in the south. The total site has not been investigated, but the area was divided into four larger trenches and several smaller trenches and test pits.

The artefacts consisted mainly of flint tools such as burnt and unburnt axes, arrowheads, scrapers and flakes, but ceramics are also well represented on the site. Most vessel

fragments are from storage vessels, but also beakers and bowls of finer ware and richly decorated are represented.

A large number of animal and human bones were also found. Bones and horns from slaughtered cattle and from hunting were used as raw material for making tools.

Crucial for interpreting the place as a central place for the local population with elements of ritual activities is its circular structure, how it is situated on an isthmus, the number of fragments from human skulls and the presence of burnt axes.

Seven samples were taken, three of which were successful:

Cranium 1, NEO036. This skull was found centrally in context 4 and with the "face" down. The back of the head was crushed and was otherwise relatively compressed and partially burnt. About 10 cm west of the skull was a skull fragment. It is unclear if it is related to the skull. Next to the skull's northern side was found a scraper. Near the skull was also a tusk from a wild boar. No traces of the rest of the skeleton were discovered. No marked burial or other marking in the skull area was observed. In osteological analysis, it was assessed that the skull belonged to an individual aged 20 - 25 years.

Cranium from square 15/71, NEO038. In osteological analysis, it was judged that the skull belonged to a young individual. Other documentation is missing.

Cranium 2, NEO039. The second skull was found on the outskirts of context 4. The skull was compressed so that the skull top was depressed in the lower part. Adjacent to the skull was a piece of a jaw with teeth. Immediately adjacent to this jaw was a mandible from a larger animal (pig or dog) and nearby a femur, possibly human, was also found. As in the case with the first skull, there is no marked burial or other marking. In osteological analysis, it was estimated that the skull belonged to a young individual, about 7 - 9 years old.

Literature: Archival material, unpublished, S 03:12-14: Malmö Museer; Salomonsson 1971[252]; Jeppsson 1976[253]; Svensson 1986[254]; Sandén et al. 2010[255]; Nilsson 2020[256].

Kastanjegården, Scania, Sweden. Cemetery.

Yvonne Magnusson

During 1972 - 1974, Malmö Museums conducted excavations at Kastanjegården for future development of the area. The excavation area is located in the southern part of Malmö at Kastanjegården and south of Fosie church. Here, settlement remains from the younger Stone Age, older Iron Age and the transition between the Viking Age and the Middle Ages

emerged. A flat earth gravefield from the younger Stone Age dated to Middle Neolithic B (Battle Axe Culture) was found. The burial ground was oriented in a north-south direction and covered an area of about 17 x 10 m.

Grave 105 was located in a north-south direction and the north-west part of the grave was partially destroyed by sand extraction. The grave consisted of a stone-framed structure measuring 2.5 x 1.5 m with the remains of a decomposed wooden coffin. In the lower part of the stone structure was found a stone with two cup marks. In the upper part of the structure lay a grindstone.

Skeletal remains that were severely weathered and partially crushed were found in the grave. Only the skull and parts of the hands were preserved, the rest was decomposed. The skeleton turned out to be a woman aged 25 - 30, lying on her right side with her head to the south and facing east. Two children were buried in the same grave, both about 5 - 7 years old.

The child in the southern part was placed next to the woman, either in front of or behind her and with its head in the south. The child in the northern part of the grave had probably been lying at the woman's feet with its head to the north facing east.

The grave goods consisted of two earthenware vessels, seven amber beads, a flint axe, four flint chips, two scrapers and five flint flakes. The two vessels were of typical Battle Axe Culture type, belonging to pottery group J.

Sometime during her lifetime, the woman had been hit severely to the left side of her head. The blows had been so violent that a tooth in the upper jaw and one in the lower jaw had been badly damaged and inflamed. Whether this is the result of abuse or an accident could not be decided, but the woman during the later part of her life suffered persistent pain in the jaw and severe toothache. The teeth in the other half of the jaw were also more worn than the injured part, suggesting that she was in pain from chewing the food.

A tooth from the adult woman in grave 105 was sampled, NEO051, MHM 4555.

Literature: Winge 1974 [257]; 1976[258]; Rosborn 1999[259].

Sillvik, Torslanda 43, Bohuslän, Sweden. Flat grave.

Karl-Göran Sjögren

Remains of three individuals were found in 1929 during gravel digging in a late glacial shell bank. Further bones were reported, but have not been recovered. Finds of two flint daggers

close by indicate a late Neolithic date. Individual A is a male >40 years old, individual B is a probable male, 20-30 years old, and individual C is a juvenile. Individual B was 14C-dated to the Late Neolithic. Despite the coastal location, his δ13C value indicates only marginal intake of marine protein.

The sample, NEO261, is a lower left PM from individual B.

Literature: Niklasson 1956[260]; Sjögren et al. 2009[241].

Skateholm I, Scania, Sweden. Cemetery.

Lars Larsson

The sample was taken from one of 65 burials excavated from a combined settlement site and cemetery at Skateholm I in the southernmost part of Sweden. Skateholm I is one of two cemeteries situated on islands in a former lagoon dated to 5200–4800 BC. The material culture belongs to the Ertebølle Culture. Both sites were submerged due to transgression during the late Mesolithic.

The sample, NEO679, is a tooth from a mature female (ca 55 years old) buried in feature 52, grave 26.

Literature: Larsson 2004[261]; 2016[262].

Vattenledningen, Scania, Sweden. Cemetery and settlement.

Yvonne Magnusson

Due to construction of a water supply line in 2005 between Hyllie water tower in Malmö and Vellinge, Malmö Kulturmiljö conducted an archaeological excavation.

The area which was surveyed consisted of long narrow excavation trenches in north-south direction through the northern part of Vellinge municipality. The area is located just east of Hököpinge and just over a km west of Hököpinge church village, and north of Pilebäcken which flows in an easterly direction towards the Öresund. The area is on a ridge, which slopes southwards towards Pilebäcken.

The excavation area turned out to be an area of relatively intense prehistoric activity. The remains that emerged consisted of settlements, graves and fire-related remains which dated from the end of the Early Neolithic to the Roman Iron Age, a span of about 3000 years.

In the southern part of Area 3, a burial ground with six flat earth graves, hearths, pits and scattered post holes appeared. Five of the six flat graves were dated to the transition between the Late Neolithic Age and the Bronze Age and one to the later part of the Early Bronze Age.

The grave A 430 has been interpreted as a skeleton grave, possibly a double grave where the bodies are buried in a row. It appeared as an approximately 3.50 m long colored staining in east-west direction with scattered skeletal parts in the surface. Skeletal parts, which were highly fragmented, from two people were found in two concentrations, one in the western and one in the eastern part of the grave.

In the western part of the grave there was a crushed skull and different bone remnants. The body had been placed with its head to the west facing north. In the eastern part of the grave, there were a few additional cranial parts and bone remains. Traces of soot were found around the skull. According to the osteological analysis, the bones were from two adult males, who died at the age of 20 and 25-30 years. One skeletal sample was 14Cdated with the result 1943–1748 BC, corresponding to the Late Neolithic in Scandinavian chronology. In the grave filling, scattered artefacts were found in the form of two flint flakes and a fossil sea urchin.

One sample, NEO052, from A430 was analysed. The sample was a tooth from the individual found in the grave N° 430.

Literature: Arcini 2007[263]; Gidlöf & Gruber 2009[264].

Ängdala, Scania, Sweden. Grave and flint mines.

Yvonne Magnusson

The area around Ängdala farm at Kvarnby and Södra Sallerup on the eastern outskirts of Malmö contains the only known Early Neolithic flint mines discovered in Sweden. They were discovered in the early 1900s when digging in the area for mining chalk, and archaeological excavations were carried out at several occasions in the area, mainly during the 1970s until the 1990s.

The mines are different in size, but usually 2 - 7 metres deep. There are also many open quarries in the area, which are characterised by pits with chalk on the surface. They are a maximum of two metres deep. In some places it has been possible to pick flint nodules in the upper soil layer without digging.

The mining activity is dated to the Early Neolithic (ca 4000 - 3300 BC). Samples show that the mines were re-used during the later part of the Neolithic era, during the Bronze Age and even during the Iron Age. C14 dating shows that the flint quarrying was most intense in the area between 4000 BC and 3650 BC.

When excavating a flint mine (A2408 C) in 1991, a skeletal burial (Grave A2408, MHM 6902) was found in the soil of the depression formed by the mine. On a stone layer and with larger stones under the head, a young woman about 18 - 20 years old had been buried. Only a few skeletal parts were found, but most probably she was buried stretched out on her back. Above the dead had been laid soil and in the next layer there was a sooty layer of stone with some bird bones. With some reservation, this layer can be interpreted as an applied layer in connection with ceremonies at the burial. A couple of flints have been interpreted as grave goods. The skeleton was C14 dated to the Early Neolithic I.

A tooth sample from this individual was analysed, NEO046.

Literature: Rudebeck 1986[265]; Frejd & Rudebeck 2013[266]; Berggren 2018[267]; Malmö Museum archive.

Turkmenistan

Monjukly Depe. Settlement.

Elizaveta V. Veselovskaya and Vasilyev Sergey

An ancient Neolithic settlement on the left bank of the Tejen River (South Turkmenistan) was discovered in 1960 by archaeologist A.A. Marushchenko. Excavations were also carried out 1961 by Berdiev and 2010-2014 by Bernbeck & Pollock. Datings range ca 6000-5650 cal BC and 4800-4350 cal BC millennium BC which corresponds to the Jeyton and Anau I A cultures, i.e. Neolithic and Eneolithic [268]. The Eneolithic settlement arose on the ruins of the village of the Jeytun culture [269]. Ceramics of the late stage of the Jeytun culture, silicon drills and scrapers were found, although microplates predominate, and there are also many copper products.

The location is important for establishing regional chronology because here the Chalcolithic layers follow the Neolithic layers. However, in 2010 subsequent excavations revealed a long break in settlement between the end of the Neolithic settlement (layers XV, 6200-5600 BC) and the Chalcolithic migration (layers IV-I, 4650-4340 BC). Based on this, the "Mean horizon" was defined here, which, apparently, is limited to the Kaka region in Turkmenistan and

precedes the phase IA of the Anau culture. Layers IV-I were excavated over a large area. They contain standard houses with a square layout and columns in the middle of the rooms. In the upper two layers, a closed open space was discovered, in which, judging by the animal bones found here, banquets took place. In the lowest layer IV, a house was found with a wall painting depicting two people, also with some abstract patterns. The inhabitants of the Monzhukli depots lived by cattle breeding and agriculture. Among herd animals, sheep and goats predominated. Cattle, as well as their skulls, played an important role at feasts. As for wild animals, the remains of gazelles and onagers were found. Barley and wheat played an important role in arable farming, and analyses potentially indicated simple irrigation. Very little pottery was produced in the Chalcolithic Monzhukli Depe. On a general level, there are ceramic parallels to the Sialk II/Ceshme Ali horizon of the Iranian highlands.

A burial ground was found with seven buried, whose bones are partially covered with ocher. Two of them are head-oriented to the north-west, the rest to the north and northeast. The anthropological type of the buried is characterised as the eastern Central Asian Mediterranean [270]. In the studied population, two anthropological types are distinguished: one Proto-European with a low and wide face, and the other having southern signs (small protrusion of the nasal bones, pronounced prognathism), which brings it closer to the South Indian anthropological type.

Literature: Korobkova 1969[269]; Ginzburg & Trofimova 1972[270]; Bernbeck & Pollock 2016[268].

Ukraine

Igren 8. Cemetery.

Alexandra Buzhilova & Natalia Berezina

Multi-layered site Igren 8 was located on the banks of the Samara River, a tributary of the Dnepr River. It was discovered in 1945 by an expedition of the Institute of Archeology of the Academy of Sciences of Ukraine [271].

Archaeologists date the site to the Neolithic – Eneolithic. The early Eneolithic age in the area is associated with local Sredniy Stog II archaeological culture [272].

Preserved bone remains reflect both the Neolithic period and later time. The bone remains are stored in the Museum of Anthropology, MSU.

According to anthropologists, the skulls are dolichocranial with a large cerebral part and with average height and width of the face; the nose is protruding [273]. According to Potekhina, two

anthropological types are represented in the Eneolithic of Ukraine: 1) massive hypermorphic variant and 2) gracile mesomorphic one. Both types are presented in the craniological series of Igren 8. The researcher notes that the gracile craniological complex in the population of this culture may be the result of mixing with representatives of the earlier Tripolie culture [274].

Literature: Dobrovolsky 1949[271]; Konduktorova 1973[273]; Telegin 1973[272]; Potekhina 1999[274].

Kleshnya III, the Seversky Donets River, Ukraine. Burial in a settlement.

Inna Potekhina

The site Kleshnya III (Claw III) was excavated by V. Man'ko and S. Telizhenko in 1998 in the Kreminsky district of the Lugansk region, Ukraine. The site is located on the cape of the floodplain terrace of the lake Kleshnya 2, on the right bank of the Seversky Donets River. Excavations revealed the settlement and burial of the Early Neolithic era, as well as the cultural horizons of the Late Eneolithic and Late Bronze Age.

For DNA analysis, bone samples were taken from the Early Neolithic and Late Eneolithic burials.

Burial No. 1 (Early Neolithic) dates to the last third of the 7th millennium BC, contained the skeleton of a woman (25-35 y.o.) buried in a stretched position, sprinkled with ocher. Above her was a child’s skull. Unfortunately, their samples did not yield results in genetic analysis.

In contrast, the burial of the Late Eneolithic era proved to be suitable for DNA analysis. Burial No. 2, NEO278 belonged to an elderly man (maturus-senilis) who suffered from a disease of the knee joint. The burial has been attributed to the Repin culture; for it, radiocarbon dates were obtained in the range from 4170 ± 60 BP to 4050 ± 60 BP (Ki-7848, Ki-7849). However, a direct date on the sample resulted in 2860±25 (UBA-40022), i.e. Bronze Age.

Literature: Manko & Telizhenko 2000[277]; 2002[278];

Lysa Gora, Lower Dnieper, Ukraine. Burial ground.

Inna Potekhina

Lysa Gora (Bald Mountain) burial ground is one of the most ancient in the group of Mariupol-type Mesolithic-Neolithic cemeteries in the Dnieper basin. The cemetery was excavated in 1959 by A. V. Bodyansky. It is situated 5 km to the west from the village of Vasylivka, Zaporizhzhya region, in an outcrop of a loessic terrace at the Kakhovka reservoir. The main part of the cemetery was covered with red ocher, this area consisted of a lens up to 60-70cm thick. There were five burial pits of round or elongated oval form, the total number of skeletons recovered exceeded 50. These included six-seven skeletons without burial pits (probably the earliest in the cemetery), eight child skeletons in pits I-III, 26 partially burnt skeletons in pits IV and V which probably comprised a single ossuary, and about six additional cremation burials. In the elongated portion were skeletons in the extended position while in the annular pit there were more than twenty human skulls. The skeletons in the grave pits were mainly in a ruined state.

The grave goods from Lysa Gora were both varied and numerous. Within the area of red ochre and the grave pits there were found sherds from 80 vessels broken during the burial rites. The pots were flat bottomed with biconical shapes and collared rims. Ornamentation usually covered the entire surface of the vessel, including its base. Stroked ornament predominated with incised and linear ornament less frequent. More than twenty flint artefacts, including large knives and knifelike blades and scrapers were found. There was a variety of ornaments among which were seven plates of boar tusk enamel of the Mariupol-type, fish teeth, deer tooth pendants and numerous annular beads of various sizes, ranging from 0.6 to 3.5cm. in diameter. They were fashioned from shale, gagate, bone and shell.

The cemetery is associated with the Neolithic habitation sites near the Dnieper rapids. The presence of a large amount of pottery in this cemetery convinced that the Mariupol-type cemeteries in the Dnieper valley and in the adjacent steppe territories were related to the Nadporizhzhya-Azov group of the Dnieper-Donets ethno-cultural community.

Two burials from Lysa Gora cemetery were sampled for DNA analysis.
Burial #3, NEO262 belongs to a 45-50 years old male. A sample of the left *Pars petrosa* was taken for DNA analysis. It was dated to 6175±35 uncal BP (UBA-40018).
Burial kv.8, NEO265 belongs to a 35-50 years old male (?). The 1st lower molar, left side, was sampled for DNA analysis. It was dated to 5276±38 uncal BP (UBA-40019).

Literature: Telegin & Potekhina 1987, pp.11-15, 110, 111[275].

Mamai Gora, Lower Dnieper, Ukraine. Burial ground.

Inna Potekhina

The Neolithic cemetery Mamai Gora is on Mamai Hill near the city of Kamyanka-Dniprovska in the Zaporizhzhya region, Ukraine. It was investigated by G.N. Toshchev in 1989-2001. 26 graves were unearthed in this burial ground. Those buried lay on their backs in a stretched position, with their heads to the east and southeast. Ocher was recorded in 13 burials, but the custom of using ocher, apparently, has not yet fully settled. The ocher was poured on the bottom before laying the person buried in the pit, it was used when filling the pit, and it covered individual bones. Most of the inventory is represented by ornaments which were obviously sewn on hats and clothes in the chest, shoulders, belt and feet. These are pendants from underdeveloped teeth of a deer, beads from mother-of-pearl shells, bone and stone. Fragments of wide flint plates and high trapezes with retouching were also found in the graves.

The Neolithic burial ground Mamai Gora is a typical representative of a large group of Mariupol-type cemeteries of the Dnieper-Donets cultural-historical region in the Northern Black Sea region. The radiocarbon dates obtained from the bones of the three burials indicate that the burial site existed in the period of about 5200-5000 (5950-5750) BC.

For genomic analysis, samples of teeth and *Pars Petrosa* bones from two burials (No. 6 and No. 9) were taken.

Burial # 6, NEO268 belonged to a 30-35 years old male. The skeleton was at a depth of 1.2m. The bones of the legs were separated by a crack and lay 0.3m below the level of the upper half of the skeleton. The man was buried in a stretched position on his back, his head to the ESE. The left arm is laid along the body, only the humerus is preserved from the right arm. At the humerus of the right hand and to the right of the skull, ring-shaped flat beads from shells (35 units) and 2 deer pendants were found. A radiocarbon date of 7055±70 BP (Ki-9193) was obtained for this skeleton.

Burial # 9, NEO270 belonged to a 45-50 years old male. The skeleton lay in an extended position on his back, his head to the SEE. The bones of the arms are stretched along the body, the face is turned to the left. On the frontal part of the skull were 37 pendants made of the deer teeth and 31 ring-shaped beads from shells, five of which with a corrugated surface. There were 14 pendants above the elbow joint of the right hand, 8 pendants above the wrist of this hand. Above the elbow and at the wrist of the left hand, 3 pendants were revealed. In

the area of the "abdomen" two "belts of deer teeth" were traced. The first “belt” consisted of 14, and the second – of 43 pendants. Under the skeleton ocher is fixed. The burial was dated twice, to 6960±70 BP (Ki-8184) and to 6823±38 uncal BP (UBA-40021).

Literature: Tuboltsev 1992[276]; Toshchev 2005 [282]; Andrukh & Toshchev 2009, P.13-34[279].

Vasilevka I, Dnepr river valley, Ukraine. Cemetery.

Alexandra Buzhilova & Natalia Berezina

Burial ground Vasilevka I was discovered in 1953 by A.V. Bodyansky on the left bank of the Dnepr River near the village of Vasilevka in the area of the modern town Dnepr, Ukraine. The excavation of the Vasilevka was done later by A.D. Stolyar (1957). On the area of about 46 square meters, 26 burials were opened. The bone remains are stored in the Museum of Anthropology, MSU.

Burials, as a rule, were single; in three cases, paired burials were recorded (Nos. 2, 14, 18). The body orientation of the head was mainly to the east. The crouched body position on the right side was most often. Some skeletons were covered partly by ochre (Nos. 2, 4, 5, 6, 7, 9, 10, 14, 14a, 17, 18a).

The river shells were found in three burials (Nos. 2, 9, 18a), stones with traces of heat treatment lay in two graves (Nos. 14, 19), and microlithic flint artifacts were found in three other graves (Nos. 10, 17, 18). Based on these findings, as well as parts of other flint tools from the cultural layer, Stolyar dated the site to the Mesolithic.

A study of the skulls showed that in the series there may be at least two anthropological components, which are reflected in two craniological complexes. The first variant demonstrates high and narrow-faced orthognathic skulls with high orbits; the second one presents the broad-faced skulls with low orbits. The first craniological complex was found also in the anthropological series of the Voloshsky burial ground − a synchronous site, which was located just 16 km from Vasilyevka 1. According to Konduktorova [273,283], the presence of several craniological variants in the Mesolithic clearly shows that the population of this territory had a different geographical origin, and the most common craniological complex could reflect the Late Palaeolithic anthropological background.

Literature: Konduktorova 1957[283]; Stolyar 1957[284]; Konduktorova 1973[273]; Grünberg 2000[285].

Vovnigi I and Vovnigi II, Dnepr river valley, Ukraine. Cemeteries.

Alexandra Buzhilova & Natalia Berezina

The burial ground of Vovnigi I (Left-bank Vovnigi) was discovered by M. Ya. Rudinsky in 1949. The site was excavated on the left bank of the Dnepr River in front of the village of Vovnigi, Solonyansky district. Numerous burials have been discovered in the mainland loess. They were densely stacked in a row, one burial was next to another, and often one was above the other. In total, 31 burials were opened. The bone remains are stored in the Museum of Anthropology, MSU.

The orientation of the buried was along the north-south line, and body orientation of the head was to the southeast. The burials, located in the central part, were richly covered by ochre; and no ochre was found in peripheral burials. Studying the positions of the bodies, the researcher suggested that the bodies were strongly pulled together in several places or swaddled [286]. The burial ground was used over a long time. Graves formed at close range and at about the same depth gradually formed one large pit. According to Rudinsky, such a cluster can be considered as a kind of ossuary. Samples N° 9481, 9482, 9483, 9484, 9487.

The burial ground of Vovnigi II (Right-bank Vovnigi) was located on the right bank of the Dnepr River in the centre of the village of Vovnigi, Solonyansky district. Rudyansky excavated about 100 square metres and opened 130 burials in 1952. Part of the bone remains is stored in the Museum of Anthropology, MSU, Moscow (63 burials) and another part is in the Museum of Anthropology and Ethnography, RAS (Kunstkamera), St. Petersburg (37 burials).

The burials located in the central part were covered by ochre; and, the same as in the site of Vovnigi I, no ochre was found in the peripheral burials [286]. The researcher identified three groups of burials: 1) in the northwestern sector, the burials lay along the north-south line, and partially some burials overlapped the others; 2) in the northeastern sector, the burials did not overlap and were located more freely one from another; 3) in the central part of the site there is a massive multi-layer accumulation of burials. The orientation of the bodies of those buried was the same as in the site of Vovnigi I. Samples N° 9840, 9844, 9874, 9876, 9879, 9892, 9864.

Rudyansky [286] notes that there are no significant archaeological finds to give a fairly narrow chronological interval for both monuments. In his opinion, both sites were formed during the Neolithic. Based on some features of burials, the author stressed that these may be late Neolithic burials.

A partial sample of Vovnigi II, housed in St Petersburg, has been dated to 5,470–4,783 cal BC (OxA-5938, OxA-5939, and OxA-5940) [287].

Anthropologists did not reveal any differences between the anthropological sequences of the two burial grounds. In many ways, the skulls are very close to the Late Palaeolithic skulls of Europe [288,289]. Previous aDNA analyses were published by Jones et al. [97].

Literature: Rudinsky 1955[286]; Konduktorova 1956[288]; Gokhman 1966[289]; Telegin et al. 2003[290]; Lillie & Budd 2011[287]; Jones et al. 2017[97].

Voloshskoe, Dnepr river valley, Ukraine. Cemetery.

Alexandra Buzhilova & Natalia Berezina

The burial ground of Voloshskoe was discovered in 1952 during archaeological explorations by A.V. Bodyansky on the bank of the Dnepr River near the village of Voloshskoe in the area of the modern town Dnepr, Ukraine. During the work Bodyansky excavated nine graves and later V.N. Danilenko finished the excavation of the site [291]. In total there were 18 burials (19 individuals). The skeletal remains are stored in the Museum of Anthropology, MSU.

Most burials were single, with grave No. 8 a paired burial (man and woman). The most common burial rite was a variant of the crouched body position (11 individuals), with the head oriented to the southeast. Moreover, 10 remains were buried lying on the right side (burials No. 1, 2 and 4 - 10), and one person laid on the left side (No. 3). The second group includes graves with remains lying on the back and oriented with their heads in the southeast.

According to Danilenko [291], the burial ground was located on the second loess terrace of the Dnepr River, that is, at the same level as the final Palaeolithic sites of the region. Archaeological analysis allowed the researcher to confirm that most of the burials belong to the Epipalaeolithic period. Both archaeologists and anthropologists note the heterogeneity of the group, and one of the reasons could be that the burial place was used for a long time [273,291–293]. The sex and age structure of the group indicates a clear male prevalence. In addition to a small number of women, only one immature individual was noted in the sample. The group does not differ from other Late Palaeolithic and Mesolithic samples of its structure. This period is characterised by the burial of mostly men, and very rarely women or immature individuals. The average age at death refers to the maximum values of this indicator, according to palaeodemography of the Mesolithic groups [294]).

Palaeopathological analysis divides this group between two patterns of trauma. The first includes two cases with healed skull injuries (Nos. 6 and 17) and persons without any traumas. The second sample includes individuals buried with evidence of postmortem body

manipulations and/or perimortem traumas of the skull that could have caused death (Nos. 3, 13, 14, 15 and 16). This group demonstrates episodes of aggressive intrusions and skirmishes in the area [295]. Sample 9881

Literature: Danilenko 1955[291]; Debetz 1955[292]; Telegin 1957[293]; Alexeev 1972[294]; Konduktorova 1973[273]; Buzhilova & Berezina 2016[295].

Volnensky, Dnepr river valley, Ukraine. Cemetery.

Veselovskaya Elizaveta V. & Vasilyev Sergey

The burial ground is located on the left bank of the Dnieper River above the currently flooded Volny rapids, near the city Zaporozhye. Excavations were carried out in 1956 by an expedition of the Institute of Archeology of the Ukrainian SSR [293]. The site belongs to the Dnieper-Donetsk culture, which existed on the territory of the Dnieper Nadporozhye in the Neolithic era from the fifth to the beginning of the third millennium BC. The burial ground is a tribal cemetery, in which burials were carried out over many generations. Stratigraphy and ritual features make it possible to distinguish three groups of burials of different times [296] single burials in elongated rounded “nest” pits; 2) collective burials in square graves; 3) single burials in small shuttle-visible (in the form of a boat) pits. The buried were laid on their backs in an extended position, covered with ocher. Funeral equipment is extremely poorly preserved.

Despite the differences in the funeral ritual in anthropological terms, the series from the Volnensky burial ground turned out to be homogeneous. The skulls are exceptionally large, massive, with a strongly pronounced relief, with a long and wide cerebral part. The forehead is wide, sloping. The face is very tall and wide, orthognathic, strongly profiled in the horizontal plane, and canine fossae are deep. Orbits are low. The nose is high, strongly protruding. The lower jaw is very large and massive [297]. The unique skull features are estimated as proto-European type, having no analogies in the Neolithic of Western Europe and Western Asia.

Literature: Telegin 1957[293]; 1968[296]; Surnina 1961[297].

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8) ^{14}C chronology and estimates of reservoir effects

Karl-Göran Sjögren[1] and Anders Fischer[1,2]

[1]Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

[2]Sealand Archaeology, Gl. Røsnæsvej 27, 4400 Kalundborg, Denmark

In total, 317 samples were successfully genome sequenced, of which two (NEO901 and NEO902) were only used for imputation due to unexpectedly late dating. In the present project, 272 new ^{14}C dates were produced. They were measured either on the same samples that were analysed for DNA or on other samples from the same individuals. Most of the dates (274 samples, 32 of which failed) were performed at the ^{14}CHRONO Centre laboratory at Queen's University, Belfast. Sample pretreatment and laboratory protocols have been described by Reimer et al. [1]. Some additional samples were analysed by the Oxford Radiocarbon Accelerator Unit (ORAU) laboratory (24 samples) and by the Keck-CCAMS Group, Irvine, California, USA (6 samples). Laboratory procedures at these labs are described in Brock et al. [2] and Beaumont et al. [3]. All new samples were also analysed for δ^{13}C and δ^{15}N in order to evaluate diet and possible reservoir effects. In addition, collagen quality values were measured systematically. The great majority of samples were within the range for well preserved collagen (C/N 2.9-3.6). For 32 samples, dating failed due to small sample sizes or low collagen content, however. Ten of these could be re-dated with new samples, but this was not always possible.

We also collected previously produced dates and isotope values for the graves/individuals in question, e.g. [4]. In cases where several radiocarbon measurements have been made on samples from the same individuals, a quality assessment was made of the available dates, avoiding outliers and less credible older radiometric dates. For the remaining cases, combined dates were calculated in Oxcal, unless χ^2-testing suggested the samples were not contemporary and should be treated as representing different individuals.

In all, 302 of the 317 samples are directly dated. For 15 samples, no direct dating was possible. In these cases, dates were estimated based on archaeological context. This includes one case (NEO587, Kongemose) where contamination from preservatives was suspected. Instead, a date from the genetically close relative NEO932; Tudse Hage) was used.

All relevant ^{14}C dates are presented in SI Tables II-IV. Supplementary Table II shows radiocarbon ages after evaluation and combination of dates. Dates were calibrated in Oxcal online ver 4.3 using the Intcal20 calibration curve (Reimer et al. 2020). Supplementary Table III contains the calculation of these corrections, the results of which are inserted also in Table II. For calculation and presentation purposes, midpoints of both the uncorrected and the corrected date ranges were calculated. Supplementary Table IV contains all raw data pertaining to the sampled individuals.

Reservoir effects

For samples from coastal regions, a marine reservoir effect (MRE) may be considered. Marine reservoir effects vary over time and space [5,6]. Marine reservoir effects are expressed either as deviation from a known age, R(t), or as ΔR, i.e. deviation from the global marine calibration curve (Marine13, [7]). Corrections can be made in two ways [6,8–10]. The first is subtraction of a diet-weighted fraction of R(t) from the measured BP value, and then calibration by the atmospheric calibration curve. The second method is to use a diet-weighted fraction of the ΔR value and then use the marine curve for calibration. Here we use the first method, as ΔR values are not available for all areas sampled. Regional values for R(t) and/or ΔR are taken from publications (see Table S8.1). There are some sources of uncertainty due to small scale variation and variation over time, which must be kept in mind but cannot be taken into account here.

Area	Country	R(t)	1s	ΔR	1s	Comment	Source
Kola peninsula	Russia	392		-8	53	modern value	Chrono database (Reimer & Reimer 2001[11])
S Norway	Norway	380	30				Günther et al. 2018[12]
Jutland, Limfjorden	Denmark	375				Brackish, variable over time. Mean of 3 values	Philippsen et al. 2013[13]
Jutland east coast	Denmark	350					Olsen et al. 2009[14], 2017[15]; Larsen et al. 2018[16]
Jutland west coast	Denmark	400				modern value	Standard ocean value
Nekselø, Zealand	Denmark	273	18			used for E Denmark	Fischer & Olsen 2021[17], cf Philippsen 2018[18]
SE Baltic	Latvia	190	43			Brackish, variable over time	Piličiauskas & Heron 2015[19]
Atlantic coast	Portugal	495		95	15		Monge Soares et al. 2016[20]
Cantabria	Spain	256	56	-105	21		Monge Soares et al. 2016[20]
Bohuslän	Sweden	259	59	-51	48	modern value	Chrono database (Reimer & Reimer 2001[11])
Scotland	UK	330	48	-126	39		Russel et al. 2015[21]; Ascough et al 2017[22]
Adriatic		378	44	28	45	without mussels	Faivre et al. 2015[23]
Aegean		480	72	154	52		Reimer & McCormac 2002[24]; Facorellis & Vardala-Theodorou. 2015[25]
W Mediterranean		400	22	40	14		Reimer & McCormac 2002[24]
Mediterranean		390	15	45	14	except Aegean	Siani et al. 2000[26]; Reimer & McCormac 2002[24]

Table S8.1. Values used for calculation of reservoir effect corrections and sources.

Samples from inland sites are assumed not to be influenced by marine reservoir effects. This is a simplification but the issue cannot be resolved without local reference data and detailed knowledge about mobility patterns.

For coastal sites, the degree of marine protein intake is calculated as a linear interpolation between a marine and a terrestrial endpoint. Again, this is a simplification, but modelling of dietary fractions requires detailed knowledge of isotopic values throughout the food chain, and this is only available for some of the study areas, e.g. Denmark. Endpoint values used here are:

- Denmark: $\delta^{13}C$ -21.7 to -10.1‰ were originally measured on coeval local fish and terrestrial fauna [4,cf. 27]. For the sake of stressing uncertainties, we here use the rounded end values of -21‰ and -10‰
- Atlantic coast: $\delta^{13}C$ -21.8 to -12‰ [28] (fauna values offset by +1‰)
- Mediterranean: $\delta^{13}C$ -21 to -11.8‰ [28] (fauna values offset by +1‰).

Reservoir effects in brackish and freshwater environments (FRE) are more difficult to estimate, due to large variation over time, between lakes/estuaries, within lakes/estuaries, and between different fish species within one and the same water system.

The present study includes individuals from the brackish systems of the Limfjord (Denmark) and the Baltic. For the former we use estimates by Philippsen et al. [13]. Reservoir effects in the Baltic Sea have been discussed by several authors, e.g. Hedenström & Possnert [29], Lougheed et al. [30,31], Piličiauskas & Heron [19]. Only two of our individuals (Skateholm I and Sope) are located by the coast of this brackish environment. In these cases there was no need for correction for marine reservoir effect, as direct dating of the former was unsuccessful, whereas the latter had a completely terrestrial $\delta^{13}C$ signal.

Freshwater reservoir effects have been treated in a number of publications, some of which are relevant to our samples. This for instance applies to samples from Aamose [32], Iron Gates [33], Zvejnieki [34], Dnepr rapids [35,36], Lake Baikal [37,38] , Sakhtysh and Minino [39,40]. We have used these estimates where relevant. For other published values, see Kulkova et al. [41], Svyatko et al. [42], Losey et al. [43], Ramsey et al. [44]. However, for some areas there are no such values available. This concerns mostly sites in Russia. For forest areas where no direct estimates have been published, we use a standard FRE of 500 years.

Another problem is to estimate the dietary contribution of freshwater protein. In some cases, such as Lake Baikal [37], this has been shown to be proportional to $\delta^{15}N$, although other sites show no clear correlation [40]. In the latter case, the relation may be obscured by chronological

or other types of variation. In inland regions, freshwater fish consumption is also indicated by low $\delta^{13}C$ values [27,35,45,46]. This is clearly visible in our samples from Ukraine and western Russia.

Isotopic signatures in most of our samples from Scandinavia on the other hand do not suggest very high levels of freshwater fish consumption, as $\delta^{13}C$ is mostly higher than -21‰ and in cases where it is lower than this, $\delta^{15}N$ is also low (<13‰), even for Mesolithic samples. Further, there is a positive correlation between $\delta^{13}C$ and $\delta^{15}N$ values, suggesting two-component mixing between terrestrial and marine sources. Only a few samples deviate from this pattern (Figures S10.1-S10.2).

In this context, we follow regional recommendations, where such are available (eg. Lake Baikal). In most cases, method 2 of Cook et al. [33] (see also Boric & Miracle [47]) is applied. This method does not involve attempts to estimate the proportion of freshwater protein but only groups the $\delta^{15}N$ values into three classes: <11‰, 11-13‰, and >13‰. This translates to 0%, 50% and 100% of the maximum FRE value. This is a coarse estimate, but has the merit of not introducing false precision into the estimates. It can be stressed that large uncertainties and high variability are at hand in the baseline values.

Steppe and arid regions of Russia and Kazakhstan present further problems in distinguishing the effect of freshwater diet from those of environmental factors such as elevation and aridity, which lead to elevated $\delta^{15}N$ in both plants, animals and humans. A further complication arises from the possible consumption of C4 plants, eg. millet, which may elevate $\delta^{13}C$ values. A number of studies [48–51] have published FRE estimates, which are followed here. These range c. 200-400 years.

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9) Bayesian chronological models of the transition applied on radiocarbon and genomic results

Bettina Schulz Paulsson[1]

[1]Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

Introduction

Previous analyses of the temporality of ancient genomes produced coarse chronologies, which tend to mask possible short-term events such as population movement, pandemics or socio-cultural changes. To this end, we adopted a Bayesian approach for the radiocarbon dates of the core region of Denmark. With this approach it is possible to unify radiocarbon results, detailed archaeogenetic information, and the high precision curve into one calibration process [e.g. 1–13], thereby gaining greater precision.

We established a highly precise chronology for altogether 81 radiocarbon dates from 64 Danish sites focusing on calculating the times of transition and overlaps of the hunter-gatherer and Neolithic genetic ancestries and defining possible Neolithic movements. There were not sufficient Bronze Age results available to calculate the transition of Neolithic-Bronze Age ancestries.

All the models and calibrated data presented in this analysis have been performed utilising OxCal v4.4 [4,7,9,10] and forms of outlier analysis and the calibration dataset from Reimer et al. [14], Intcal20. OxCal can accomplish automated 'wiggle matching' and calculate probability distributions for samples in sequences and phases.

For the Bayesian approach, the models had to be defined first in OxCal in sequences and phases making use of all available information generated from the human remains (such as the genetic ancestries, or vertical and horizontal stratigraphy). Depending on the problems or questions that arose, boundaries were determined and incorporated into the model structure. The program first calculates the probability distribution of each radiocarbon result and then attempts to reconcile this information by a repeated sampling of the distribution of these dates with the information previously determined. Thus, it builds up a set of solutions consistent with the structure of the model [6,10,14].

A trapezoidal phase prior [15,16] is used in a contiguous framework to model the transitional phases of the different ancestry groups. For the reconstruction of the movement of the Neolithic farmers we tested different models defining the phases by taking possible horizontal stratigraphies of the sampled material into consideration. Posterior beliefs are expressed as probability distributions known as 'posterior density estimates' and they are always given in *italics.*

Materials

From 102 radiocarbon dates from Danish contexts, 81 were applicable from individuals with hunter-gatherer and Neolithic anchestries for the Bayesian models (the remaining data stem from Bronze Age individuals).

We corrected the reservoir effect on bones with significantly elevated isotope values ($\delta^{13}C$ -18.00 and $\delta^{15}N$ +12.00) directly in the models using previously defined reservoir ages and calculated the DRE (diet reconstruction estimates) for the individual in ^{14}C years based on the collagen isotope values (SI Note 8, SI Table III-IV; for a similar method see [17,18].

Reservoir ages affected predominantly samples with hunter-gatherer ancestry. The values for the Neolithic populations indicate a mainly terrestrial diet and in most cases there is no clear evidence for reservoir effects on human bones. For combining radiocarbon dates that are related to the same individual we used the R_Combine() function. For four of the radiocarbon dates the X-Test failed (Viksø Mose /X-Test failed at 5% df=1 T=3.849(5% 3.8, Tudse Hage, X2-Test: df=1 T=7.510(5% 3.8), Dragsholm B X2-Test: df=3 T=24.652(5% 7.8). Here were the earlier data excluded from the models, they might exhibit a rest contamination or.

Furthermore we excluded the earliest data (n=5), all from the Kongemose phase (7-8th millennium cal BC) to calculate the time interval for the transition to Neolithic farmer ancestry more accurately.

OxCal Model Details and Outputs

The datasets in figures S9.1, S9.2, S9.7 and S9.88 provide the OxCal model details and outputs for the Bayesian statistical framework of the analysis. OxCal´s chronological query language (CQL) was defined in Bronk Ramsey [9,10] and the model specifications are presented in this form. Figures S9.2 and S9.8 illustrate model outcomes, including the un-

modelled and modelled calibrated ranges in their 68.2% and 95.4% probability. In order to test for unreliable chronological models or intrusive material, the agreement index A is calculated to exclude inconsistencies from a model. This has a value of ~100%, sometimes it is higher and it can fall down to 60%. The agreement index A overall is calculated as a whole for the model, 5 which is likewise ~100%, it should not fall below 60%. These two indices represent a threshold value analogue to the 0.05 significance level in a χ^2-test. Furthermore, a posterior outlier probability is calculated for each of the radiocarbon dates in the models and represented with the model outcomes in the datasets (figures S9.2 and S9.8).

Trapezoidal Model for Calculating the Hunter-Gatherer/European Farmer Ancestry Transition Phase

In this study, we used a trapezoidal phase prior [15,16] instead of a uniform prior (for abrupt transition) for calculation the transitional time intervals
because:

• The different phases can be overlapped, indicating transitional periods.
• Changes in the genetic ancestries across whole regions can be characterised as slow, non-instantaneous processes such as e.g. migrations. These processes probably lasted for a longer period of time

This framework assumes that the different phases and genetic ancestries (hunter-gatherer, European farmers) are contiguous to each other and thus also allows time periods representing phases of transition. The trapezoidal models are used to calculate the highest probability for the co-existence of the groups, e.g. the time interval from the earliest possible appearance of the first farmers to the last hunter-gatherer DNA. Such a trapezoid model produces information across three components: first, a gradual increase (introductory period); then, a period of constant rate of activity (blooming period); and finally, a gradual decrease (period of decline) [16].

Results

Trapezoidal Model Outcomes for the Hunter-Gatherer/European Farmer Transition

A Bayesian trapezoidal model was applied on 81 radiocarbon dates with genomic data from altogether 64 individuals. For a subset of these individuals we had several radiocarbon dates

from partly different AMS-laboratories at our disposal. For combining radiocarbon dates that are related to the same individual we used the R_Combine() function. The presented end model shows with Amodel 104.4 and Aoverall 90.2 a very high agreement. The resultant model for the end date of this transition shows very high agreement between A_{model}=104.4 and $A_{overall}$=90.2 (Figure S9.1).

The individuals with Hunter-Gatherer genomes were corrected with regional reservoir ages of between 350y and 250y (for the reservoir ages see SI part 8 and Table 3-4). The sequence starts with an individual from Røntesten, which is calculated to *6217-5920 cal BC (95.4%; 6079-5990 cal BC, 68.2%).*

The Western Hunter-gatherer genetic ancestry component is declining in Denmark at the transition from the 5th to the 4th millennium cal BC. The last known Hunter-Gatherer in this phase is represented by the individuals from Rødhals and Ravnsbjerggård (Rødhals, *3961-3811 cal BC, 68.2%; 4035-3769 cal BC, 95.4*% and Ravnsbjerggård *3965-3809 cal BC, 68.2%; 4040-3716 cal BC, 95.4%*).

The earliest known individual with Neolithic Farmer genetic ancestry is from Viksø Mose (5050 +/- 15 BP, UCIA-232706). The death of this individual is thus calculated to *3934-3774 cal BC (95.4%; 3880-3782 cal BC, 68.2%),* followed by Tysmose II *3791-3645 cal BC (95.4%; 3752-3653 cal BC, 68.2 %*).

The gradual increase or the introductory period of the Early European Farmers ancestry in Denmark proceeds within *4085-3796 cal BC (95.4%; 3965-3824 cal BC, 68.2%).* The time intervals for the 95.4% probability of the latest Hunter-Gatherer and the early European farmer are overlapping and the transition from the earliest possible European Farmer DNA to the last possible Hunter-Gatherer proceeded relatively fast between *186-416 years (68.2%)* and *93-579 years (95.4%)* (figures S9.3-5). These values represent the maximal possible overlaps or co-existence of the two genomic groups. The final transition from hunter-gatherer to European farmer DNA occurs between *3735-3458 cal BC (95.4%; 3668-3538, 68.2%)*. Within this time interval the last HG ancestry genomes in Denmark are identified. Radiocarbon measurements for 38 individuals with European farmer genetic ancestry were utilised in these calculations. These individuals are present in Denmark until *2886-2619 cal BC (95.4%; 2876-2737 cal BC, 68.2%,* Stenderup Hage, UBA-39152). The duration of the Neolithic period is thus calculated to between *936-1010 years, 68.2%* and to between *876-1100 years 95.4%* (figure S9.6). Genetically European farmer individuals were present around 1000 years in Denmark before replacement by genetically Bronze Age individuals.

In the Middle Neolithic, ~200-300 years after the death of the last possible hunter-gatherers, new hunter-gatherer groups from the Scandinavian peninsula reached the Danish coasts. Vittrup Man belongs to this group. He died between *3368 and 3104 cal BC* (95.4%; *3363-3125 cal BC,* 68.2%).

```
Plot()
 {
  Sequence(Neolithisation Denmark)
  {
   Boundary("Start 1")
   {
    Start("Start of Start 1");
    Transition("Period of Start 1");
    End("End of Start 1");
   };
   Phase("Ancestry Group Hunter-Gatherer
West")
   {
    Delta_R("DRE Røntestenen,AAR-11355",
350,40);
    R_Date("Røntesten,AAR-
11355",7542,42);
    Phase(Orehoved Sejlrende)
    {
     Delta_R("DRE Orehoved Sejlrende,UBA-
37880", 273,18);
     R_Date("Orehoved Sejlrende,UBA-
37880",7505,36);
     Delta_R("DRE Orehoved Sejlrende, UBA-
38222 ", 273,18);
     R_Date("Orehoved Sejlrende, UBA-
38222",7415,53);
    };
    Delta_R("DRE Vedbæk Boldbaner,Ua-
23792", 273,18);
    R_Date("Vedbæk Boldbaner,Ua-
23792",7115,55);
    Delta_R("DRE Tybrind Vig,AAR-9342 ",
350,40);
    R_Date("Tybrind Vig,AAR-9342",6905,55);
    Delta R("DRE Tudse Hage,UBA-
38242,273,18")
    R_Date("Tudse Hage,UBA-38242",6608,47);
    Delta_R("DRE Korsør Nor,K-4263",
273,18);
    R_Date("Korsør Nor,K-4263",6760,75);
    Delta_R("DRE Koed IV,UBA-35710",
350,40);
    R_Date("Koed IV,UBA-35710",6443,44);
    Delta_R("DRE Bodal K,UBA-38238",
273,18);
    R_Date("Bodal K,UBA-38238",6435,44);
    Phase(Bøgebakken, Vedbæk)
    {
     Delta_R("DRE Ua-23787", 273,18);
     R_Date("Ua-23787",6420,70);
     Delta_R("DRE UBA-35717", 273,18);
     R_Date("UBA-35717",6298,58);
     Delta_R("DRE Ua-23794", 273,18);
     R_Date("Ua-23794",6260,75)
     Delta_R("DRE Ua-23784", 273,18);
     R_Date("Ua-23784",6140,50);
     Delta_R("DRE Ua-23786", 273,18);
     R_Date("Ua-23786",6060,60);
    };
    Delta_R("DRE Koed I,UBA-39552",350,40);
    R_Date("Koed I,UBA-39552",6400,37);
    Delta_R("DRE Fannerup F, AAR-19687",
350,40);
    R_Date("Fannerup F, AAR-
19687",6377,30);
    Phase(Dagsholm)
    {
     Delta_R("DRE AAR-8725", 273,18);
     R_Date("AAR-8725",6310,60);
     R_Combine Delta_R ("DRE A
Dragsholm",273,18)
     {
      R_Date("AAR-7414-2",6209,40);
      R_Date ("NZA-15676",6208,60);
      R_Date("AAR-7414",6187,43);
      R_Date("NZA-15953",6115,60);
     };
     R_Combine Delta_R("DRE B Dragsholm",
273,18)
     {
      R_Date("NZA-15954",6030,55);
      R_Date("NZA-15678",6002,60);
     };
    };
    Delta_R("DRE Nederst,AAR-28401",
350,40);
    R_Date("Nederst,AAR-28401",6289,45);
    Delta_R("DRE Korsør Nor,AAR-10246",
273,18);
    R_Date("Korsør Nor,AAR-10246",6263,36);
    R_Combine Delta_R("DRE Holmegard-
Djursland", 350,40)
    {
     R_Date("OxA-533",6080,80);
     R_Date("K-3559",6030,80);
    };
    Delta_R("DRE Havnø,UBA-39153", 350,40);
    R_Date("Havnø,UBA-39153",5947,33);
    Delta_R("DRE Fannerup E, UBA-35705",
350,40);
    R_Date("Fannerup E,UBA-35705",5911,43);
    Delta_R("DRE Fannerup F, AAR-28400",
350,40);
    R_Date("Fannerup F, AAR-
28400",5821,37);
    Delta_R("DRE Bjørnsholm,UBA-35718",
375,40);
    R_Date("Bjørnsholm,UBA-35718",5792,41);
    Delta_R("DRE Norsminde,AAR-8556",
350,40);
    R_Date("Norsminde, AAR-8556",5800,35);
    Phase(Ertebølle)
    {
     Delta_R("DRE UBA-35704", 375,40);
     R_Date("UBA-35704",5611,53);
     Delta_R("DRE UBA-31308", 375,40);
     R_Date("UBA-31308",5690,34);
    };
    Delta_R("DRE Vængesø, K-3921", 350,40);
    R_Date("K-3921",5540,40);
    Delta_R("DRE Sølager, K-3921", 273,18);
```

```
    R_Date("Sølager, K-3921",5540,40);
    Delta_R("DRE Langø Skaldynge, UBA-
37896", 273,18);
    R_Date("Langø Skaldynge UBA-
37896",5496,57);
    Delta_R("DRE Rødhals,AAR-8552",
273,18);
    R_Date("Rødhals,AAR-8552",5360,50);
    Delta_R("DRE Ravnsbjerggård,AAR-10993",
260,40);
    R_Date("Ravnsbjerggård, AAR-
10993",5308,43);
    R_Date("Dragsholm II/D, AAR-7416-
2",5102,37);
   };
   Boundary("Transition 1/2")
   {
    Start("Start of Transition 1/2");
    Transition("Period of Transition 1/2");
    End("End of Transition 1/2");
   };
   Phase("Ancestry Group Farmer Central
Europe")
   {
    R_Date("Viksø Mose, UCIA-
232706",5050,15);
    R_Date("Tysmose II,UBA-35722",4959,43);
    R_Date("Roskilde Fjord,UBA-
37910",4939,45);
    R_Date("Pandebjerg, UCIAMS-
232705",4910,15);
    Phase(Rude)
    {
     R_Date("UBA-37877",4901,37);
     R_Date("UBA-37876",4838,29);
     R_Date("UCIAMS",4725,15);
    };
    R_Date("Sigersdal Mose,UBA-
39125",4853,29);
    R_Date("Tissøe,UBA-39159",4846,53);
    R_Date("Lohals Nord,UBA-
35699",4843,40);
    R_Date("Bygholm, grav I,UBA-
38227",4836,35);
    R_Date("Grøfte A,UBA-38228",4828,35);
    R_Combine("Salpetermosen")
    {
     R_Date("AAR-21343",4789,25);
     R_Date("AAR-21344",4752,29);
    };
    R_Date("Dalmosegaard (Borre),UBA-
39141",4774,52);
    R_Date("Sejerby (Sejerø,UBA-
35721",4746,45);
    R_Date("Lundby-Falster,UBA-
40439",4743,31);
    R_Date("Jorløse Mose,AAR-
11122",4720,40);
    R_Date("Porsmose ,K-3748",4710,90);
    R_Date("Vig Femhøve, UBA-
37893",4709,52);
    R_Date("Mandemarke, UBA-
39554",4698,32);
    R_Date("Femhøve,UBA-37893",4709,52);
    R_Date("Lendemark,UBA-39554",4698,32);
    R_Date("Lundby-Falster,UBA-
39128",4688,31);
    R_Date("Sludegård Sømose,UBA-
39145",4688,56);
    R_Date("Læsten Mose,UBA-
39151",4674,51);
    R_Date("Elkenøre,UBA-40440",4647,31);
    R_Date("Døjringe I,UBA-40108",4629,31);
    R_Date("Jørlundegaard,UBA-
35714",4619,41);
    R_Date("Vibygårds Mose,UBA-
39147",4573,33);
    R_Date("Storelyng (Øgårde boat III), K-
3746",4570,60);
    Phase(Hunter-Gatherer Baltic)
    {
     R_Combine (Vittrup)
     {
      R_Date("UBA-39121",4565,29);
      R_Date("UBA-29904",4464,52);
     };
     Delta_R ("DRE Svinninge Vejle, UBA-
37912",273,18);
     R_Date("Svinninge Vejle, UBA-37912",
4539,72);
    };
    R_Date("Storelyng Østrup,AAR-
10248",4523,37);
    R_Date("Neverkær Mose I,UBA-
38232",4518,33);
    R_Date("Avlebjerg,UBA-40443",4510,32);
    R_Date("Vanløse Mose II,AAR-
10994",4485,41);
    R_Date("Kainsbakke,AAR-21424",4464,29);
    R_Date("Klokkehøj,UBA-35708",4086,42);
    R_Date("Stenderup Hage,UBA-
39152",4072,61);
   };
   Span("Neolithic ancestry");
   Interval("Neolithic");
   Boundary("End 2")
   {
    Start("Start of End 2");
    Transition("Period of End 2");
    End("End of End 2");
   };
  };
 };
```

Figure S9.1. CQL code for the trapezoidal model of the Hunter-Gatherer West/European Farmer transition.

Name Show all Show structure	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices A_{model}=104.4 $A_{overall}$=90.2				
	from	to	%	from	to	%	from	to	%	from	to	%	A_{comb}	A	L	P	C
▼ Sequence Neolithisation																	
▼ Boundary Start 1							-5728	-5159	68.3	-6140	-5078	95.4					98.1
Start Start of Start 1							-6639	-6217	68.3	-6995	-6104	95.4					99.1
Transition Period of Start 1							1416	2715	68.3	0	3030	95.4					95.3
End End of Start 1							-4968	-3850	68.3	-6138	-3817	95.4					98.1
▼ Phase Ancestry Group Hunter-Gatherer West																	
Delta_R DRE Rønnestenen,AAR-11355	308.5	391.5	68.3	270	430	95.4	310	395.5	68.3	265	435	95.4		96.7			99.8
R_Date Rønnestenen,AAR- 11355	-6207	-5987	68.3	-6221	-5925	95.4	-6079	-5990	68.3	-6217	-5920	95.4		103.9			99.7
▼ Phase Orehoved																	
Delta_R DRE Orehoved Sejlrende,UBA-37880	253	293	68.3	236	310	95.4	252.5	291	68.3	234.5	309.5	95.4		97.6			99.9
R_Date Orehoved Sejlrende,UBA- 37880	-6214	-6024	68.3	-6221	-6017	95.4	-6206	-6019	68.3	-6218	-6014	95.4		103.8			99.8
Delta_R DRE Orehoved Sejlrende, UBA-38222	253	293	68.3	236	310	95.4	255	293.5	68.3	237.5	310.5	95.4		99.5			99.9
R_Date Orehoved Sejlrende, UBA-38222	-6064	-5931	68.3	-6210	-5887	95.4	-6061	-5927	68.3	-6086	-5853	95.4		99.1			99.8
Delta_R DRE Vedbæk Boldbaner,Ua-23792	253	293	68.3	236	310	95.4	254.5	291	68.3	235.5	310	95.4		99.4			99.9
R_Date Vedbæk Boldbaner,Ua-23792	-5780	-5663	68.3	-5842	-5629	95.4	-5772	-5661	68.3	-5841	-5627	95.4		101.2			99.7
Delta_R DRE Tybrind Vig,AAR-9342	308.5	391.5	68.3	270	430	95.4	305	390	68.3	269	433.5	95.4		98.5			99.8
R_Date Tybrind Vig,AAR-9342	-5614	-5473	68.3	-5624	-5376	95.4	-5613	-5419	68.3	-5623	-5375	95.4		99			99.7
Delta_R DRE Tudse Hage,Skælskør,UBA-38242,273,18	-0.5	0.5	68.3	-0.5	0.5	95.4	-0.5	0.5	68.3	-0.5	0.5	95.4		100			100
Delta_R DRE Korsør Nor,K-4263	253	293	68.3	236	310	95.4	255	293	68.3	237	310.5	95.4		99.8			99.9
R_Date Korsør Nor,K-4263	-5526	-5366	68.3	-5616	-5311	95.4	-5521	-5365	68.3	-5616	-5234	95.4		100.3			99.7
Delta_R DRE Koed IV,UBA-35710	308.5	391.5	68.3	270	430	95.4	307	390.5	68.3	269	430	95.4		98.7			99.8
R_Date Koed IV,UBA-35710	-5205	-4905	68.3	-5210	-4847	95.4	-5204	-4904	68.3	-5209	-4847	95.4		100			99.7
Delta_R DRE Bodal K,UBA-38238	253	293	68.3	236	310	95.4	255	290.5	68.3	236.5	309.5	95.4		101			99.9
R_Date Bodal K,UBA-38238	-5208	-5045	68.3	-5290	-4955	95.4	-5207	-5043	68.3	-5286	-4954	95.4		99.7			99.7
▼ Phase Bøgebakken																	
Delta_R DRE Ua-23787	253	293	68.3	236	310	95.4	255	291.5	68.3	236.5	310	95.4		100.3			99.9
R_Date Ua-23787	-5208	-5004	68.3	-5301	-4852	95.4	-5207	-5001	68.3	-5299	-4851	95.4		99.5			99.7
Delta_R DRE UBA-35717	253	293	68.3	236	310	95.4	255	291	68.3	235.5	310	95.4		100.2			99.9
R_Date UBA-35717	-4997	-4841	68.3	-5204	-4729	95.4	-4996	-4840	68.3	-5203	-4729	95.4		100.3			99.6
Delta_R DRE Ua-23794	253	293	68.3	236	310	95.4	254.5	291.5	68.3	236	310.5	95.4		99.4			99.9
R_Date Ua-23794	-4988	-4790	68.3	-5204	-4698	95.4	-4988	-4788	68.3	-5202	-4693	95.4		100.2			99.7
R_Date Ua-23784	-4827	-4681	68.3	-4881	-4554	95.4	-4827	-4680	68.3	-4881	-4553	95.4		99.8			99.6
Delta_R DRE Ua-23786	253	293	68.3	236	310	95.4	255	292	68.3	237	310	95.4		100.4			99.9
R_Date Ua-23786	-4710	-4551	68.3	-4789	-4494	95.4	-4708	-4551	68.3	-4788	-4494	95.4		100			99.7
Delta_R DRE Koed I,UBA-39552	308.5	391.5	68.3	270	430	95.4	312	394	68.3	269.5	430	95.4		99.9			99.6
R_Date Koed I,UBA-39552	-5028	-4848	68.3	-5206	-4793	95.4	-5010	-4847	68.3	-5206	-4792	95.4		100.2			99.5
Delta_R DRE Fannerup F, AAR-19687	308.5	391.5	68.3	270	430	95.4	314.5	390	68.3	270	429	95.4		102.3			99.7
R_Date Fannerup F, AAR-19687	-4991	-4847	68.3	-5198	-4792	95.4	-4988	-4847	68.3	-5047	-4791	95.4		100.2			99.6
▼ Phase Dagsholm																	
Delta_R DRE AAR-8725	253	293	68.3	236	310	95.4	255	291.5	68.3	236	310	95.4		100.1			99.8
R_Date AAR-8725	-5008	-4841	68.3	-5207	-4732	95.4	-5006	-4841	68.3	-5206	-4731	95.4		100.6			99.6
R_Combine DRE A Dragsholm	-5206	-4461	68.3	-5473	-4256	95.4	-5057	-4451	68.3	-5467	-4237	95.4		101			99.2
R_Combine DRE B Dragsholm	-4950	-4331	68.3	-5301	-3995	95.4	-4927	-4268	68.3	-5215	-3991	95.4		101.6			99.1
Delta_R DRE Nederst,AAR-28401	308.5	391.5	68.3	270	430	95.4	305.5	389	68.3	266	429.5	95.4		99.5			99.8
R_Date Nederst,AAR-28401	-4897	-4725	68.3	-4988	-4695	95.4	-4896	-4725	68.3	-4987	-4691	95.4		100.2			99.6
Delta_R DRE Korsør Nor,AAR-10246	253	293	68.3	236	310	95.4	255	290	68.3	235	310	95.4		100.7			99.9
R_Date Korsør Nor,AAR-10246	-4936	-4804	68.3	-4996	-4784	95.4	-4936	-4802	68.3	-4996	-4736	95.4		99.9			99.7
R_Combine DRE Holmegard-Djursland	-5205	-4261	68.3	-5478	-3951	95.4	-5019	-4251	68.3	-5378	-3952	95.4		102.5			99
Delta_R DRE Havnø,UBA-39153	308.5	391.5	68.3	270	430	95.4	312	387	68.3	268	419.5	95.4		103.8			99.8
R_Date Havnø,UBA-39153	-4456	-4360	68.3	-4537	-4347	95.4	-4456	-4360	68.3	-4536	-4346	95.4		100.1			99.7
Delta_R DRE Fannerup E, UBA-35705	308.5	391.5	68.3	270	430	95.4	303.5	379.5	68.3	264.5	422	95.4		101.5			99.8
R_Date Fannerup E,UBA-35705	-4447	-4352	68.3	-4536	-4271	95.4	-4446	-4351	68.3	-4535	-4271	95.4		100.1			99.6
Delta_R DRE Fannerup F, AAR-28400	308.5	391.5	68.3	270	430	95.4	316	410	68.3	264	443.5	95.4		91.5			99.6
R_Date Fannerup F, AAR-28400	-4361	-4252	68.3	-4448	-4172	95.4	-4361	-4251	68.3	-4448	-4172	95.4		99.9			99.5
Delta_R DRE Bjørnsholm,UBA-35718	333.5	416.5	68.3	295	455	95.4	349	427.5	68.3	308.5	467	95.4		98.4			99.7

R_Date Bjørnsholm,UBA-35718	-4341	-4176	68.3	-4358	-4054	95.4	-4341	-4176	68.3	-4358	-4055	95.4		99.7		99.7
Delta_R DRE Norsminde,AAR-8556	308.5	391.5	68.3	270	430	95.4	324.5	408	68.3	272	446	95.4		94.9		99.8
R_Date Norsminde, AAR-8556	-4350	-4251	68.3	-4443	-4065	95.4	-4350	-4251	68.3	-4443	-4066	95.4		99.6		99.7
▼ Phase Ertebølle																
Delta_R DRE UBA-35704	333.5	416.5	68.3	295	455	95.4	325	405	68.3	288.5	446	95.4		99.7		99.8
R_Date UBA-35704	-4224	-3970	68.3	-4315	-3946	95.4	-4224	-3970	68.3	-4313	-3947	95.4		100.6		99.5
Delta_R DRE UBA-31308	333.5	416.5	68.3	295	455	95.4	340	410.5	68.3	302	448	95.4		106.2		99.8
R_Date UBA-31308	-4239	-4052	68.3	-4323	-3991	95.4	-4238	-4052	68.3	-4323	-3991	95.4		100		99.8
Delta_R DRE Vængesø, K-3921	308.5	391.5	68.3	270	430	95.4	294	382	68.3	257	433	95.4		93.9		99.8
R_Date K-3921	-4156	-3951	68.3	-4230	-3805	95.4	-4156	-3951	68.3	-4230	-3809	95.4		101.9		99.6
Delta_R DRE Sølager, K-3921	253	293	68.3	236	310	95.4	251.5	289.5	68.3	235	306.5	95.4		100.4		99.9
R_Date Sølager, K-3921	-4226	-3991	68.3	-4238	-3981	95.4	-4226	-3992	68.3	-4237	-3981	95.4		99.6		99.7
Delta_R DRE Langø Skaldynge, UBA-37896	253	293	68.3	236	310	95.4	251	290	68.3	234.5	307.5	95.4		99.5		99.9
R_Date Langø Skaldynge UBA-37896	-4221	-3963	68.3	-4243	-3945	95.4	-4221	-3963	68.3	-4241	-3947	95.4		100.4		99.8
Delta_R DRE Rødhals,AAR-8552	253	293	68.3	236	310	95.4	256	293.5	68.3	238.5	310	95.4		100.9		99.9
R_Date Rødhals,AAR-8552	-3958	-3802	68.3	-3986	-3713	95.4	-3961	-3811	68.3	-4035	-3769	95.4		101.9		99.8
Delta_R DRE Ravnsbjerggård,AAR-10993	218.5	301.5	68.3	180	340	95.4	180	264.5	68.3	145	318.5	95.4		79.9		99.7
R_Date Ravnsbjerggård, AAR-10993	-3946	-3788	68.3	-3966	-3659	95.4	-3965	-3809	68.3	-4040	-3716	95.4		97.4		99.7
R_Date Dragsholm II/D, AAR-7416-2	-3701	-3529	68.3	-3765	-3386	95.4	-3769	-3627	68.3	-3893	-3550	95.4		70.2		99.7
▼ Boundary Transition 1/2							-3793	-3716	68.3	-3842	-3681	95.4				99.9
Start Start of Transition 1/2							-3965	-3824	68.3	-4085	-3796	95.4				99.7
Transition Period of Transition 1/2							186	416	68.3	93	579	95.4				98.5
End End of Transition 1/2							-3668	-3538	68.3	-3735	-3458	95.4				99.8
▼ Phase Ancestry Group Farmer Central Europe																
R_Date Viksø Mose, UCIA-232706	-3942	-3797	68.3	-3947	-3791	95.4	-3880	-3782	68.3	-3934	-3774	95.4		83.1		99.9
R_Date Tysmosen II,UBA-35722	-3775	-3655	68.3	-3932	-3643	95.4	-3752	-3653	68.3	-3791	-3645	95.4		108.2		99.9
R_Date Roskilde Fjord,UBA-37910	-3764	-3650	68.3	-3899	-3638	95.4	-3751	-3646	68.3	-3781	-3641	95.4		107.6		99.9
R_Date Pandebjerg, UCIAMS-232705	-3703	-3648	68.3	-3709	-3642	95.4	-3701	-3647	68.3	-3708	-3643	95.4		97.3		99.9
▼ Phase Rude																
R_Date UBA-37877	-3707	-3641	68.3	-3770	-3635	95.4	-3705	-3640	68.3	-3765	-3633	95.4		102.9		99.8
R_Date UBA-37876	-3648	-3537	68.3	-3699	-3528	95.4	-3648	-3537	68.3	-3655	-3527	95.4		96.5		99.8
R_Date UCIAMS	-3606	-3382	68.3	-3625	-3378	95.4	-3606	-3383	68.3	-3625	-3378	95.4		98.4		99.9
R_Date Sigersdal Mose,UBA-39125	-3653	-3540	68.3	-3705	-3531	95.4	-3652	-3541	68.3	-3704	-3531	95.4		97.3		99.8
R_Date Tissøe,UBA-39159	-3702	-3531	68.3	-3766	-3518	95.4	-3697	-3530	68.3	-3760	-3516	95.4		101.9		99.8
R_Date Lohals Nord,UBA-35699	-3653	-3533	68.3	-3705	-3527	95.4	-3652	-3533	68.3	-3703	-3526	95.4		99.1		99.7
R_Date Bygholm, grav I,UBA-38227	-3650	-3533	68.3	-3700	-3527	95.4	-3650	-3533	68.3	-3696	-3527	95.4		98.1		99.7
R_Date Grøfte A,UBA-38228	-3646	-3533	68.3	-3652	-3527	95.4	-3646	-3533	68.3	-3651	-3527	95.4		98.7		99.7
R_Combine Salpetermosen	-3630	-3529	68.3	-3633	-3526	95.4	-3629	-3529	68.3	-3632	-3526	95.4		99.3		99.8
R_Date Dalmosegaard (Borre),UBA-39141	-3633	-3526	68.3	-3645	-3378	95.4	-3631	-3526	68.3	-3645	-3378	95.4		100.4		99.8
R_Date Sejerby (Sejerø,UBA-35721	-3631	-3384	68.3	-3636	-3377	95.4	-3630	-3386	68.3	-3636	-3377	95.4		99.9		99.8
R_Date Lundby-Falster,UBA-40439	-3628	-3386	68.3	-3633	-3380	95.4	-3628	-3416	68.3	-3633	-3380	95.4		99.7		99.9
R_Date Jorløse Mose,AAR-11122	-3623	-3379	68.3	-3631	-3373	95.4	-3622	-3379	68.3	-3631	-3374	95.4		99.3		99.9
R_Date Porsmose ,K-3748	-3626	-3374	68.3	-3697	-3123	95.4	-3622	-3377	68.3	-3654	-3192	95.4		101.9		99.7
R_Date Vig Femhøve, UBA-37893	-3617	-3376	68.3	-3630	-3371	95.4	-3615	-3377	68.3	-3630	-3371	95.4		99.5		99.8
R_Date Mandemarke, UBA-39554	-3522	-3378	68.3	-3623	-3371	95.4	-3522	-3379	68.3	-3623	-3371	95.4		99.2		99.8
R_Date Femhøve,UBA-37893	-3617	-3376	68.3	-3630	-3371	95.4	-3615	-3377	68.3	-3630	-3371	95.4		99.5		99.7
R_Date Lendemark,UBA-39554	-3522	-3378	68.3	-3623	-3371	95.4	-3522	-3379	68.3	-3622	-3371	95.4		99.1		99.9
R_Date Lundby-Falster,UBA-39128	-3516	-3379	68.3	-3605	-3369	95.4	-3517	-3380	68.3	-3606	-3369	95.4		99.3		99.9
R_Date Sludegård Sømose,UBA-39145	-3525	-3372	68.3	-3629	-3365	95.4	-3525	-3374	68.3	-3628	-3366	95.4		99.9		99.8
R_Date Læsten Mose,UBA-39151	-3516	-3374	68.3	-3626	-3361	95.4	-3518	-3374	68.3	-3625	-3362	95.4		99.9		99.7
R_Date Elkenøre,UBA-40440	-3501	-3368	68.3	-3516	-3363	95.4	-3501	-3369	68.3	-3516	-3364	95.4		100		99.8
R_Date Dejringe I,UBA-40108	-3496	-3363	68.3	-3516	-3353	95.4	-3496	-3364	68.3	-3515	-3354	95.4		99.6		99.6
R_Date Jerlundegaard,UBA-35714	-3498	-3356	68.3	-3522	-3191	95.4	-3499	-3357	68.3	-3522	-3196	95.4		101.7		99.6
R_Date Vibygårds Mose,UBA-39147	-3486	-3136	68.3	-3495	-3103	95.4	-3488	-3191	68.3	-3496	-3104	95.4		103.7		99.6
R_Date Storelyng (Øgårde boat III), K-3746	-3492	-3105	68.3	-3515	-3041	95.4	-3495	-3112	68.3	-3516	-3097	95.4		100.1		99.7
▼ Phase																
R_Combine Vittrup	-3362	-3121	68.3	-3368	-3103	95.4	-3363	-3126	68.3	-3368	-3104	95.4		101.3		99.8
Delta_R DRE Svinninge Vejle, UBA-37912	253	293	68.3	236	310	95.4	250.5	290	68.3	233.5	307.5	95.4		98.3		99.9
R_Date Svinninge Vejle, UBA-37912	-3011	-2700	68.3	-3092	-2625	95.4	-3072	-2789	68.3	-3315	-2700	95.4		98.5		99.6
R_Date Storelyng Østrup,AAR-10248	-3356	-3106	68.3	-3363	-3099	95.4	-3359	-3111	68.3	-3364	-3101	95.4		99.4		99.8
R_Date Neverkær Mose I,UBA-38232	-3351	-3106	68.3	-3360	-3099	95.4	-3355	-3110	68.3	-3361	-3101	95.4		99.1		99.8
R_Date Aviebjerg,UBA-40443	-3345	-3105	68.3	-3356	-3098	95.4	-3348	-3114	68.3	-3357	-3102	95.4		99.3		99.8
R_Date Vanløse Mose II,AAR-10994	-3333	-3099	68.3	-3355	-3026	95.4	-3340	-3104	68.3	-3357	-3031	95.4		102.1		99.8

R_Date Kainsbakke,AAR-21424	-3327	-3033	68.3	-3336	-3024	95.4	-3331	-3091	68.3	-3339	-3026	95.4	102.7		99.8
R_Date Klokkehøj,UBA-35708	-2846	-2501	68.3	-2868	-2490	95.4	-2869	-2805	68.3	-2879	-2611	95.4	86.5		99.9
R_Date Stenderup Hage,UBA-39152	-2847	-2493	68.3	-2868	-2470	95.4	-2876	-2737	68.3	-2886	-2619	95.4	82.7		99.9
Span Neolithic anchestry							3218	3406	68.3	3190	3553	95.4			99.8
Interval Neolithic							-382	-232	68.3	-460	-146	95.4			99.8
▼ Boundary End 2							-3152	-3014	68.3	-3202	-2920	95.4			99.4
Start Start of End 2							-3606	-3411	68.3	-3680	-3254	95.4			99.5
Transition Period of End 2							683	978	68.3	521	1153	95.4			98.5
End End of End 2							-2784	-2591	68.3	-2820	-2443	95.4			99.3

Figure S9.2. Model outcomes for the trapezoidal model of Hunter-Gatherer West/European Farmer transition. *Green indicates modelled data, purple indicates phases.*

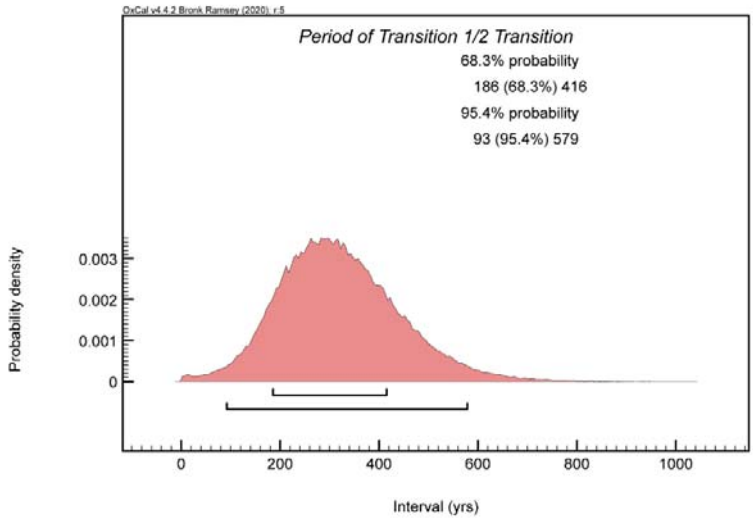


Figure S9.3. Interval period for the Hunter-Gatherer West/European Farmer transition. *This figure and figures S9.4-5 illustrate a period of constant rate of activity (blooming period); gradual increase (introductory period) and gradual decrease (period of decline) for the trapezoidal model transition Hunter-Gatherer West/European Farmer.*

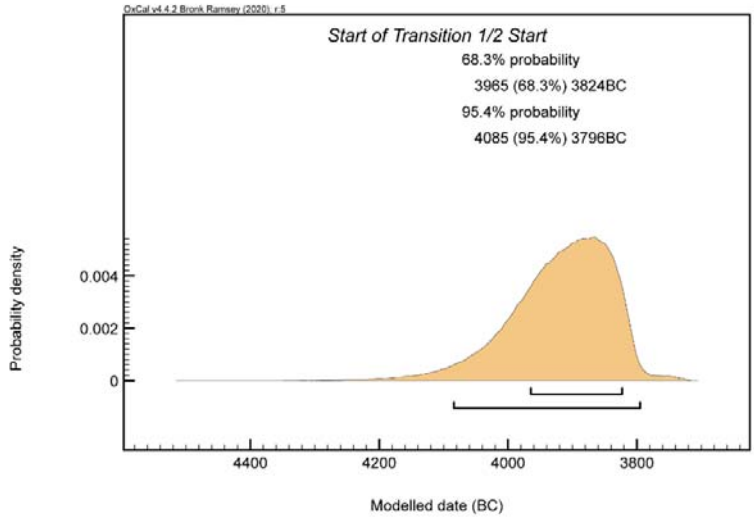


Figure S9.4. Modelled start date for the Hunter-Gatherer West/European Farmer transition.

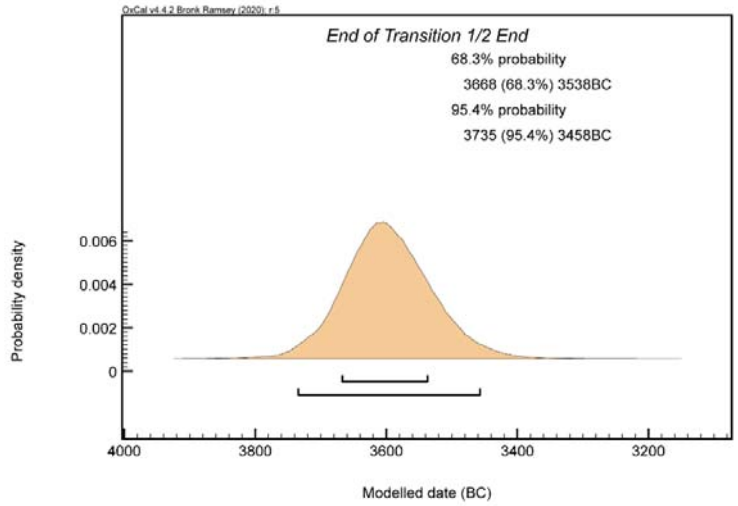


Figure S9.5. Modelled end date for the Hunter-Gatherer West/European Farmer transition.

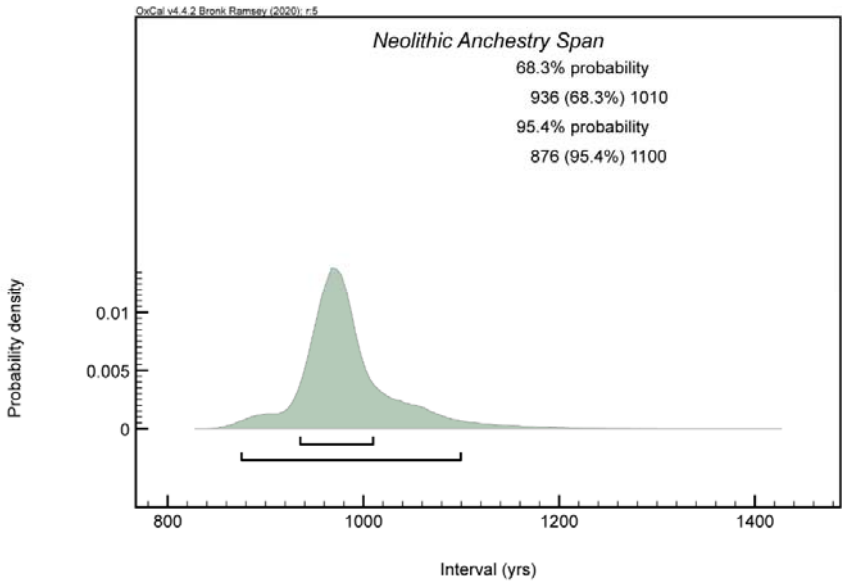


Figure S9.6. Duration of Neolithic ancestry in Denmark.

The Neolithic Movement into Denmark / Horizontal Stratigraphy of European Farmer Ancestry

Testing ~50 hypothetical spatial models for individuals with European farmer ancestry allowed us to reconstruct a scenario for the Neolithic movement into Denmark from the East to the West within three main phases. These three Neolithic phases have a span or a duration of between 28 to 501 years and last from 3934 to 3157cal BC (95.4%). We used Oxcal's inbuilt outlier analysis and the agreement index [9] to test the different spatial Bayesian models and the horizontal stratigraphy. The presented final model shows with A_{model}=114.3 and $A_{overall}$=112.8 a high statistical agreement.

Phase 1 Zealand

The earliest European farmer ancestry appears after this model on Northeastern Zealand (Viksø Mose, Tysmose, Roskilde Fjord, Sigersdal Mose) between *3934-3551 cal BC (95.4%; 3881-3637 cal BC, 68.2%).* The start of the Neolithic expansion further westwards is excluded. The earliest ancestry on eastern Jutland for example would result in poor agreement of the model (A= 6.4% (A'c= 60.0%)
and A= 5.1%(A'c= 60.0%). This earliest phase 1 is lasting between 73-297 years (95.4%; 99-238 years 68.2%)

Phase 2 Expansion westwards

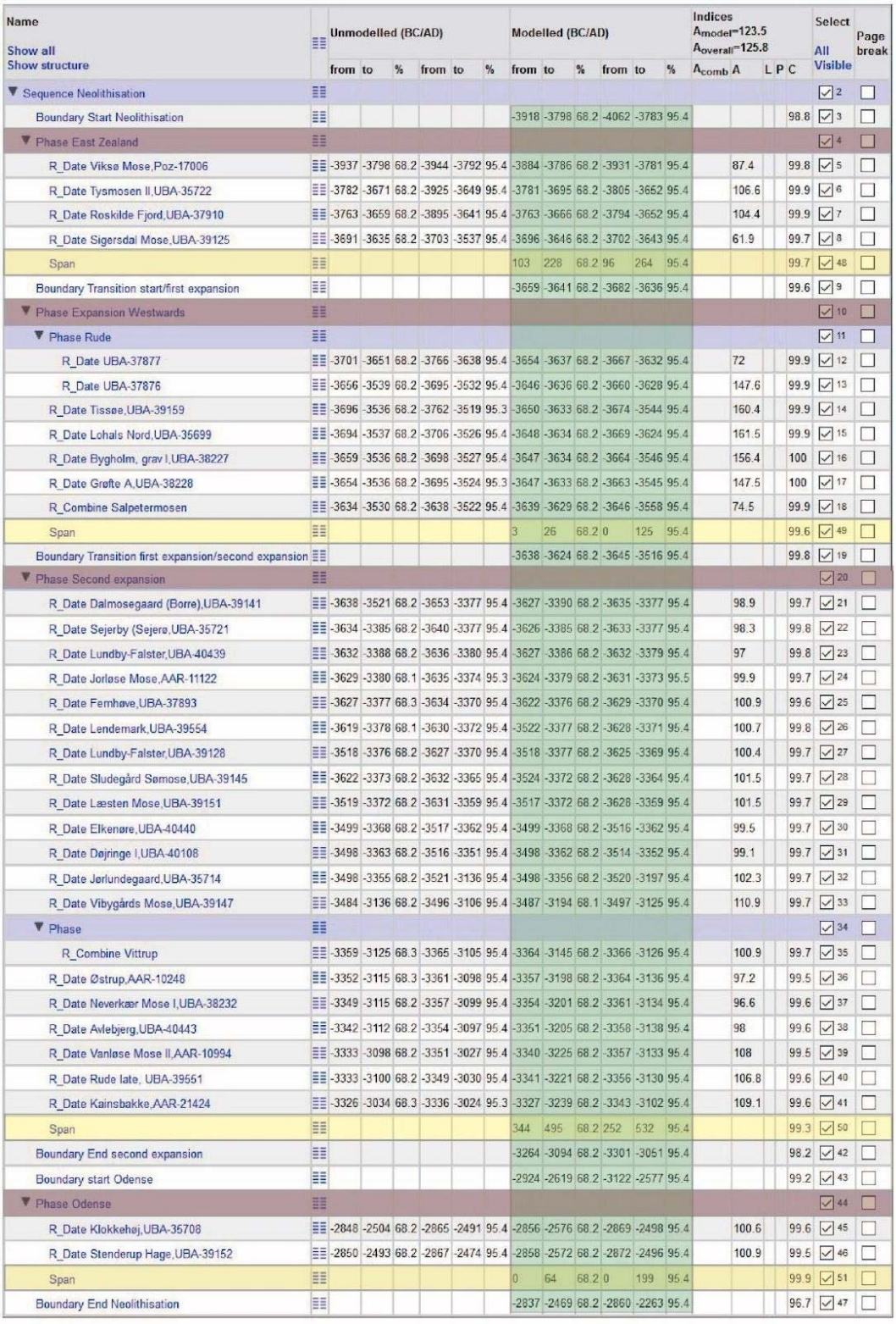
Outside Northeastern Zealand are the European farmer genomes spreading to the West of Zealand, Langeland and the east of Jutland within a short time interval of *0-125 years (95.4%) or 0-28 years (68.2%).* These movements proceed from *3670 to 3531 cal BC (95.4%; 3654-3624 cal BC, 68.2%).* This is the final period of Western Hunter-gatherer ancestry in Denmark.

Phase 3 Second expansion

Between *3627-3157 cal BC (95.4%; 3587-3261 cal BC, 68.2%)* there is a second expansion of European Farmers defined, with Neolithic genetic ancestry spreading across the Danish islands to Western Zealand, Fyn, Northern Jutland, Lolland and Falster. The duration of this phase is between *185-501 years (95.4%) and 212-423 years (68.2%).* Currently, the available radiocarbon dates do not allow a more detailed phasing.

```
Plot()
 {
  Sequence (Neolithisation Denmark)
  {
   Boundary("Start Neolithisation");
   Phase("East Zealand")
   {
    R_Date("Viksø Mose,Poz-17006",5050,15);
    R_Date("Tysmosen II,UBA-35722",4959,43);
    R_Date("Roskilde Fjord,UBA-37910",4939,45);
    R_Date("Sigersdal Mose,UBA-39125",4853,29);
    Span();
   };
   Boundary("Transition start/first expansion");
   Phase("Expansion Westwards")
   {
    Phase(Rude)
    {
     R_Date("UBA-37877",4901,37);
     R_Date("UBA-37876",4838,29);
    };
    R_Date("Tissøe,UBA-39159",4846,53);
    R_Date("Lohals Nord,UBA-35699",4843,40);
    R_Date("Bygholm, grav I,UBA-38227",4836,35);
    R_Date("Grøfte A,UBA-38228",4828,35);
    R_Combine("Salpetermosen")
    {
     R_Date("AAR-21343",4789,25);
     R_Date("AAR-21344",4752,29);
    };
    Span();
   };
   Boundary("Transition first expansion/second expansion");
   Phase("Second expansion")
   {
    R_Date("Dalmosegaard (Borre),UBA-39141",4774,52);
    R_Date("Sejerby (Sejerø,UBA-35721",4746,45);
    R_Date("Lundby-Falster,UBA-40439",4743,31);
    R_Date("Jorløse Mose,AAR-11122",4720,40);
    R_Date("Femhøve,UBA-37893",4709,52);
    R_Date("Lendemark,UBA-39554",4698,32);
    R_Date("Lundby-Falster,UBA-39128",4688,31);
    R_Date("Sludegård Sømose,UBA-39145",4688,56);
    R_Date("Læsten Mose,UBA-39151",4674,51);
    R_Date("Elkenøre,UBA-40440",4647,31);
    R_Date("Døjringe I,UBA-40108",4629,31);
    R_Date("Jørlundegaard,UBA-35714",4619,41);
    R_Date("Vibygårds Mose,UBA-39147",4573,33);
    Phase(Hunter-Gatherer Baltic)
    {
     R_Combine(Vittrup)
     {
      R_Date("UBA-39121",4565,29);
      R_Date("UBA-29904",4464,52);
     };
    };
    R_Date("Østrup,AAR-10248",4523,37);
    R_Date("Neverkær Mose I,UBA-38232",4518,33);
    R_Date("Avlebjerg,UBA-40443",4510,32);
    R_Date("Vanløse Mose II,AAR-10994",4485,41);
    R_Date("Rude late, UBA-39551",4488,38);
    R_Date("Kainsbakke,AAR-21424",4464,29);
    Span();
   };
   Boundary("End second expansion");
   Boundary("start Odense");
   Phase("Odense")
   {
    R_Date("Klokkehøj,UBA-35708",4086,42);
    R_Date("Stenderup Hage,UBA-39152",4072,61);
    Span();
   };
   Boundary("End Neolithisation");
  };
 };
```

Figure S9.7 CQL code for the Horizontal model of the Neolithic expansion into Denmark with 33 radiocarbon dates from 31 individuals.



Name Show all Show structure	Unmodelled (BC/AD)						Modelled (BC/AD)						Indices A_{model}=123.5 $A_{overall}$=125.8				Select All Visible	Page break
	from	to	%	from	to	%	from	to	%	from	to	%	A_{comb}	A	L	P C		
▼ Sequence Neolithisation																	☑ 2	☐
Boundary Start Neolithisation							-3918	-3798	68.2	-4062	-3783	95.4				98.8	☑ 3	☐
▼ Phase East Zealand																	☑ 4	☐
R_Date Viksø Mose,Poz-17006	-3937	-3798	68.2	-3944	-3792	95.4	-3884	-3786	68.2	-3931	-3781	95.4		87.4		99.8	☑ 5	☐
R_Date Tysmosen II,UBA-35722	-3782	-3671	68.2	-3925	-3649	95.4	-3781	-3695	68.2	-3805	-3652	95.4		106.6		99.9	☑ 6	☐
R_Date Roskilde Fjord,UBA-37910	-3763	-3659	68.2	-3895	-3641	95.4	-3763	-3666	68.2	-3794	-3652	95.4		104.4		99.9	☑ 7	☐
R_Date Sigersdal Mose,UBA-39125	-3691	-3635	68.2	-3703	-3537	95.4	-3696	-3646	68.2	-3702	-3643	95.4		61.9		99.7	☑ 8	☐
Span							103	228	68.2	96	264	95.4				99.7	☑ 48	☐
Boundary Transition start/first expansion							-3659	-3641	68.2	-3682	-3636	95.4				99.6	☑ 9	☐
▼ Phase Expansion Westwards																	☑ 10	☐
▼ Phase Rude																	☑ 11	☐
R_Date UBA-37877	-3701	-3651	68.2	-3766	-3638	95.4	-3654	-3637	68.2	-3667	-3632	95.4		72		99.9	☑ 12	☐
R_Date UBA-37876	-3656	-3539	68.2	-3695	-3532	95.4	-3646	-3636	68.2	-3660	-3628	95.4		147.6		99.9	☑ 13	☐
R_Date Tissøe,UBA-39159	-3696	-3536	68.2	-3762	-3519	95.3	-3650	-3633	68.2	-3674	-3544	95.4		160.4		99.9	☑ 14	☐
R_Date Lohals Nord,UBA-35699	-3694	-3537	68.2	-3706	-3526	95.4	-3648	-3634	68.2	-3669	-3624	95.4		161.5		99.9	☑ 15	☐
R_Date Bygholm, grav I,UBA-38227	-3659	-3536	68.2	-3698	-3527	95.4	-3647	-3634	68.2	-3664	-3546	95.4		156.4		100	☑ 16	☐
R_Date Grøfte A,UBA-38228	-3654	-3536	68.2	-3695	-3524	95.3	-3647	-3633	68.2	-3663	-3545	95.4		147.5		100	☑ 17	☐
R_Combine Salpetermosen	-3634	-3530	68.2	-3638	-3522	95.4	-3639	-3629	68.2	-3646	-3558	95.4		74.5		99.9	☑ 18	☐
Span							3	26	68.2	0	125	95.4				99.6	☑ 49	☐
Boundary Transition first expansion/second expansion							-3638	-3624	68.2	-3645	-3516	95.4				99.8	☑ 19	☐
▼ Phase Second expansion																	☑ 20	☐
R_Date Dalmosegaard (Borre),UBA-39141	-3638	-3521	68.2	-3653	-3377	95.4	-3627	-3390	68.2	-3635	-3377	95.4		98.9		99.7	☑ 21	☐
R_Date Sejerby (Sejerø,UBA-35721	-3634	-3386	68.2	-3640	-3377	95.4	-3626	-3385	68.2	-3633	-3377	95.4		98.3		99.8	☑ 22	☐
R_Date Lundby-Falster,UBA-40439	-3632	-3388	68.2	-3636	-3380	95.4	-3627	-3386	68.2	-3632	-3379	95.4		97		99.8	☑ 23	☐
R_Date Jorløse Mose,AAR-11122	-3629	-3380	68.1	-3635	-3374	95.3	-3624	-3379	68.2	-3631	-3373	95.5		99.9		99.7	☑ 24	☐
R_Date Fernhøve,UBA-37893	-3627	-3377	68.3	-3634	-3370	95.4	-3622	-3376	68.2	-3629	-3370	95.4		100.9		99.6	☑ 25	☐
R_Date Lendemark,UBA-39554	-3619	-3378	68.1	-3630	-3372	95.4	-3522	-3377	68.2	-3628	-3371	95.4		100.7		99.8	☑ 26	☐
R_Date Lundby-Falster,UBA-39128	-3518	-3376	68.2	-3627	-3370	95.4	-3518	-3377	68.2	-3625	-3369	95.4		100.4		99.7	☑ 27	☐
R_Date Sludegård Sømose,UBA-39145	-3622	-3373	68.2	-3632	-3365	95.4	-3524	-3372	68.2	-3628	-3364	95.4		101.5		99.7	☑ 28	☐
R_Date Læsten Mose,UBA-39151	-3519	-3372	68.2	-3631	-3359	95.4	-3517	-3372	68.2	-3628	-3369	95.4		101.5		99.7	☑ 29	☐
R_Date Elkenøre,UBA-40440	-3499	-3368	68.2	-3517	-3362	95.4	-3499	-3368	68.2	-3516	-3362	95.4		99.5		99.7	☑ 30	☐
R_Date Døjringe I,UBA-40108	-3498	-3363	68.2	-3516	-3351	95.4	-3498	-3362	68.2	-3514	-3352	95.4		99.1		99.7	☑ 31	☐
R_Date Jørlundegaard,UBA-35714	-3498	-3355	68.2	-3521	-3136	95.4	-3498	-3356	68.2	-3520	-3197	95.4		102.3		99.7	☑ 32	☐
R_Date Vibygårds Mose,UBA-39147	-3484	-3136	68.2	-3496	-3106	95.4	-3487	-3194	68.1	-3497	-3125	95.4		110.9		99.7	☑ 33	☐
▼ Phase																	☑ 34	☐
R_Combine Vittrup	-3359	-3125	68.3	-3365	-3105	95.4	-3364	-3145	68.2	-3366	-3126	95.4		100.9		99.7	☑ 35	☐
R_Date Østrup,AAR-10248	-3352	-3115	68.3	-3361	-3098	95.4	-3357	-3198	68.2	-3364	-3136	95.4		97.2		99.5	☑ 36	☐
R_Date Neverkær Mose I,UBA-38232	-3349	-3115	68.2	-3357	-3099	95.4	-3354	-3201	68.2	-3361	-3134	95.4		96.6		99.6	☑ 37	☐
R_Date Avlebjerg,UBA-40443	-3342	-3112	68.2	-3354	-3097	95.4	-3351	-3205	68.2	-3358	-3138	95.4		98		99.6	☑ 38	☐
R_Date Vanløse Mose II,AAR-10994	-3333	-3098	68.2	-3351	-3027	95.4	-3340	-3225	68.2	-3357	-3133	95.4		108		99.5	☑ 39	☐
R_Date Rude late, UBA-39551	-3333	-3100	68.2	-3349	-3030	95.4	-3341	-3221	68.2	-3356	-3130	95.4		106.8		99.6	☑ 40	☐
R_Date Kainsbakke,AAR-21424	-3326	-3034	68.3	-3336	-3024	95.3	-3327	-3239	68.2	-3343	-3102	95.4		109.1		99.6	☑ 41	☐
Span							344	495	68.2	252	532	95.4				99.3	☑ 50	☐
Boundary End second expansion							-3264	-3094	68.2	-3301	-3051	95.4				98.2	☑ 42	☐
Boundary start Odense							-2924	-2619	68.2	-3122	-2577	95.4				99.2	☑ 43	☐
▼ Phase Odense																	☑ 44	☐
R_Date Klokkehøj,UBA-35708	-2848	-2504	68.2	-2865	-2491	95.4	-2856	-2576	68.2	-2869	-2498	95.4		100.6		99.6	☑ 45	☐
R_Date Stenderup Hage,UBA-39152	-2850	-2493	68.2	-2867	-2474	95.4	-2858	-2572	68.2	-2872	-2496	95.4		100.9		99.5	☑ 46	☐
Span							0	64	68.2	0	199	95.4				99.9	☑ 51	☐
Boundary End Neolithisation							-2837	-2469	68.2	-2860	-2263	95.4				96.7	☑ 47	☐

Figure S9.8. Model outcomes for the horizontal model with the Neolithic expansion into Denmark.

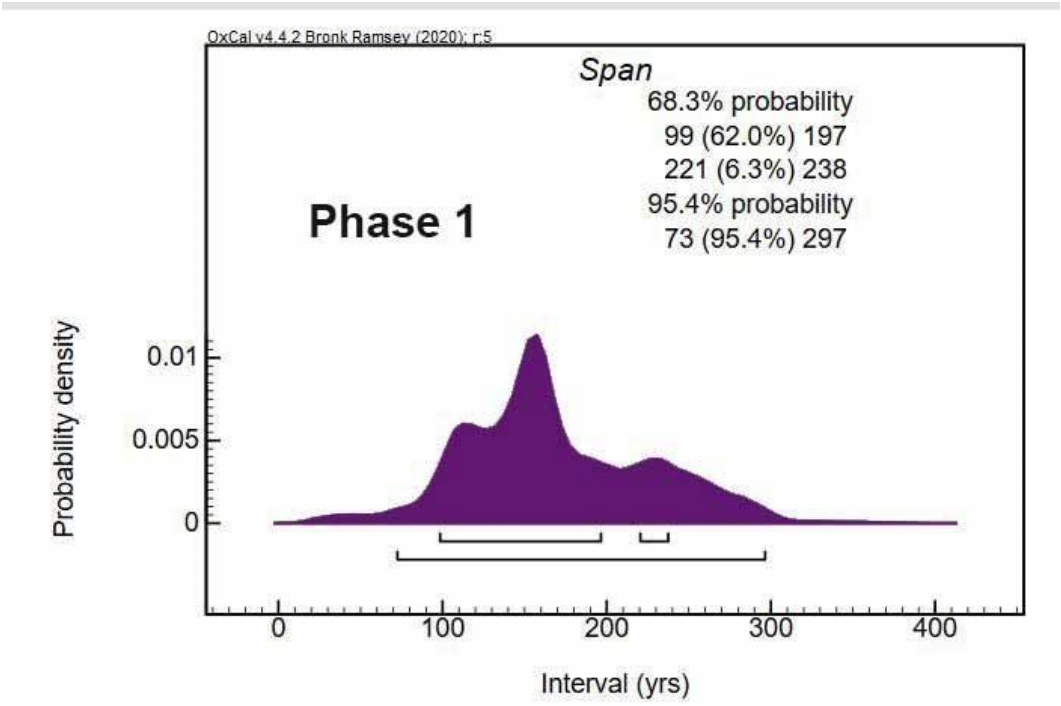


Figure S9.9. Modelled duration of Phase 1 of the horizontal model for Neolithic expansion into Denmark.

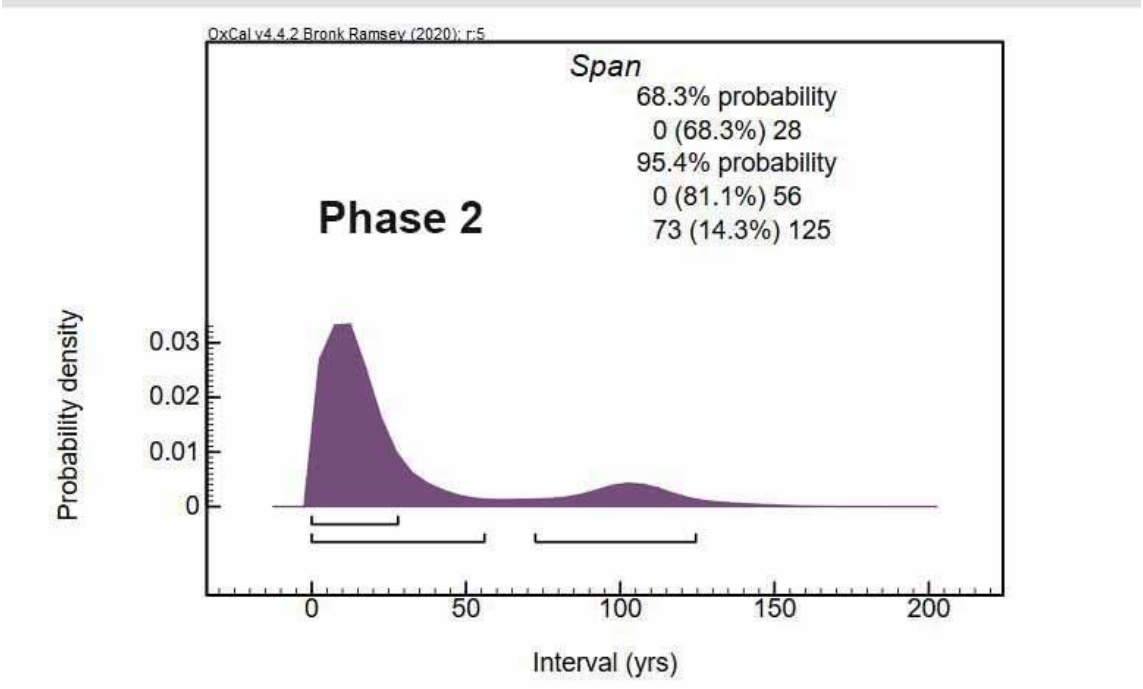


Figure S9.10. Modelled duration of Phase 2 of the horizontal model for Neolithic expansion into Denmark.

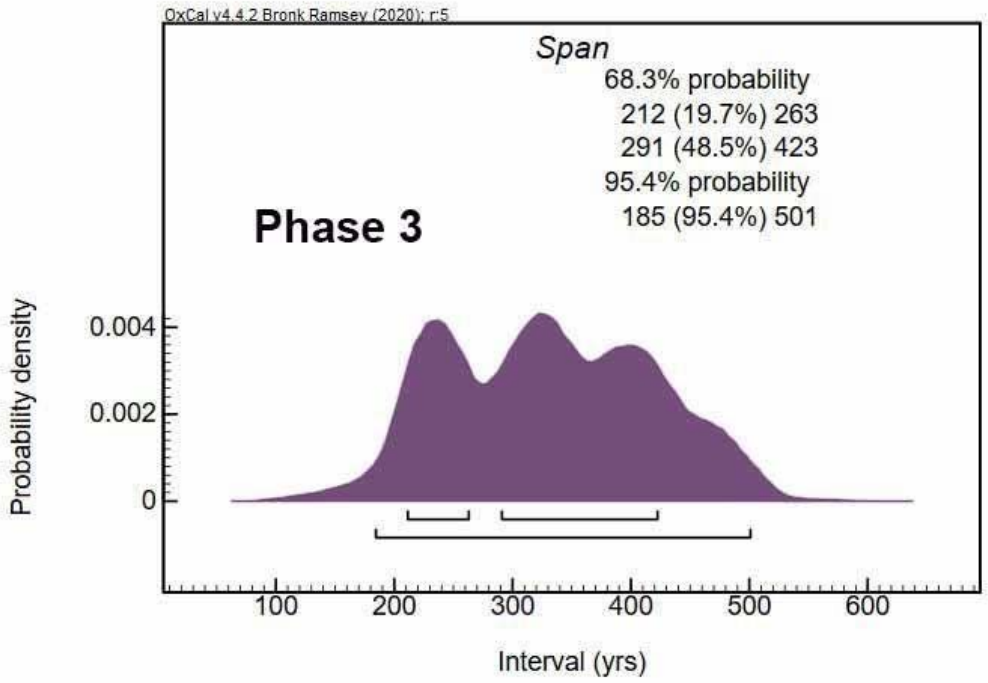


Figure S9.11. Modelled duration of Phase 3 of the horizontal model for Neolithic expansion into Denmark.

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10) Dietary variation in Mesolithic, Neolithic and Bronze Age Denmark

Anders Fischer[1,2] and Karl-Göran Sjögren[1]

[1]Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

[2]Sealand Archaeology, Gl. Røsnæsvej 27, 4400 Kalundborg, Denmark

Introduction

Stable isotope values for carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) in collagen in genetically characterised human bones and teeth from 100 individuals form the basis for the present overview on dietary variation in early prehistoric Denmark. We deal with data from skeletal material dated *c. 8500-1000 cal BC*, which according to the local archaeological chronology spans the periods from the Early Mesolithic to the Middle Bronze Age. A tripartite chronological grouping stands out: 1) inland hunter-fisher-gatherers, 2) coastal fisher-hunter-gatherers, and 3) farmers. Integration of the dietary and genetic data for these individuals reveals co-relations that allow for hitherto unattainable insights into the prehistory of the region.

Material and methods

The dietary stable isotope values discussed in this study were measured on collagen from 40 samples of dentine, 60 of bone, and 12 samples of tooth or bone. 20 of the bone samples derived from the outer parts of petrous bones - excluding the otic capsule, which was reserved for DNA and strontium analyses. The carbon and nitrogen isotope values represent food composition over an interval of time, which generally lasted several years. In case of tooth samples, the values may represent a period up to decades of years before death [1,2]. A closer understanding of individual dietary life histories can be reached via isotopic analyses of tooth increments, as will be elucidated in forthcoming publications on the skeletons from Vittrup, Rødhals and Dragsholm [3–5].

The isotope measurements were mainly produced at the ^{14}C Centre at the University of Belfast. They were conducted according to standard protocols [6], based on a modified Longin [7] method [8]. Ultra-filtering was standard procedure, and measuring uncertainty was within the generally accepted range of ±0.2‰ (1 sd). All are within the acceptable atomic C:N range of 2.9-3.6, and therefore show a low likelihood of diagenesis [9,10]. The full assemblage of isotopic measurements is available in Supplementary Table IV.

Generally, $\delta^{13}C$ values inform on the proportion of marine versus terrestrial protein, while $\delta^{15}N$ values reflect the trophic level from which the proteins were acquired. Dietary interpretation demands reference measurements from potential major protein food sources, temporarily and geographically as closely as possible associated with the humans under study. A large and varied set of such data is available for Danish Mesolithic and Neolithic mammals and fish, but not to the same extent from plants [3,4,11–19].

In addition, an understanding of the trophic-level enrichment factor for $\delta^{13}C$ and $\delta^{15}N$ values is mandatory for dietary interpretation of our assemblage of human isotope values [20]. An array of ecological studies on animals indicates that each trophic level shift results in an increase in isotope values of around 1 and 3-5‰, respectively, with variation due to such factors as species, biological age, quantity, quality and composition of diet and physiological stress [e.g. 21–27]. A $\delta^{15}N$ increase in the order of 3.5‰ is seen in bone collagen of females and infants from three Danish Mesolithic sites, including mother-and-child burials from Tybrind Vig and Henriksholm-Bøgebakken grave 19 [12,28,29]. In addition, a study based on hair from modern Indian children measured before and after weaning gave the result 3.3‰ [30]. However, a compilation of studies based on present-day human hair samples suggests enrichment around 5.5‰ [31]. Moreover, a controlled human diet study, based on red blood cell samples, suggests an enrichment factor as high as c. 6‰ [32].

Application of these different enrichment values will lead to differing interpretations of the human diet. The use of a relatively high $\delta^{15}N$ enrichment factor will suggest lower proportions of fish consumption and probably also higher intake of plant proteins. Further complications in dietary interpretation result from the raised nitrogen values observed in local early prehistoric cereals [17,19,33,34]. These raised values are due to manuring that also affected the $\delta^{15}N$ levels of domestic animals, which grazed on manured fields. It is beyond the scope of the present supplement to discuss in detail the consequences of these matters to human dietary isotope values, and we shall therefore satisfy noting that there is solid knowledge on widespread fishing activity (and consequently fish consumption) for most of the Mesolithic, Neolithic and Bronze ages [e.g. 35–43].

Dietary variation versus cultural and genetic history

An overview of carbon and nitrogen isotope variation over time among humans from Denmark is given in Figures S10.1 and S10.2. A most dominant divide is seen *c. 3900 cal BC*, which is the time when domesticates, pottery of Neolithic manufacture and immigrants of Anatolian ancestry turned up in the region [44,45], main text this paper).

Rødhals Man (NEO645) is coeval to this watershed episode. He is the latest dated individual in our assemblage of Danish individuals who combines a dominantly marine dietary isotope signature with a western European hunter-gatherer ancestry [4]. Most noteworthy, *Dragsholm Man* (NEO962b) of nearly the same date is also of local hunter-gatherer ancestry, even though his bone collagen dietary signature is that of a farmer (figures S10.1 and S10.2) [5,46].

Figures 1 and 2 show a general development throughout the Mesolithic towards an increase in both $\delta^{13}C$ and $\delta^{15}N$ values. The latter trend results from a growing importance of protein from high trophic levels, common in aquatic food chains, whereas the former reflects an increase in consumption of marine protein. Both trends correlate with the rise in sea-level that changed the geographic character of the present-day Danish area from inland to archipelago [cf. 47].

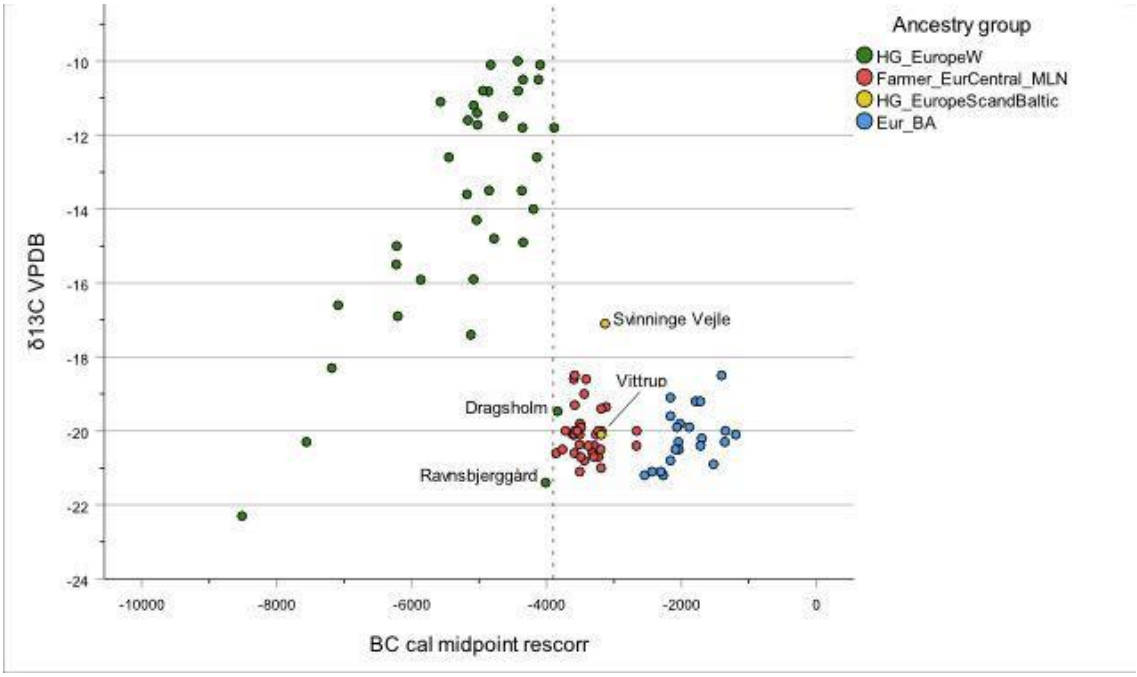

Figure S10.1. $\delta^{13}C$ values in Danish early prehistoric human bone and dentine, compared with their nuclear DNA signature. *A fundamental dietary and genetic change is seen at the transition from the Mesolithic to the Neolithic c. 3900 cal BC (dashed line). Four anomalous individuals are marked. Data from SI Table II.*

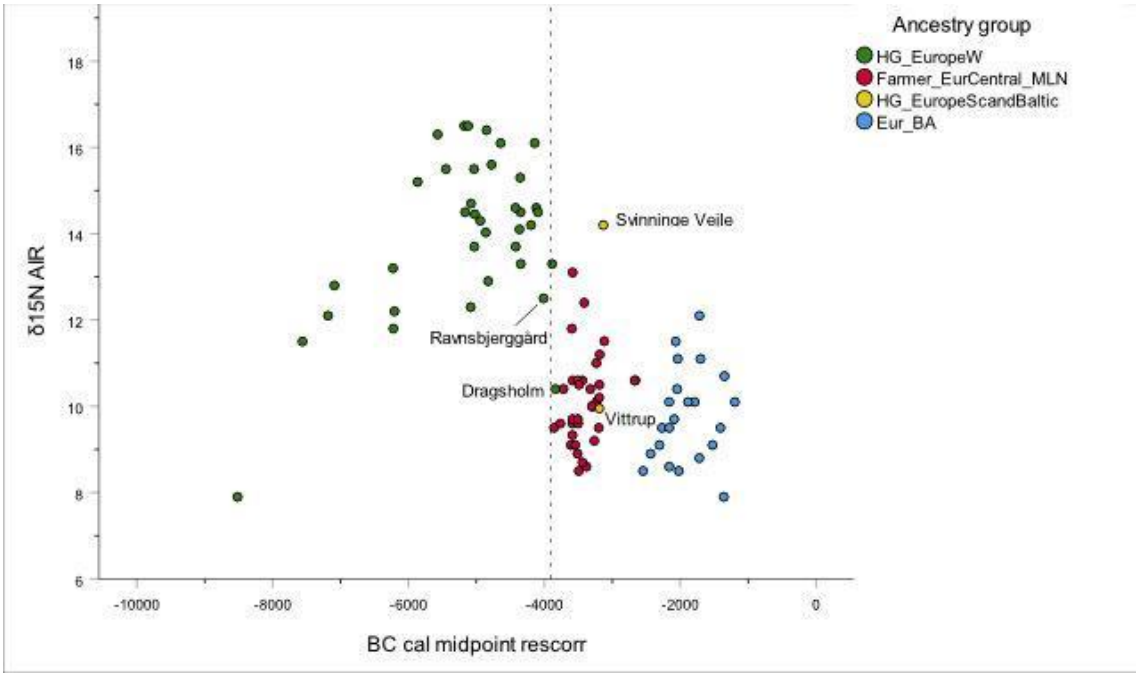

Figure S10.2. δ[15]N values in Danish humans of Early Mesolithic to Middle Bronze Age date, compared with their genetic signature*. Four anomalous individuals are marked. Data from SI Table II.*

Mesolithic food composition

The earliest Danish individual of the present study, *Koelbjerg* (*c. 8500 cal BC*, NEO254), has remarkably low isotopic values. These may be typical of the period, since similar values are known from the second earliest human skeletal remains available from Denmark (Tømmerupgård, [12]. They can reflect a protein diet based on terrestrial plants and game in combination with freshwater sources. The terrestrial meat could, for instance, derive from elk, the bones of which are frequently found in local bogs and settlements of the period [12,15,48,49]. Evidence for freshwater food is seen in the period's many barbed bone points from fish spears found in the lakes of the region [50,51]. The uncertainty as to trophic level enrichment, outlined above, complicates estimation of the relative importance of freshwater sources in Early Mesolithic diet [12], which is therefore not included in this short supplementary.

The much higher $\delta^{15}N$ values of all other Mesolithic individuals indicate a considerable dependence on higher-level aquatic protein sources. The low $\delta^{13}C$ values among the individuals from the early and middle part of this period suggest that initially the nutrients of the wet element were of freshwater or highly brackish origin. From *c. 7000 to 3900 cal BC*, the general trend was an increase in the proportion of proteins from genuinely marine environments.

One individual clearly stands out dietarily from all other Middle and Late Mesolithic members of our assemblage. It is from the site of *Ravnsbjerggård* in the Aamose Bog (NEO960). The protein food of this human was most likely derived from a mixture of freshwater food (fish, mollusks) and forest game. Similar dietary signatures are found in one other human (Tingbjerggård Vest) and several dogs of roughly the same date and deriving from the same bog ([12] and unpublished data). The lack of a marine signal in their isotopes indicates a radical turn away from a long-existing settlement pattern that included prolonged seasonal stays at fishing sites by the sea [12,52–54]. The precise absolute age of these humans and dogs cannot presently be established due to problems in estimating freshwater reservoir effect on their radiocarbon dates (Supplementary Note 8). According to the relatively conservative estimate of the effect applied in Figures S10.1 and S10.2 (250 years), they belong to a time shortly before the arrival of farming and immigrant farmers to the region. A larger correction factor (still within realistic limits) will make them coeval with the first farming societies of the region. Genetically the Ravnsbjerggård individual is of local hunter-gatherer ancestry. Our preliminary interpretation is that this person, as well as the chronologically and isotopically closely related humans and dogs from the Aamose, represent a social group that gave up its coastal territory – possibly due to impact (violence/diseases) from immigrant farmers.

As to vegetable ingredients in diet, our collagen-based isotope analyses have little of substance to contribute. We know such components were on the menu (e.g. [28], but their generally low protein content prevents them from leaving a clear signature. The relative importance to energy supply of carbohydrates and vegetable fats can, however, to some extent be resolved by modelling [31,cf. 55,56].

Neolithic and Bronze Age food composition

The stable isotope values seen in Figures 1 and 2 imply a primarily terrestrial diet for nearly all of our Neolithic and Bronze Age individuals. Further nuances to this may, however, be added. Thus, other sources tell that domestic herbivores contributed significantly to the diet of those days' inhabitants of Denmark in terms of meat as well as milk [e.g. 57–60].

The $\delta^{13}C$ values centre around -20‰, with a variation from c. -21‰ to -18‰. This would suggest a moderate intake of protein from marine sources, ranging from 0% up to some 20% - in accordance with the frequent observations of large fish weirs of Neolithic date along the coeval coasts [61–63]. To what extent freshwater sources contributed to diet can be estimated by modelling, as is the case with the proportion of cereal versus terrestrial animal protein [cf. 31,64].

Among the 61 Neolithic and Bronze Age individuals, only one deviates significantly from the others in terms of dietary isotope values (Figs. S101 and S10.2). This is the individual from *Svinninge Vejle* (*c. 3100 cal BC*; NEO898). A large proportion of the protein intake of this person certainly derived from the sea, and his combination of $\delta^{13}C$ and $\delta^{15}N$ values suggests a protein diet dominated by marine mammals such as seal. This human also has a deviating genetic profile that is closely related to individuals of Neolithic age from eastern Sweden[3]. The latter are associated with the archaeological complex termed Pitted Ware Culture [65], for which seals contributed importantly to diet [e.g. 66]. Our genetic and dietary analyses thus agree in pointing out this individual as a foreigner in Neolithic Denmark.

Genetically *Vittrup Man* (NEO33) was of the same foreign ancestry as the Svinninge Vejle individual. This had no bearing on the isotopic values of his bone collagen, however (Figs. 1 and 2). His external background is nonetheless visible via measurements of strontium isotopes (Supplementary Note 7; [3]).

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11) Strontium analysis of Danish samples

T. Douglas Price[1] and Karl-Göran Sjögren[2]

[1] Laboratory for Archaeological Chemistry, University of Wisconsin-Madison, Madison, United States of America

[2] Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

Studies of human movement in the past have traditionally relied on exotic artefacts as a proxy for people. But artefacts can be copied, stolen, traded, or gifted and may not represent the actual movement of people. In the last 25 years or so, isotopic proveniencing of human remains has become common practice in the investigation of burial populations and provides a direct way to look at human mobility [1]. Isotopes of oxygen, strontium, and lead have been used in such studies. A number of studies have been completed in Denmark [2–8].

Strontium isotope analysis provides a robust means for examining past mobility. Strontium moves into humans from rocks and sediments through the food chain [1,9,10] and is found primarily in the skeleton. Enamel forms during early childhood and has the strontium isotope ratio of the food consumed by the mother and during the first years of life. Enamel is largely inert. The strontium isotope ratio in the enamel usually remains unchanged during life and after death. The enamel thus can provide a chemical signal of place of birth. If an individual moved to a new location or was buried in a new place, the enamel isotope ratio may differ from the new location, allowing the designation of that individual as non-locally born. Because the same strontium isotope ratio can characterise several locations, it is difficult to determine the precise place of origin.

The strontium isotope ratio ($^{87}Sr/^{86}Sr$) varies among different kinds of rocks, based on their age and composition. The heavier isotope (^{87}Sr) is formed by the radioactive decay of rubidium-87. Thus, older rocks and sediments with more rubidium have higher $^{87}Sr/^{86}Sr$ values, while younger materials with less rubidium are at the opposite end of the range with lower ratios [e.g. 11]. The proportion of ^{87}Sr varies in the terrestrial ecosystem, but averages around 7% of total strontium; ^{86}Sr is about 10%. Their ratio normally varies from about 0.700 in rocks with low Rb to 0.730 and much higher in high-Rb rocks that are billions of years old. Most measurements of human enamel fall in the range of 0.705 to 0.735.

Strontium isotope analysis for information on prehistoric residential mobility requires samples of uncremated dental enamel. Powder for isotopic analysis is collected from the teeth by first

burying the area to be sampled to remove possible surface contamination and then extracting a cusp or fragment. The powder is weighed and submitted for measurement. For this study, measurement of $^{87}Sr/^{86}Sr$ in the powder was done in the Geochronology and Isotope Geochemistry Laboratory (Dept. of Geological Sciences, University of North Carolina- Chapel Hill). Samples are dissolved in nitric acid and the strontium fraction purified by ion selective chromatography (Eichrom Sr resin) prior to analysis by TIMS on a VG Sector 54 mass spectrometer run in dynamic mode. Internal precision in the laboratory is consistently around 0.0007% standard error (or $1\sigma = 0.00006$ in the ratio of a particular sample). Long-term, repeated measurements of SRM-987 are around 0.710260—an acceptable difference from the recognized value of 0.710250—and raw sample values from individual runs are standardised to the recognized value of SRM-987.

Levels of strontium isotopes in human enamel and bone may vary from geological background for a number of reasons that include differential weathering of minerals in rock, atmospheric dust, and the deposition of eolian, alluvial, or glacial sediments on top of bedrock geology. Complex geological areas may have several different sources of $^{87}Sr/^{86}Sr$ contributing to human diets. Coastal populations are impacted by other phenomena. Marine foods, for example, have a constant strontium isotope ratio on average of 0.7092. The same ratio, 0.7092, may also be introduced by salt spray and rainfall in coastal areas. For these and other reasons, it is important to measure bioavailable levels of $^{87}Sr/^{86}Sr$ to ascertain local strontium isotope ratios [12].

Bioavailable strontium isotope ratios are those ratios actually available in the food chain. The bioavailable strontium isotopic signal (or baseline) of the place of burial can be determined in several ways: in human bone from the individuals whose teeth were analysed, from the bones of other humans or archaeological fauna at the site, or from modern fauna, water, soil extracts or vegetation in the vicinity [13]. This baseline information on isotope values across an area needs to be obtained in order to make useful and reliable statements about the origins of the human remains under study. Some baseline information is available for Denmark [14,15] with a mean of 0.7092 and a range largely between 0.7078 and 0.7108. Samples for these baselines were taken at a large scale and, because of variation in the surface deposits across Denmark, measurement of baseline samples at the local level is essential. Local variation has indeed been discovered in some areas with denser sampling [5,16], and there is an ongoing discussion on the Danish Sr baseline, which may possibly have to be revised [16].

One of the strengths of our project has been the availability of radiocarbon dates for all samples. Figure S11.1 is a scatterplot of ^{14}C age vs. $^{87}Sr/^{86}Sr$ value for each tooth from 146 samples from Mesolithic and Neolithic Denmark, including also individuals for which aDNA

was not successful. There are few burials from the end of the Mesolithic, but also from the end of the Middle Neolithic from 4500 to 4000 BP. The plot has several interesting features. A dramatic change can be seen with the start of the Neolithic, as these data include both higher and lower values than before, and are generally somewhat higher. This would indicate a different mobility pattern, with many of the Neolithic individuals originating from more distant areas, or possibly from areas that were not utilised or settled in the Mesolithic. The variability in $^{87}Sr/^{86}Sr$ values continues in the later Neolithic as well after 2500 BC.

One of us [17] has argued the last hunters were more sedentary and the first farmers in prehistoric southern Scandinavia were more mobile than has generally been realised. Certainly this graph supports such an interpretation, at least in terms of long-distance movement. In addition, this pattern is very similar to what happened in the British Isles [18].

There are two individuals above 0.714, one from the Mesolithic and one from the Neolithic. These individuals likely come from the Scandinavian Peninsula. There are three individuals between 0.712 and 0.714, all Neolithic, place of origin difficult to determine. There are also some individuals below 0.709 that may be non-local, but could also come from areas within Denmark, such as Limfjorden.

Carbon isotopes indicate that later Mesolithic diets contained substantial amounts of marine food which would have had an $^{87}Sr/^{86}Sr$ value of 0.7092 and kept $^{87}Sr/^{86}Sr$ in Mesolithic humans low. Neolithic diets on the other hand did not include large quantities of marine foods and imply little or no suppression of $^{87}Sr/^{86}Sr$ values. It is therefore surprising that the average $^{87}Sr/^{86}Sr$ values for the Neolithic is only slightly higher (Table S11.1).

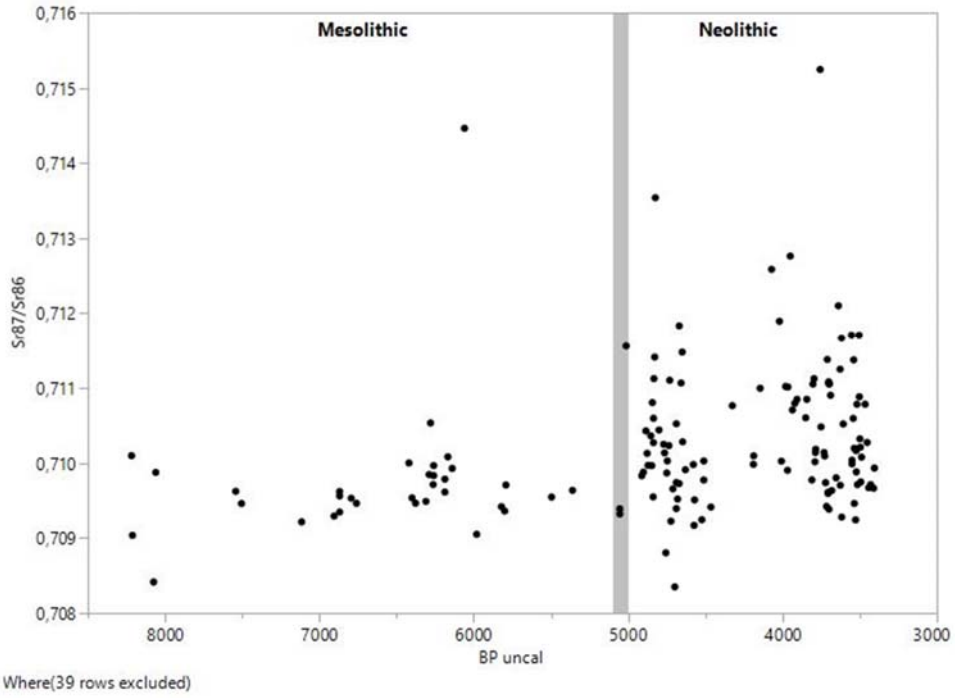

Figure S11.1. Scatterplot of ^{14}C age vs. $^{87}Sr/^{86}Sr$ value for each tooth from each sample from Mesolithic and Neolithic Denmark earlier than 3400 BP uncal. *The grey vertical line indicates the advent of the Neolithic c. 5100-5000 BP uncal (4000 cal BC). Data from Supplementary Table II.*

Statistic	All Samples	Mesolithic	Neolithic
Mean	0.71024	0.70975	0.71038
Standard Deviation	0.001	0.0009	0.001
Minimum	0.70835	0.70841	0.70835
Maximum	0.71525	0.71446	0.71525
Count	146	32	114

Table S11.1. Descriptive statistics for $^{87}Sr/^{86}Sr$ for all samples (both periods) and for the Mesolithic and Neolithic components of the sample.

Table S11.1 provides descriptive statistics for all Mesolithic and Neolithic samples and for the two components of the sample combined. The very high $^{87}Sr/^{86}Sr$ value in one of the Mesolithic samples (0.714) affects the mean and s.d. for the entire Mesolithic group. These values for the Mesolithic recalculated without the high value are 0.70959 ± 0.0004.

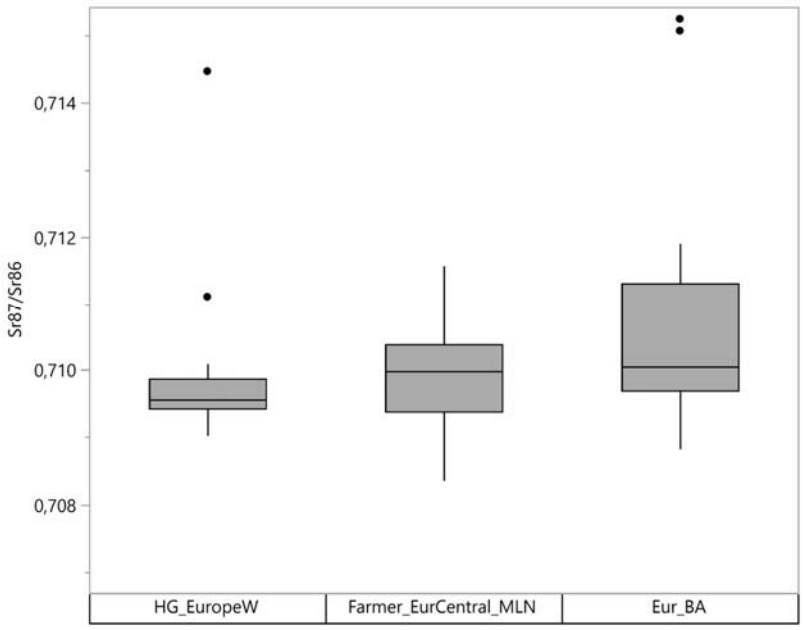

Figure S11.2. Boxplot of Sr isotope ratios for the main ancestry groups in our Danish dataset. See also figure 4 in the main text.

Figure S11.2 shows the distribution of Sr isotope ratios for the Danish samples that could be genetically characterised (Vittrup (NEO33) and Svinninge Vejle (NEO898) excluded). Higher variation as well as slightly higher medians for individuals with farmer and steppe ancestry are suggested by the boxplot. This is supported by nonparametric significance tests. Both Median and Kruskal-Wallis tests suggest overall significant differences between ancestry groups, p=0.0378 resp p= 0.0304.

Pairwise testing between HG and Farmers gave the following: Median test p=0.0211, Kolmogorov-Smirnov test p=0.0187, Kruskal-Wallis test p=0.0536. Only the K-W test resulted in a smaller significance. We can safely say that the distribution of Sr isotope values are significantly different from those in the Mesolithic. Pairwise testing between the Eur_BA (Steppe ancestry) against the other two groups also showed significant differences in the distribution of values. Figure S11.3 shows the spatial distribution of the three ancestry groups, all of which are concentrated in the more easterly parts of Denmark where bone preservation is better.

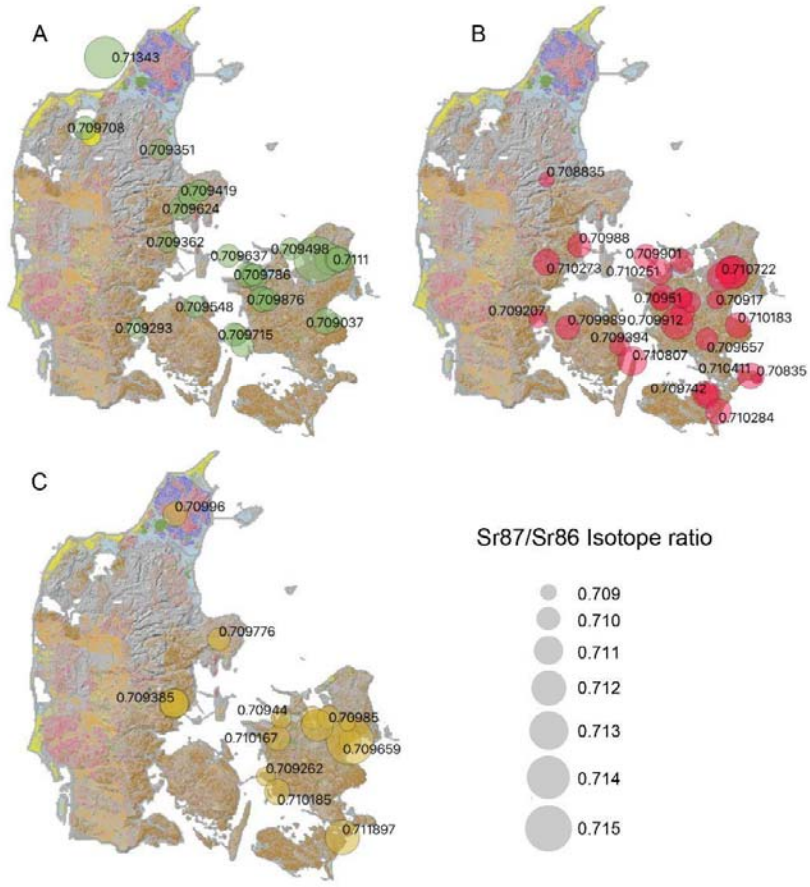

Figure S11.3. Spatial Sr isotope ratios for the main ancestry groups in our Danish dataset. A) HG_Europe_W B) Farmer_EurCentral_MLN C) Eur BA. *Modified soil classification as background map from GEUS.*

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12) Vegetation and landscape at the Mesolithic-Neolithic transition – illustrated using a high-resolution land cover reconstruction (LOVE) from Lake Højby, Northwest Zealand, Denmark

Morten Fischer Mortensen[1], Anne Birgitte Nielsen[2], Mikkel Ulfeldt Hede[3], Anthony Ruter[4], Kristian Kristiansen[5] and Peter Rasmussen[6]

[1] National Museum of Denmark, Environmental Archaeology and Materials Science, I.C. Modewegsvej, Brede, DK-2800 Kgs. Lyngby, Denmark

[2] Department of Physical Geography and Ecosystem Science, Lund University, Sölvegatan, Lund, Sweden

[3] Tårnby Gymnasium og HF, Tejn Alle 5, 2770 Kastrup, Denmark.

[4] GLOBE Institute, University of Copenhagen, 1350, Copenhagen K, Denmark

[5] Department of Historical Studies, University of Gothenburg, 405 30 Gothenburg, Sweden

[6] Section for Environmental Archaeology and Materials Science, The National Museum of Denmark, I.C. Modewegs Vej, Brede, 2800 Copenhagen, Denmark

The Mesolithic-Neolithic transition in Denmark: palynological evidence

Vegetation and landscape development in Denmark over the last 15000 years is well documented through a large number of pollen stratigraphic records from lakes, bogs and kettle holes [1–5]. The main drivers for vegetation changes through the Late Palaeolithic and Mesolithic periods were climate, soil conditions and the succession of various plant species [6,7]. So far, there is no unequivocal evidence of anthropogenic influence on the vegetation on a regional scale before the Neolithic period.

With the introduction of agriculture in Denmark *c. 3900 cal BC* humans became a crucial driving force behind vegetation changes. Johannes Iversen was the first to demonstrate this in his groundbreaking publication on the expansion of Neolithic settlement (`landnam´: land-taking) in Denmark [8]. With the subsequent studies of Iversen [9,10] and Troels-Smith [11,12], the most important features of the Neolithic vegetation development on the fertile soils in eastern Denmark were clarified. First is the classic "elm decline", which marks the beginning of the

Neolithic in historic vegetation studies. The decline of elm is followed by a brief increase in the frequency of grass (*Poaceae*) and herb pollen, which are then followed by a longer-lasting maximum of birch (*Betula*), which coincides with the first occurrence of the grazing indicator ribwort plantain (*Plantago lanceolata*) and sporadic evidence of grain cultivation (occurrence of cereal pollen grains). Birch then declines, while hazel (*Corylus*) achieves high frequencies in the pollen records until the primary forest taxa reemerge.

Iversen originally interpreted the development as a relatively short sequence: 1) first the forest was cleared by burning and the land was cultivated, 2) after a few growing seasons, the soil was nutrient deficient and the fields were abandoned, after which a natural plant succession began. First with birch forest, where the farmers´ cattle grazed 3), but over time the birch was outcompeted by hazel in a natural order towards the re-establishment of the primary forest. However, as pollen records have been ^{14}C dated and chronology has improved, we now know that this development extends over nearly a thousand years. Thus, it is not a single cycle of natural succession, but different stages of landscape utilisation and agricultural strategies that are expressed [13,14]. The phase division of the landnam period described by Iversen [15] is of a general nature and there are significant variations from locality to locality.

To illustrate the vegetation development at the transition from the Mesolithic to the Neolithic in eastern Denmark, we use a new high-resolution and well-dated pollen diagram from Lake Højby, Northwest Zealand, covering the period *5000-2400 cal BC* [16]. In this study, a "Landscape-Reconstruction Algorithm" (LRA; [17,18]) is used to reconstruct the vegetation changes in the catchment area of Lake Højby over a period of c. 2500 years. In the LRA, vegetation cover composition of the most common plants with wind-dispersed pollen types within the local area is estimated with the model LOVE (Local Vegetation Estimates; [17]). This corrects for differences in pollen productivity and dispersal, as well as for changes in the regional background pollen rain, estimated from the regional vegetation composition, which has previously been estimated with the model REVEALS [17] based on pollen data from six lakes on Zealand (see Fig. S12.1).

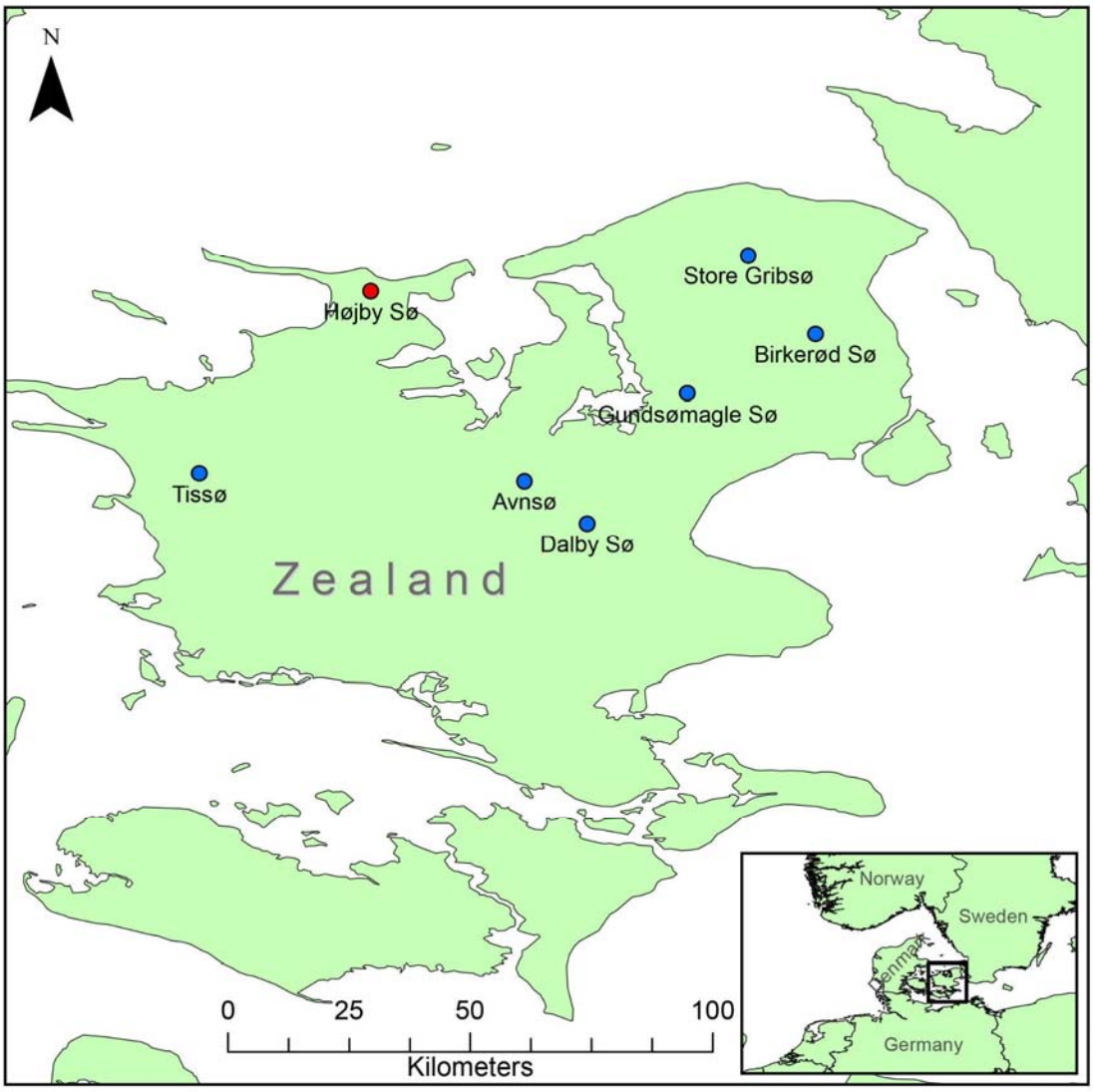

Figure S12.1. Map showing the location of Lake Højby in Northwest Zealand (red), and the other six lakes (blue). *These were used to estimate the regional vegetation composition with the LRA-REVEALS model.*

The development in eastern Denmark will be compared with the development on the sandier and less nutrient-rich soils in western and northern Jutland, where the vegetation development deviates to some extent from the development in eastern Denmark.

Mesolithic

Succession of temperate deciduous forest started in Denmark around *7000 cal BC*. This primary forest, often named the Atlantic primeval forest, consisted of a series of trees,

dominated by lime (*Tilia*), elm (*Ulmus*), oak (*Quercus*), alder (*Alnus*) and ash (*Fraxinus*). These shade-tolerant species gradually outcompeted the hazel and pine (*Pinus*) which dominated the older Boreal forests. On the nutrient-rich soils prevalent in eastern Jutland, Funen and Zealand, relatively low pollen proportions of light-demanding herb species have been registered. This indicates that the primary forest was relatively dense, with few and small open areas [19]. Modelling of the area distribution from Lake Højby shows that between 85 % and 90 % of the area was covered by primary forest (Fig. S12.2), which is in accordance with previous studies from eastern Denmark on a regional scale [20]. The open areas have primarily been concentrated around wetlands and along the coasts.

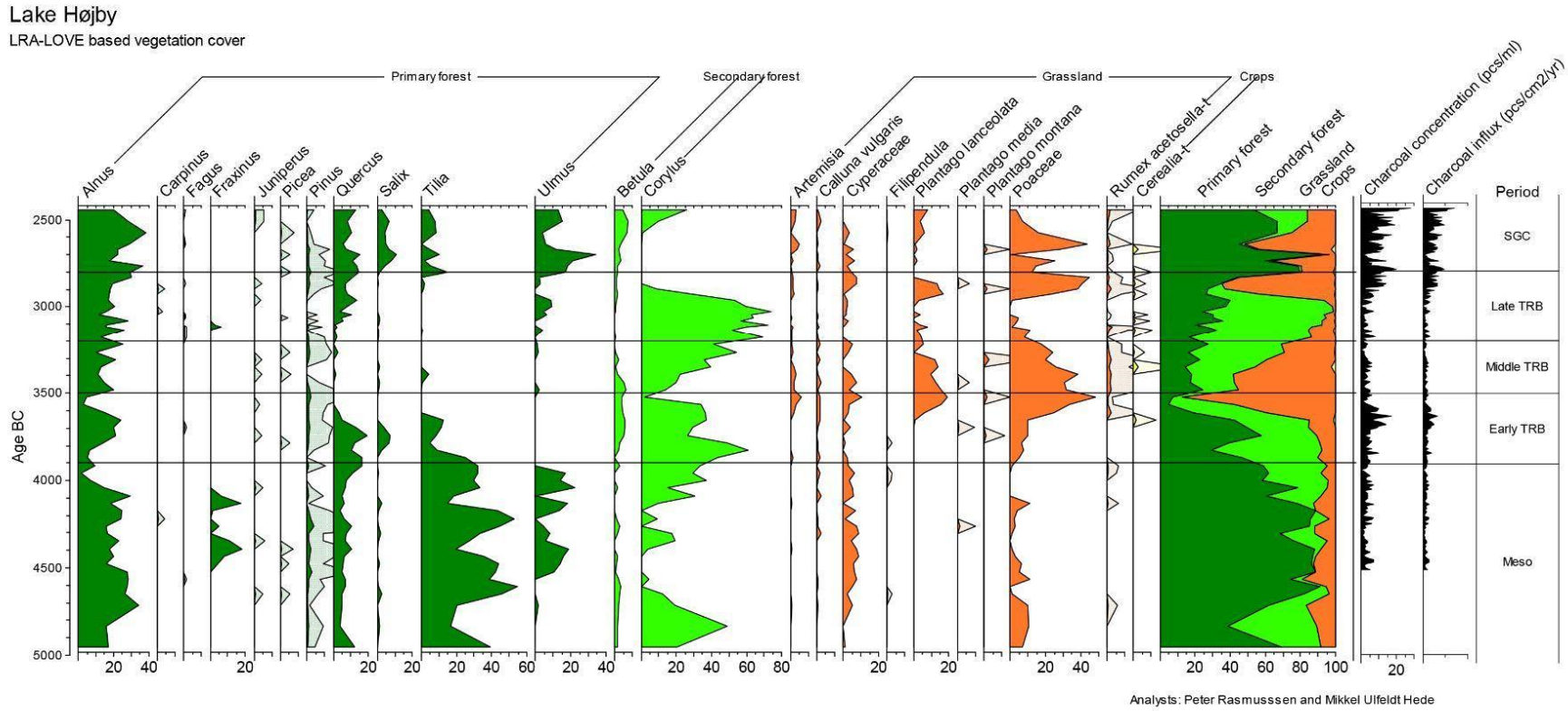

Figure S12.2. Local vegetation cover percentages around Lake Højby, estimated from pollen assemblages using the LRA-LOVE model. *Charcoal concentration and influx is also shown. Archaeological periods are indicated on the diagram: Meso, Mesolithic; Early TRB, Early Funnelbeaker Culture; Middle TRB, Middle Funnelbeaker Culture; Late TRB, Late Funnelbeaker Culture; SGC, Single Grave Culture.*

On the sandier and less fertile soils in western and northern Jutland, the Boreal forest was similarly replaced by temperate deciduous forest of the same tree species as in the east, but the forest maintains a more open character with a field layer of grasses and heather. Modelling of pollen data from Lake Solsø, located on the leached meltwater plain, indicates a forest dominated by hazel and birch (Haak *et al*. in press). The grassy openings covered between 20 % and 30 % of the landscape on a regional scale and up to 40 % furthest to the west [20]. The openness was partly maintained by forest fires that occurred regularly in this region [2]. On the moraine areas in northern Jutland, the forest composition was similar to the primary forest in eastern Denmark, yet, with a more open character [21,22].

These different forest development sequences highlight the marked geographical variation in the forest composition in Denmark during the Atlantic period (*7000-3900 cal BC*). A variation that can mainly be attributed to different soil conditions. A common feature of all the areas is a marked decrease in elm pollen around *4000 cal BC*. The decline of elm roughly coincides with traces of the first farmers detected in the archaeological record. Human activity has therefore been connected to the elm decline and especially leaf-feeding of cattle as the primary cause [12]. Today, however, elm disease is recognized to be the cause of the elm decline, which has now been detected over large parts of Europe and appears to have occurred over a very short number of years [23–25].

Early TRB *3900-3500 cal BC*

With the occurrence of the first farmers, significant changes in forest composition were initiated. In Lake Højby, there is a marked decrease in lime, probably because the first farmers preferred the high-lying and drier soils also preferred by lime. With the clearing of the lime dominated forest, grasses, oak, alder, willow (*Salix*) and hazel temporarily increased, as a secondary succession in the cleared areas. Despite these major changes in the composition of the forest, only an insignificant change in the ratio between forest and open land is observed. The absence of species indicating grazing, such as ribwort plantain and sheep's sorrel (*Rumex acetosella*) and other herbs associated with open and grazed landscapes indicates that large herds of free-ranging livestock were not common, despite the fact that the archaeological record contains bones of cows, pigs and sheep/goats [26,27]. Therefore, these animals were part of the earliest farming economies, but this did not significantly affect the vegetation composition in terms of openness. One possible explanation is that pigs, as well as sheep/goats, were the primary animals in the first century of the Neolithic, while cattle farming was less significant [e.g. 13]. From around *3800 cal BC*, the distinct increase in birch is caused by the farmers' clearing the forest with fire (Fig. S12.2).

Birch has a competitive advantage on the newly burned areas, and the increase in birch cover follows an increase in the charcoal concentration in the lake sediments, suggesting that regular burning was used as an integrated agricultural strategy. This phase covers the period from *3800 to 3400 cal BC*. Repeated burning of the forest is also supported by pollen preserved under the oldest long barrows. Here, birch pollen dominates, many of which show signs of having been exposed to strong heat, demonstrating that the successional birch groves were burned in subsequent swidden episodes [14].

Between *3650 cal BC* and the onset of the Middle TRB at *3500 cal. BC*, deforestation and burning intensified and a very open landscape formed, with less than 15 % tree cover locally around Lake Højby. At the same time, the first cereal pollen and grazing indicators such as ribwort plantain and sheep's sorrel occur in the diagram. Studies of plant macrofossils from a number of Danish TRB archaeological sites show that a variety of cereals were grown such as einkorn, emmer, bread / dwarf wheat, as well as naked and hulled barley [28,29]. Macrofossil studies indicate that these cultivars were present from the beginning of the Neolithic. The extensive deforestation and burning observed at Lake Højby are seen in large parts of eastern Denmark, and resulted in a very open landscape, while this development is much less pronounced in western and northern Denmark [13].

Middle TRB *3500-3200 cal. BC*

Around Lake Højby the opening of the landscape only existed for a short time period before the forest increased. Especially hazel increased, whilst the open-ground taxa like grasses and ribwort plantain decreased (Fig. S12.2). Around *3400 cal BC*, birch declines markedly, which may indicate that swidden cultivation as an agricultural practice declined. The continued presence of grazing indicators (ribwort plantain and grasses) indicate that cattle had become a much more important part of the agricultural package. However, it also indicates that grazing pressure was not intensive enough to prevent regrowth of the forest on areas that had been cleared at the end of the previous period. In contrast, grazing pressure had been high enough to form a hazel-dominated forest as hazel, unlike birch, produces new shoots when browsed. It must be concluded that extensive "forest grazing" was common over a fairly large area. This strategy dominated for about 400 years and a similar vegetation development has been demonstrated in other studies in eastern Denmark. This development is also supported by pollen records from contemporary long barrows and dolmens [14]. Despite increasing forestation, the presence of cereal pollen shows local cultivation.

Late TRB *3200-2800 cal. BC*

The development that started in the Middle TRB culminated around *3000 cal BC*, where hazel reached a coverage of approximately 60 % and the primary forest almost 40 %.

Thereafter, hazel is drastically reduced, and within only a hundred years hazel became an insignificant component of the forest composition. The former hazel-dominated landscape is transformed into open grazing land, dominated by grasses, ribwort plantain and sheep's sorrel. In addition to this development, cereal cultivation seems to be intensified, a development that is supported by pollen studies of soil profiles below passage graves [14].

A significant part of the grazing land was reforested with climax forest during the transition to the Single Grave Culture (SGC). A likely interpretation is that fields and grazing areas became more permanent, in contrast to the previous periods when agriculture was based on regular claiming of new land.

SGC *2800-2400 cal BC*

The development of permanent open grazing areas is observed at the transition to SGC in many regions. However, it is particularly pronounced in Northern and Western Jutland [13]. Here, the forest is cleared, creating the open and forest-poor landscape that has dominated the region until the 19th century AD. In eastern Denmark, there are several examples of deforestations in the SGC [e.g. 30], but in many areas the forest dominated during the SGC, as we see at Lake Højby, and remained dominant until the Late Bronze Age [31]. During the SGC, barley became the most common cereal variety and the diversity of the crops grown seems to decline compared to previous periods [32].

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