Radiocarbon dating of Holocene archaeological sites in the Far Northeast of Europe: scopes and limits of a supraregional database

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ABSTRACT – *The paper is devoted to the critical analysis of the radiocarbon dating results of Mesolithic, Neolithic and Chalcolithic complexes of the northeastern part of the East European Plain (Republic of Komi, Arkhangelsk and Vologda Regions and the Nenets Autonomous Area, Russian Federation). The comprehensive evaluation of all available geochronometric data in relation with the studied archaeological events highlighted the following three data sets: reliable, ambiguous and invalid dates. A new chronological model of Far Northeast of Europe colonization and dispersal of innovations over the Holocene is proposed based upon reliable radiocarbon dating results.*

KEY WORDS – *Mesolithic; Neolithic; Chalcolithic; Northeastern Europe; radiocarbon dating*

Radiokarbonsko datiranje holocenskih arheoloških najdišč na skrajnem severovzhodu Evrope: obseg in omejitve nadregionalne baze podatkov

IZVLEČEK – *Članek je posvečen kritični analizi rezultatov radiokarbonskega datiranja mezolitskih, neolitskih in halkolitskih kompleksov iz območja severovzhodnega dela Vzhodnoevropskega nižavja (Republika Komi, regiji Arkhangelsk in Vologda ter avtonomno okrožje Nenets, Ruska federacija). S celovito oceno vseh razpoložljivih geokronometričnih podatkov, v povezavi s preučenimi arheološkimi dogodki, izpostavljamo naslednje tri podatkovne zbire: zanesljive, dvoumne in neveljavne datume. Na podlagi zanesljivih rezultatov radiokarbonskih datumov predlagamo nov kronološki model kolonizacije raziskovalnega območja in razpršitve inovacij v holocenu.*

KLJUČNE BESEDE – *mezolitik; neolitik; halkolitik; severovzhodna Evropa; radiokarbonsko datiranje*

Introduction

The majority of researchers use instrumental methods of dating to determine the timing of archaeological events. However, the possibilities for applying them are far more comprehensive, and we suggest that they should become part of the critique of archaeological evidence and independent expertise for ideas relating to prehistory. Meanwhile, as users of external data, the archaeologists must have confidence in their reliability, which must be proven.

Many studies are devoted to this problem where researchers propose criteria for objective evaluation of radiocarbon age determinations of archaeological events. Since the problem was first raised in 1971 (*Waterbolk 1971*), researchers have attempted to improve the accuracy of such estimations and adapt the criteria for the study of materials of specific regions and periods (*Rick 1987; Spriggs 1989; Pettitt 2003; Graf 2009; Seitsonen* et al. *2012*). However, in Rus-

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sian archaeology, noteworthy studies in this direction are poorly represented (*i.e. Kuzmin, Tankerslay 1996; Kuzmin, Keates 2005; Kuzmin 2009; 2010; Seitsonen* et al. *2012; Zazovskaya 2016*), and for some regions and periods are completely absent. Although sequences of dates are published regularly, the primary reaction to them is blind faith in the numeric values obtained by scientific methods and an unfounded, often emotional conclusion about the correspondence or inconsistency of new data with archaeological concepts: 'good or bad', 'acceptable or unacceptable' dates. The dated material goes through a complicated path with obvious and uncertain influences from prehistoric individuals to the ^{14}C date, so the rationale for the result should be complex, considering all determinable factors (see below for details).

In this work, we have turned to identify opportunities and restrictions of radiocarbon dating of Holocene materials from the Mesolithic to the Chalcolithic in the Far Northeast of Europe (hereafter FNE). Archaeological periods are defined according to Russian (Soviet) research traditions and current regional data. The beginning of the Mesolithic is associated with the formation of modern postglacial landscapes (around 11.7 ka BP); the Mesolithic/Neolithic boundary is marked by the spread of pottery (early 6th millennium BC), and the Neolithic/Chalcolithic by the appearance of the early copper artefacts and their processing (around the 3rd millennium BC).

Our research aims to determine how reliable radiocarbon dating results are for improving the quality of our archaeological evidence and the amount of information it can provide. Such work that can lead to general conclusions is relevant, since it helps arrange the available data better. Moreover, it indicates directions in which we can conduct further studies regarding the use of geochronometric methods in archaeology and the interpretation of their results.

The objectives of this research are as follows: a review of the history and special features of the use of radiocarbon dating in regional studies; the collection and systematic organization of the available data and their evaluation. In order to determine specific regional variations regarding the use of radiocarbon dating for the Holocene archaeological sites, we have formulated answers to the following questions: (i) which materials are available for dating, and what has been dated?; (ii) what factors affect the reliability and accuracy of the data?; (iii) which results have been obtained, and how far do they correspond to archaeologists' ideas and data obtained using other natural sciences?; (iv) how do archaeologists interpret these dates?

Geographical and historical backgrounds

The territory under consideration includes the following regions of the Russian Federation: the Komi Republic, the eastern part of the Arkhangelsk Region, and the Nenets Autonomous Area. To extend the factual basis of our research, we also use data from the regions adjacent to the territory mentioned above, particularly the northeastern part of the Vologda Region (Fig. 1). The approximate area of the region under study is 700 000km^2.

The FNE is a territory between the Barents and White Seas, the Ural Mountains, the Northern Hills, and the Severnaya Dvina River's right bank. The northernmost part of the region is located in the tundra zone; the southern part is confined to the northern and middle taiga. Geomorphologically, most of the region is located in the northeast of East European Plain, while the foothills of the Ural Mountains represent its eastern edge.

The known archaeological assemblages are found exclusively in the taiga zone, occupied predominantly by primary forests (about 60%), bogs (about 14%) and a dense river network of three river basins: the Pechora, the Mezen and the Severnaya Dvina with the Vychegda, but very few lakes. The total area of the lakes is 450 000 hectares, which is 0.1% of the entire territory of the region.

According to the palaeogeographic data, during both Boreal and Atlantic periods the FNE was a part of the dark-coniferous taiga, and only the boundaries of landscape subzones – middle and southern taiga (*Nikiforova 1982.154–162*) – shifted, or the vegetation cover structure changed mainly due to quantitative redistribution within the coniferous species group (*Smirnova 1971*). For detailed information on the relationship between FNE Mesolithic colonization and the natural environment (see *Volokitin, Gribchenko 2017.75–104*).

In recent years, an interdisciplinary study has shown that the surfaces occupied by archaeological sites result from the impact of winds in the river valleys (*Karmanov* et al. *2013*). Aeolian ridges and fields cover the alluvial landscape and bedrocks, either flattening them or elevating the relief of floodplain ridges and levees while creating new dunes and deflation hollows.

The relief was formed in the Late Glacial and Early Holocene (*Zaretskaya* et al. *2014; Karmanov* et al. *2013*), but active geomorphological processes – erosion and alluvium accumulation – continue in the river valleys. As a result, the aeolian forms composed of loose sands are covered by poorly developed forest litter with reindeer lichen (*Cladonia rangiferina*) or green mosses (indefinite species) and occupied by pine forests. The choice of such landscapes as the most comfortable habitats and burial grounds is characteristic for the entire Holocene.

Archaeological evidence is confined to modern soil profiles, specifically to Albic Podzols (*World Reference Base Soil Resources 2006*). Back in the mid-1970s, soil scientists identified the features of their structure, properties and regimes (temperature, hydrological, redox, and nutritional) and gave their genetic characteristics (*Zaboeva 1975*). Later, researchers identified the mechanisms of the related physical, biochemical, and chemical processes; formation of soil structure; humus substances; organic-mineral complexes; mechanisms underlying the variability of soils in time and space (*Lapteva* et al. *2016. 26, 27*), and created the Atlas of Soils of the Komi Republic (*Atlas pochv Respubliki Komi 2010*). There is thus an exhaustive characterization of the initial natural state of deposits.

In our case, there are only five exceptions out of 200 sites, namely Vis 1 peat bog, Parch 1 and 2, Vylys-Tom 2, and Pezmog 4. Their cultural layers lay at different levels under alluvial deposits. Of course, there could have been more such sites, but the constant migration of river channels has left them with little chance of preservation. However, it undoubtedly affects our perceptions of the choice of habitat and habitation in prehistory.

At present, the known Mesolithic, Neolithic and Chalcolithic assemblages are represented mainly by campsites and settlements and only three burials (*Karmanov 2020*). The most informative sites including those discussed in this article are the remains of hunting campsites and subterranean dwellings, *i.e.* places where small and disparate population groups lived on a short-term basis (*Stokolos 1986; 1997; Volokitin 1997; 1999; 2003; 2004; 2006; Karmanov 2008; 2012*). This means that their impact on the sedimentary strata was insignificant and explains why the earthen structures and their components at such sites were temporary. In addition, the high mobility of small groups of people over a wide area gave rise to flexibility in diet and the use of materials for different needs. However, on the other hand, the short 'lifetime' of the studied sites and dwellings increases the likelihood that the dated materials are

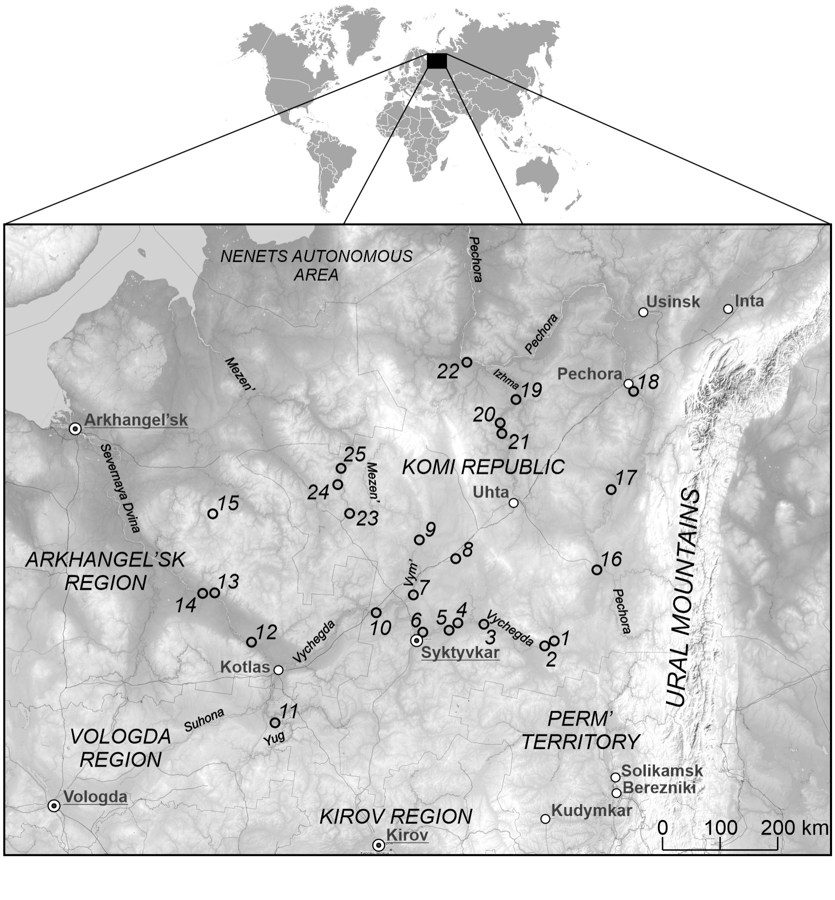

Fig. 1. European Far Northeast; distribution of sites mentioned in the text: **1** ***Cherdyb 1, Cherdyb 2;*** **2** ***Parch 1, Parch 2;*** **3** ***Podty 1;*** **4** ***Ugdym 1A, Ugdym 1D, Chertas 2;*** **5** ***Pezmog 4,*** **6** ***En'ty 1A, Vadnyur 1/5; Vadnyur 1/7A;*** **7** ***Niremka 1;*** **8** ***Vis 1 peatbog, Vis 2;*** **9** ***Yovdino 2/4;*** **10** ***Revyu 1;*** **11** ***Pavshino 2;*** **12** ***Prilulkskaya;*** **13** ***Chernaya Rechka 1;*** **14** ***Yumizh 1;*** **15** ***Yvron'ga 1;*** **16** ***Martyushevskoe 2/1, Martyushevskoe 8;*** **17** ***Dutovo 1;*** **18** ***Topyd-nyur 7a;*** **19** ***Lasta 8;*** **20** ***Lek-Lesa 1;*** **21** ***Vylys-Tom 2;*** **22** ***Shihovskoe 2/2;*** **23** ***Choynovty 2, Choynovty 1;*** **24** ***Oshchoy 5/3;*** **25** ***Muchkas. Based on OpenTopoMap available at https://opentopomap.org***

associated with one phase of habitation and are not a mixture of remnants of asynchronous events.

The small number and low density of the mobile FNE population hampered the long existence of cultural traditions here. In addition, these traditions originated in adjacent territories. This allows us to apply the principle of synchronization of similar phenomena in prehistoric cultures for an approximate determination of their age. However, the regions of Northern Eurasia have been studied unevenly and the chronology of cultures has been developed to different degrees. In this way, ^{14}C dating is useful for verifying archaeological reconstructions.

The history of radiocarbon dating in the context of archaeological investigations

Radiocarbon dating began to be used in the FNE at the end of the 1960s. In particular, it was promoted by the field-research department of the Institute of Archaeology, affiliated with the USSR Academy of Sciences, which assessed a report by Grigoriy M. Burov on excavations carried out in 1961. The Commission responsible for field research departments 'decided to advise' him to send wooden artefacts found in the Vis 1 peat bog site "*for radiocarbon analysis to the laboratory of the Leningrad Branch of the Institute of Archaeology of the Academy of Sciences*" (*Burov 1962*). As early as 1972, Burov – together with the Leningrad Branch staff members mentioned above – published a series of radiocarbon dates from the Vis 1 and Marmugino peat bog sites (*Burov* et al. *1972; Semyontsov* et al. *1972.348*).

The next attempt to date the Mesolithic was in the 1980s. It was the Chertas 2 site located in the upper part of the Vychegda river valley. Unfortunately, the experiment turned out to be unsuccessful (Tab. 1.7, 8), and the archaeologist Ekaterina S. Loginova lost interest in radiocarbon dating. The initial dates for the Neolithic (Prilukskaya site) were only obtained at the beginning of the 1990s and published later in 1996 (*Timofeyev, Zaitseva 1996.52*). For Chalcolithic contexts, the first dates were obtained from charcoal samples taken from various dwellings at Oshchoy 5, Choinovty 1 (*Stokolos 1986.100–101*) and Niremka 1 (*Kosinskaya 1987*) – and not before the mid-1980s.

The abovementioned failures of archaeologists in the ^{14}C dating of regional complexes and the lack of contacts with radiocarbon laboratories can partly explain the relatively small number of samples examined in this way, and the lack of research interest. In the 1970–1990s, the FNE archaeological community did not appreciate radiocarbon analysis as much as it does today. We pointed out two periods in the history of radiocarbon dating of archaeological sites in the region under study: 1972–1999 and 2000–2020. The first period is characterized by episodic use of instrumental dating, while the second indicates the systematic use of ^{14}C for solving archaeological problems. Figure 2.a compares the number of radiocarbon determinations for the two periods. The positive dynamics show the increased interest of regional archaeologists in ^{14}C dating as an independent method for determining prehistoric events.

Data covering such an extensive territory (around 700 000km^2) and long time (*c.* 6 ka) is not yet representative: 97 radiocarbon dates has been obtained from 46 assemblages of 37 FNE sites. The quantitative distribution of dated materials is shown in Figure 3. Charcoal samples predominate among them due to their better preservation rate, and thus availability for the liquid scintillation dating, applied with most samples (Fig. 2.b). Other materials – wood and plant remains, food crust – were less often dated because of the scarce archaeological contexts for this kind of sample type (Fig. 3).

All the available data are included in Tables 1–3 and Figures 4–6. The calibration of radiocarbon dates was performed using the Calib 8.2 program (*Stuiver* et al. *2020; Reimer* et al. *2020*) and the OxCal v. 3.10 program for the graphic presentation of the dates (*Bronk Ramsey 1995; 2000*). These dates compose the database, which is the subject of the critical analysis in this paper.

FNE samples: from the prehistoric project to the chronological framework

Christopher Bronk Ramsey proposed radiocarbon dating sequence patterns as the major elements of radiocarbon dating. The 'history' of the sample includes everything relating to the sample prior to 'investigation'. The latter incorporates all of the physical actions carried out on the sample. The final stage of the dating process is 'interpretation', which aims to uncover the main elements of the sample's 'history' (*Bronk Ramsey 2008.267, Fig. 2*).

In our study, we add regional geographic characteristics and the impact of unpredictable human behaviour to the sample history. For example, uncertain-

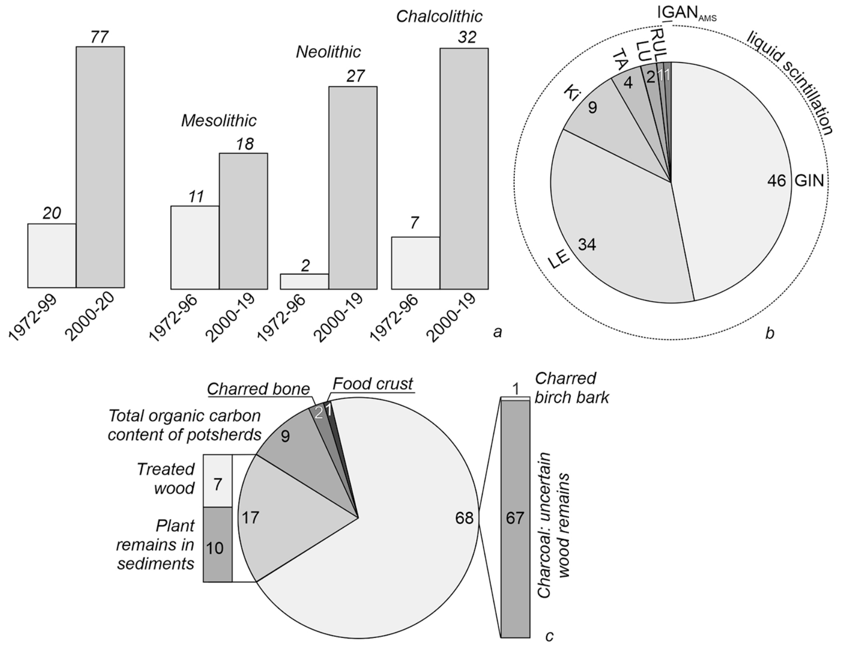

Fig. 2. History of investigations in EFN:* a *comparison of the number of ^{14}C dating for the periods 1972–96 and 2000–19;* b *distribution of the number of measurements in the ^{14}C laboratories of Soviet Union and modern Russia;* c *distribution of dated materials.

ties may arise in connection with the use of objects or substances older than the prehistoric events under study. These facts are not documented when archaeological assemblages are discovered or archived in museums.

Taphonomy and geomorphological effects

These are two related groups of factors that influence the quality of dating. Most sites with dated materials (32 out of 37) are open sites with subterranean dwellings. Therefore, we can assume that they were in 'open access' for a long time after their abandonment by ancient people. However, preservation of organic materials (above- and underground parts of dwelling structures, food remains) in the northern taiga could not be long term.

Many of the sites are located in pine forests growing on sandy fluvial terraces with an aeolian cap. Later forming of noncarbonated Albic Podzols (*Arkheologicheskaya karta Respubliki Komi 2014.7–13*) modified these sediments. Such soils form in a cold climate with seasonal ground freezing and a leaching regime. We can find the archaeological features and remains of structures in eluvial horizons at a depth from 0.05 to about 0.5m. Tree roots and periodic forest fires were thus constantly affecting the buried archaeological contexts.

In addition, fungal decomposition develops in the forest soils: fine mycelium fibres penetrate the pores of charcoal and cracks in organic materials (authors' observations). These unfavourable factors thus negatively affect the preservation of organic matter and contaminate the samples at the macro-level (for example, mixing of different-age and dissimilar materials) and micro-level (for example, mycelium).

Preserved dating materials from such FNE archaeological sites are charcoal, calcinated and charred bones, less often adhesives for repairing pots (bitumen, resin or tar), food crust, *i.e.* substances that have undergone significant thermal effects as a kind of conservation, and wet wood (Tab. 4).

The most common material is charcoal, which occurs in different states in the cultural layers of all sites. It represents the burnt structures of dwellings and fires and is scattered as small fragments throughout the deposits. There are remains of trees burned down during forest fires as a natural admixture in every archaeological context in the taiga. Their post-depositional transformation may produce structures that can be erroneously interpreted as artificially created. For this reason, when taiga sites are being dated, the origin of the samples can most probably explain the 'pitfalls' of radiocarbon dating. However, it should be pointed out that this is not

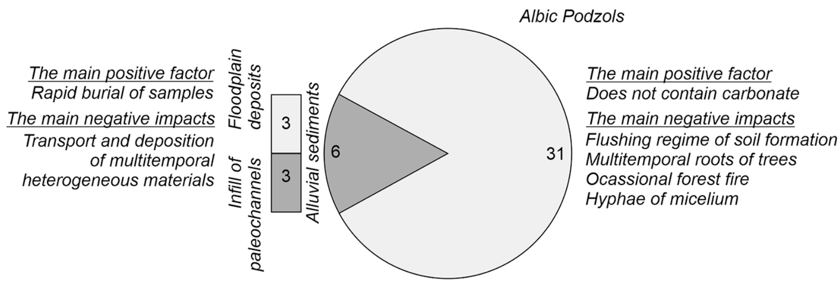

Fig. 3. Overview of culture-bearing deposits in two main geological contexts and their impacts upon them.

a problem of the method itself but the excavated archaeological assemblages, sample selection and the interpretation of certain situations by archaeologists. In 2004 the authors of this paper conducted an experiment and selected samples from charcoal clusters, including some found among the single pot fragments within the remains of a homogenous dwelling complex of the Middle Neolithic site Pezmogty 4 (Tab. 2.13–15; Fig. 5.b). All the dates obtained turned out to be outside the confines of the most likely age range for the context in question – the first half of the 5th millennium BC. This is proved by the sedimentary succession and dating results of similar complexes of the adjacent regions of European Russia. This thus meant that certain natural events had been dated, testifying that they had impacted the archaeological context.

Such situations may include ^{14}C dates, which do not correspond to the archaeological material since it is much younger. These are, for example, charcoal dates within 4250–3330 cal BC from the early Holo-

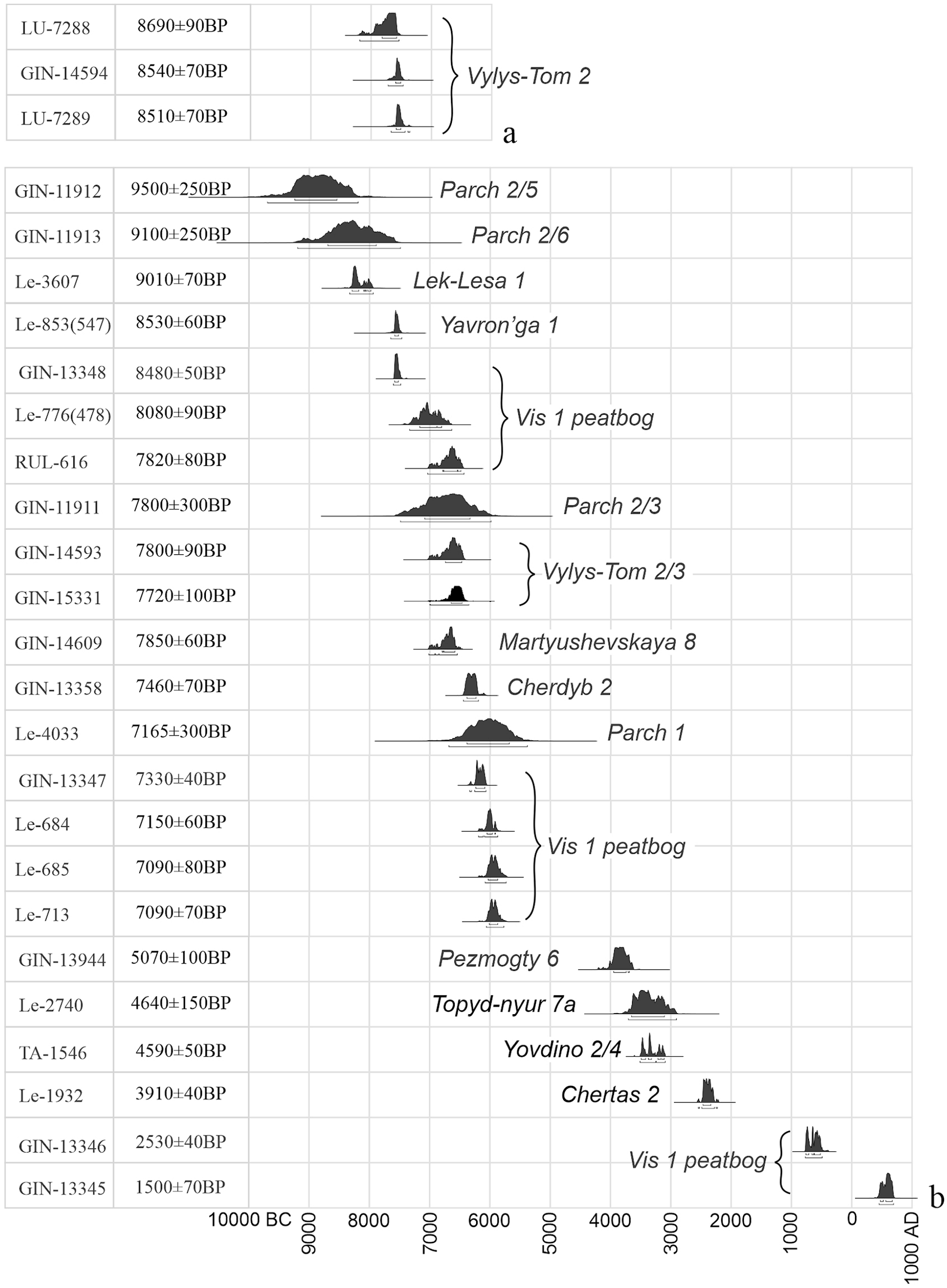

Fig. 4. Results of radiocarbon dating of Mesolithic assemblages:* a *reliable data;* b *ambiguous data.

cene sites of Pezmogty 6 (Tab. 1.9; Fig. 4.b), Yovdino II/4 (Tab. 1.19; Fig. 4.b) and Ugdym 1A (Tab. 2.16; Fig. 3.b).

Natural adverse impacts are most likely to explain different dates in groups of samples taken from the same archaeological assemblage and analysed in the same laboratory. Examples are the ^{14}C charcoal dates from the contexts of the Topydnyur 7a sites (Tab. 1.20, 21; Fig. 4.b), Prilukskaya (Tab. 2.26, 27; Fig. 5.b) and dwellings Shikhovskoye 2 (Tab. 3.11, 12; Fig. 6.b), Lasta 8 (Tab. 3.13, 14; Fig. 6.b), Choinovty 1 (Tab. 3.17–20; Fig. 6.b), Yumizh 1 (Tab. 3.28–30; Fig. 6.b) and Pavshino 2/2 (Tab. 3.32, 33; Fig. 6.b).

Bones have been found at most of the FNE Holocene sites (Tab. 4). They often occur as compact accumulations of a large number (up to 2500) of calcinated fragments confined to fireplaces, less often pits. In addition, they contain remains of various types, including species not living in pine forests (for example, beaver). All this points to their connection with human activities, and therefore it is a reliable material for dating, but only using the AMS technique, which was unavailable for the local archaeologists, and thus only two LSC dates were obtained (Tab. 2.22, 25; Fig. 5.a).

Wood and plant remains as available dating materials were found in the floodplains and paleochannel

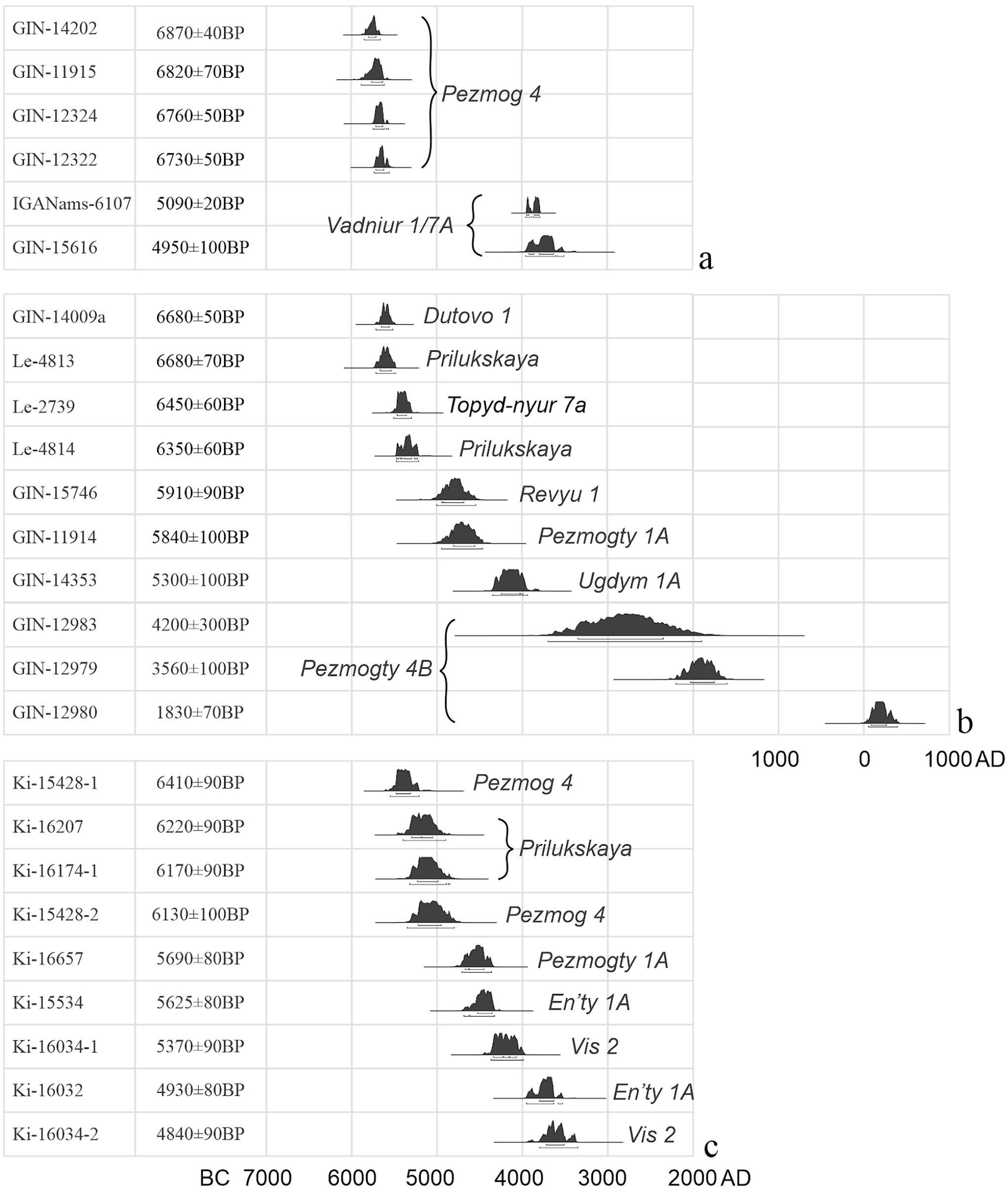

Fig. 5. Results of radiocarbon dating of Neolithic assemblages:* a *reliable data;* b *ambiguous data;* c *unreliable data.

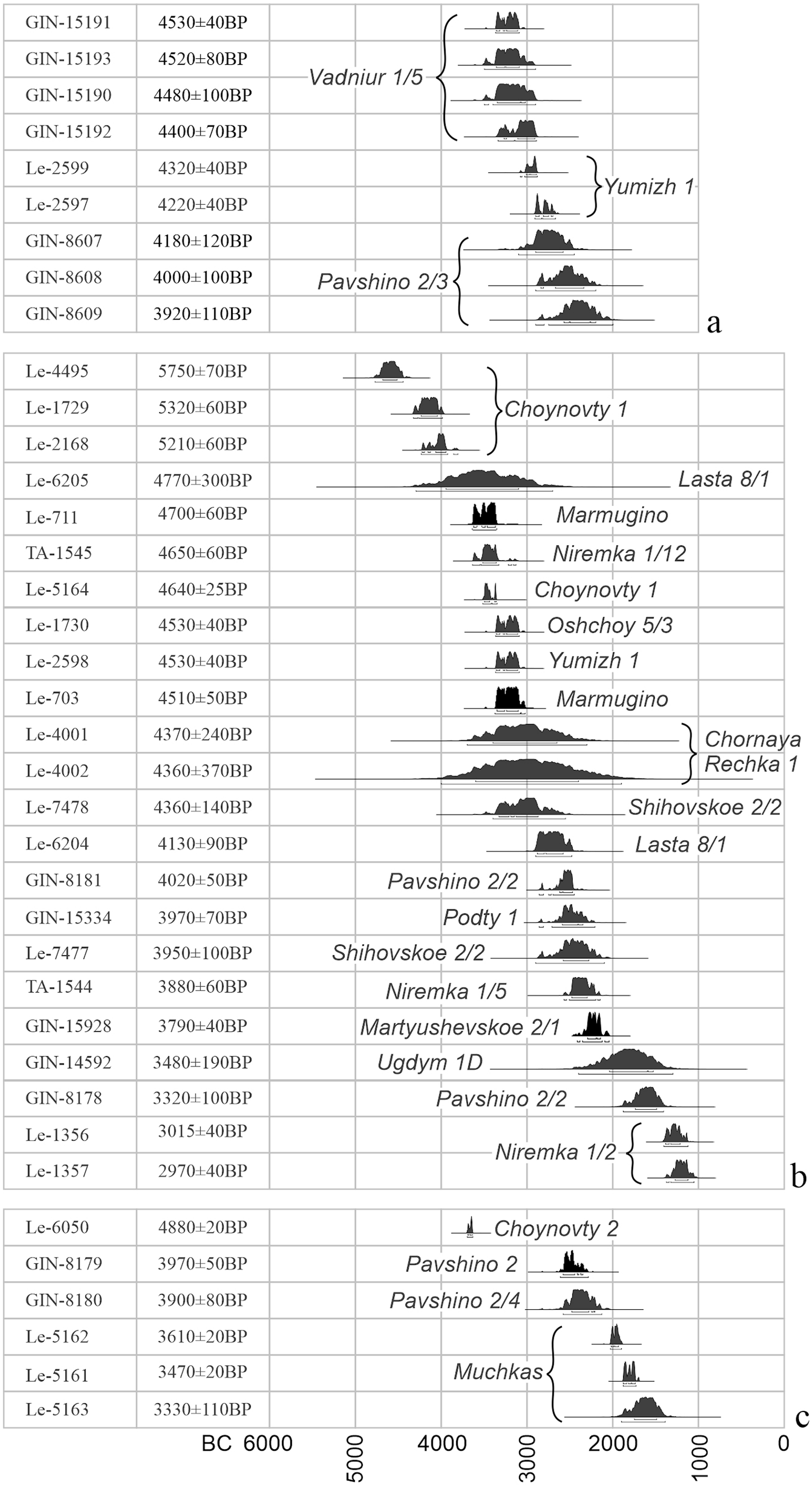

Fig. 6. Results of radiocarbon dating of Chalcolithic assemblages:* a *reliable data;* b *ambiguous data;* c *unreliable data.

infills at wetland sites. However, geoarchaeological archives of that kind are very few in the FNE and derive from following sites: Vis 1 peat bog site, Marmugino peat bog (*Burov 1967; 1969*), Parch 2 (*Volokitin 2006*), Vylys-Tom 2 (*Volokitin* et al. *2013*) and Pezmog 4 sites (*Karmanov* et al. *2014*). These localities have specific and different geomorphological features. The main negative factors are the transport and deposition of multitemporal heterogeneous materials and the activity of subterranean animals.

The examples of Parch 2 and Vylys-Tom 2 (Mesolithic) show that radiocarbon dating contexts enclosed within alluvial deposits can be ambiguous. The first example is the Parch 2 site (*Volokitin, Gribchenko 2017.97–101*). Here, the remains of eight dwellings were studied at a depth of 1.5m. Charcoals from three fireplaces of three dwellings have been dated (*Volokitin 2006.23–38*). Unfortunately, the obtained measurements have a large standard deviation range (Tab. 1.3–5; Fig. 4.b). Two dates are statistically close to each other, and the third is much younger. Such differences in occupation date among dwellings might be feasible if the site was located on the upper part of a fluvial terrace, but are implausible for the floodplain of Vychegda, one of the most active rivers in Europe. The most obvious explanation in this case is that the three dwellings might all date to 9000–8000 cal BC but bulk samples may include different amounts of younger carbon (due to *e.g.*, some local bioturbation) which would be difficult to remove during the pre-treatment stage.

Another example is the Vylys-Tom 2 multilayer site (*Volokitin* et al. *2013; 2014; Budzanivskiy, Volokitin 2014*), where two Mesolithic cultural horizons no. 3 and 4 (humified loam/ sandy loam) were discovered at a depth of more than 2m separated by archaeologically sterile sandy bed of 0.1m thick (Fig. 7). In both horizons the remains of fireplaces were found above each other. The investigation of these has provided samples for a series of dates obtained in different laboratories. Three of the five published dates form a compact group (Tab. 1.26–28; Fig. 4), while the other two are far outside the group's boundaries (Tab. 1.24, 25; Fig. 4). However, geomorphological and paleochannel studies at the site and in its vicinity make it possible to state that the cultural horizons were separated by an interlayer of alluvial sand accumulated over a brief period, most probably 10–20 years (*Volokitin, Volokitina 2019. 396*). This shows that when seeking to establish the age of a site, it is essential to rely on stratigraphy and archaeological data, revealing that the materials in the two horizons are identical. Therefore, it is appropriate to link together the three similar dates from the two layers, acknowledging that the gap between the periods of Mesolithic habitation was tiny.

Several publications have been devoted to describing and analysing the Vis 1 peat bog site, both since it was first investigated in the 1960s (*Burov 1967; 1990*) and more recently (*Burov 2012; Zaretskaya* et al. *2014; Volokitin, Gribchenko 2017.93–96*). Burov based his conclusions on the dating of wooden artefacts from the site (Tab. 1.10–14), analysis of the small number of stone tools, and palaeographic reconstructions carried out in the 1960s by Sergey N. Tyuremnov. In 2005–2014, new radiocarbon dates were obtained on deposits from Vis peat bogs 1, 2 and 3 and on the palaeogeography of ancient river

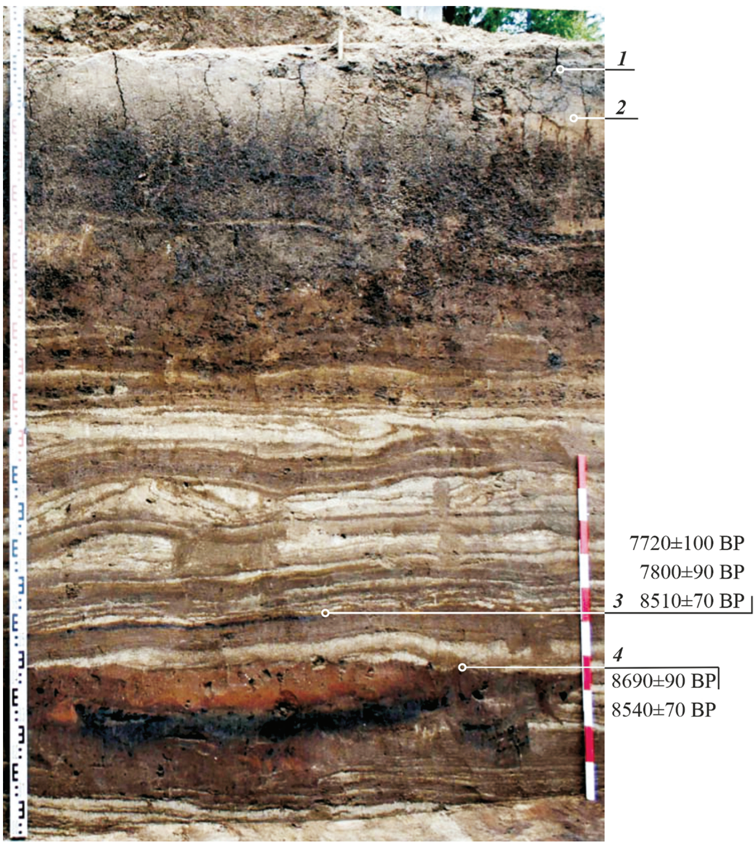

Fig. 7. Vylys-Tom 2: stratigraphy and radiocarbon dating results (after* Budzanivskiy, Volokitin 2014.Fig. 2*). 1–4 cultural horizons.

channels (*Karmanov* et al. *2013*). However, analysis of the results showed an inversion of the dates obtained from wood samples: this can be explained by the specific features of oxbow lake development, in which redeposition of formerly buried material can take place due to periodic renewal of watercourses along paleochannels (*Zaretskaya* et al. *2014. 94*). Moreover, neither bones nor pottery with food crust were preserved.

A successful example of dating archaeological context related to paleochannel infill is the Pezmog 4 site study (Tab. 2.1,2,5–10; Figs. 5.a, 8). Dating the food crust on the inner pot surface, culture-bearing deposits (silty peat), and charcoals from them coincided with the results. The subsequent age determination of the overlying deposits also demonstrated the reliability of the archaeological context and the absence of date inversions (Tab. 2.1,2,5–10). So far, this is the only example of dating food crust in the region using the LSC method. At the same time, a series of dates (Tab. 2.2, 5, 8) obtained from other materials shows that there is no significant freshwater reservoir effect.

Sampling during the excavations

At this stage of ^{14}C sample history, two main groups of problems can be identified in the regional aspect. The first is related to the historical background and geomorphological effects (see above). Due to the short duration of the habitation of small forager groups, there are few artefacts and ecofacts in the collections. Unfavourable conditions for preserving organic materials further reduce the informative value of contexts. The primary available material is charcoal (Fig. 3). For this reason, during excavations there is always the need to distinguish between wood deliberately burnt by prehistoric individuals and charcoal of natural origin – for example, in the wake of a forest fire. Nor is a guarantee of identifying prominent components of structures – fireplaces, for instance, in which there might have been admixtures of natural charcoals (see above). Sometimes archaeologists take every opportunity for instrumental dating and sample, for example, charcoal dispersed in the cultural layer. Such samples are highly unreliable subject for dating, as they may contain remains of diachronous forest fires (Tabs. 1.7,8; 2.13–16; 3.26,27,33). This is a problem not only of the studied region, but of other forest zone archaeological sites of boreal forests, *e.g.*, Karelian (*Seitsonen* et al. *2012.104*).

Erroneous conclusions from excavations can also lead to the archaeological perspective's production of 'inappropriate' data. For example, at the Mesolithic site Chertas 2 charcoal and enclosing sand were selected from the considerable depth of 1m. However, the two dates obtained did not correspond to the early Holocene (Tab. 1.7,8). This was not surprising because the spatial relationship between the artefacts and the studied structure makes us doubt its ancient age and the correctness of its interpretation as a prehistoric dwelling. A ditch of regular shape made in loose sand at such depth could not have been preserved from the Mesolithic under the constant effect of tree roots and ground processes. As the author of excavations testified, it is also appropriate to consider modern destruction (*Loginova 1985.19–22, Fig. 4b*). Probably in the 19th to early-20th centuries, a charcoal-burning pit had been dug up within the area of that site located on an aeolian dune. During the creation and usage of the pit, the Mesolithic cultural layer was distorted and re-deposited, and the charred timber of different age would have been moved together with soil and the artefacts enclosed in it. Later human impact on the site would eventually have destroyed it.

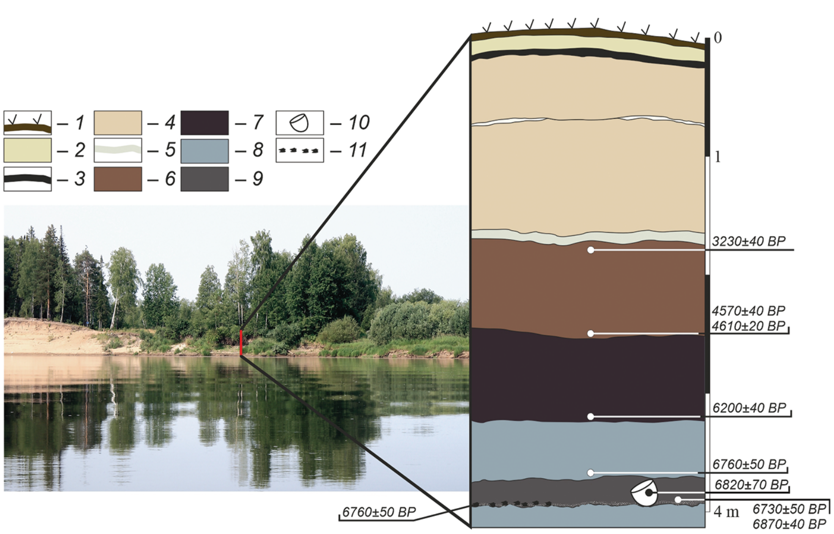

Fig. 8. Pezmog 4: outcrop of 1st terrace and floodplain (view from the river); stratigraphy and results of radiocarbon dating (after* Karmanov et al. 2013.Fig. 3*). 1 turf; 2 sand (result of flood); 3 buried soil; 4 sandy silt; 5 clay silt; 6 peat; 7 peaty silt; 8 clay; 9 silty peat with sand (culture-bearing deposits); 10 potsherds; 11 fragments of charcoal.

Some sampling strategies are not successful. For example, from the area of the Pavshino 2 settlement, fragments of charcoal were selected from Albic Podzol outside the archaeological context (Tab. 3.31) and the local remains of a damaged structure (lair?) in a depression (Tab. 3.37). The second example is the data from the Prilukskaya site. There, the radiocarbon age was determined for two charcoal samples taken from the fireplace remains identified by Irina V. Vereshchagina in excavation pit 2 in 1988: the fireplace had been found at a distance of approximately 4m from the central cluster of finds (Tab. 2.26,27; Fig. 5). However, no artefacts were found in the fireplace infill and its immediate vicinity (*Vereshchagina 1989*). Therefore, the connection between the dated fireplace and archaeological material is uncertain.

However, in some cases archaeologists have managed to identify archaeological objects or their parts without obvious negative impacts (for example, wooden roots and traces of ground deformation). For example, at Vadniur 1/5 and 1/7A we obtained two groups of dates (Tabs. 2.19,20; 3.3–6; Figs. 5.a, 6.a, 9) due to the discovery of horizontal chimney remains containing charcoal (*Karmanov* et al. *2017; Karmanov 2020*). The preservation rate of the deposits filling the investigated chimneys was relatively high. In addition, the intense ochre-like sand colour allowed us to avoid potentially problematic areas of deformation in the tubes and inclusions of the allochthonous material.

The second group of problems is the lack of accurate data on the sample location and the poor documentation accompanying their identification and transition to the laboratory. The archaeological situations revealed during excavations cannot be fully restored, and therefore the role of accurate 3D fixation and comprehensive photographic documentation is essential. However, in most studies of the 20th century charcoal and bone were considered as raw materials, and their field documentation is extremely rare. Nowadays, we often cannot determine where the samples were taken. The most striking example is the series of radiocarbon dates obtained from Muchkas settlement (Tab. 3.23–25; Fig. 6.c). They were valid for the Chalcolithic or the Bronze Age, but there is no proper information supplied on their context. Furthermore, four dwellings had been excavated (*Stokolos 1995*), and it is not possible to ascertain precisely the assemblage or assemblages the samples were taken from. The Choinovty 2 site context (Tab. 3.21) also has to be considered unreliable because it is not known which fireplace outside the dwelling area had been dated, and which archaeological material was concerned.

Laboratory stage

All samples of archaeological contexts in the region were analysed in the radiocarbon laboratories of the Soviet Union and Russia. Figure 2b shows the quantitative distribution according to this criterion: the laboratories GIN- (Geological Institute, Russian Academy of Sciences, Moscow, RF) and the Le- (Institute of History of material culture, Russian Academy of Sciences, Saint-Petersburg, RF) are leaders. All dates were obtained by the LSC method, except one (index $IGAN_{AMS}$) (Tab. 2.19). We shall not analyse here the peculiarities of different pre-treatment procedures of conventional radiocarbon dating in different Russian laboratories – they are shared over the area of the former Soviet Union (see details in *Zazovskaya 2016*), except the direct dating of pottery which became popular in the Neolithic archaeological community at the beginning of the 21st century (*e.g., Vybornov 2008*).

Nine dates have been obtained from the total organic carbon content or direct dating of pottery (Tab. 2.3,4,12,17,18,23,24,28,29) using the LSC method (*Kovaliukh, Skrypkin 2007*). Many publications have been devoted to the limitations and pitfalls of this approach (*e.g., O'Malley* et al. *1999; Gomes, Vega 1999; Kulkova 2014.116, 117; Meadows 2020. 54–56*). The authors of this paper have also touched on this subject earlier (*Karmanov* et al. *2014*), and for that reason we regard it as unnecessary to include the critical analysis here.

Data interpretation

The paradox of interpreting dating results lies in the fact that archaeologists often explain the validity of their dates, *i.e.* which of the dates correspond to the age of the prehistoric event or not. In other words, the results they expect are already presupposed before any dating, so the primary purpose would have been to confirm what they expected. Nevertheless, some of the interpretations provided are very interesting: Burov wrote concerning the dated artefacts from Vis 1 peat bog: "*The only exception is the Le-713 date, which is incorrect because it coincides with the Le-685 date. The samples had simply been mixed up in the laboratory*" (*Burov 2012.361, Tab. 1.13,14*). Thus, Burov tried to explain the inversion of these dates which have the same values but lie at different depths – 1.2 and 1.9m.

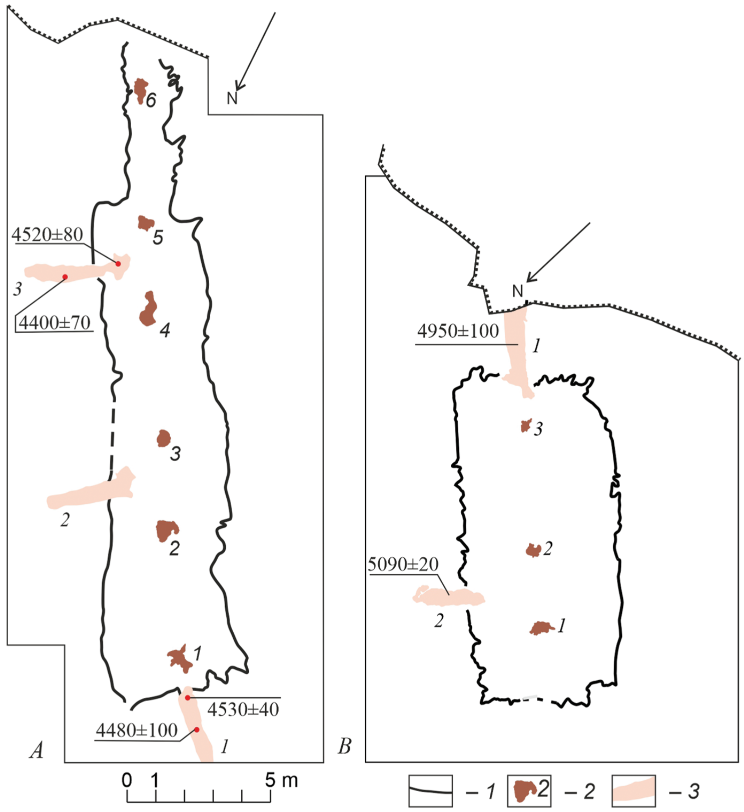

Fig. 9. Dwelling structure and results of ^{14}C dating. A ***Vadniur 1/5 (Chalcolithic);*** B ***Vadniur 1/7A (Neolithic).*** 1 ***dwelling limits;*** 2 ***fireplaces;*** 3 ***traces of horizontal chimney.***

An explanation appears after the result has been obtained, although ideally the archaeologist himself should make a statement regarding the reliability of the sample during his fieldwork. However, based on our practice and analysis of available data, it can be stated that if the sample selection context is reliable, the radiocarbon dates are valid. These statements are based on our studies (Tab. 4).

Examples of speculations with single dates or invalid ideas are as follows. First is the Mesolithic campsite, Topydnyur 7a (Tab. 1.20,21). Aleksandr V. Volokitin makes the following comment about the data concerning its radiocarbon dates: "*Unfortunately the radiocarbon dating of the Topydnyur 7a site does not inspire complete confidence. One date is too young, and this leads to doubts regarding the second, 6450±60 (Le-2790)*" (*Volokitin 1997.116*). In addition to Volokitin's view, we offer another explanation: charcoal fragments scattered among the remains of a dwelling with an area of about 10m^2 have been dated. The first date (Tab. 1.21) is related to the Chalcolithic. However, the second, indicating the Early Neolithic, would require a more detailed analysis of the context, including the technical-typological characteristics of the stone tools found in the excavated dwelling. Inside it, 266 objects (including débitage) were found (*Volokitin 1987.6–9*), and the quantitative and qualitative composition of that assemblage meant that it was not possible to provide an unambiguous answer to the question of its cultural and chronological attribution. Nevertheless, it could be classified with an equal degree of probability as a site of the Chornaya Vadya type (*Kosinskaya 2002; Karmanov 2008.29–31*). Materials of this kind could occur in the 6th millennium BC, and the date 6450±60 (5480–5370 cal BC, Le-2790) could correspond to the time when the assemblage had been created.

The following example is from Niremka 1 settlement. The series of dates to define the age of dwellings from different cultures at this site (Tab. 3.7–10) was commented on by Lyubov' L. Kosinskaya, who investigated it. In the context of our research, it is important to consider the reasoning of different researchers, and therefore let us cite verbatim from the paper of Kosinskaya: "*Not one of those dates should be regarded as entirely satisfactory*". The date for dwelling no. 5 does not link in with the series for the Fatyanoid vessels found inside it.

The dates for dwelling 2 are acceptable, but they would seem to be on the relatively late side. In addition, the fact that fragments from the same pots were found in dwellings 2 and 5 shows that there was no significant chronological gap between them.

The date for dwelling 12 is acceptable. As for the pottery finds, the stone collection and the type of dwelling itself, it is closest to and forms a pair with dwelling no. 9, so it is inappropriate to have a significant temporal gap between them: furthermore, a Fatyanoid pot was found in dwelling no. 9 (*Kosinskaya 1987.119, 120*).

To a large extent, a commentary of that kind has ceased to be relevant. For example, the so-called Fatyanoid pots – represented in this particular region by the Chirkov-Seyminsky type – found near the top of the section both inside and outside the dwellings have been identified in other diachronous settlements containing dwelling remains in the valleys of Severnaya Dvina (*Vereshchagina 1985*) and Pechora (*Stokolos 1988.95–101*) rivers. Those who maintained this pottery tradition probably used the depressions left behind from the dwellings of their predecessors as shelters. This means that the 'Fatyanoid pottery' bear witness to a later habitation and their presence cannot be interpreted as an indication that the radiocarbon dates are invalid. Far more important are data on fragments of a pot found in various dwellings but assigned to different dates. As the previous examples have shown, even samples from one fireplace are assigned to different ages, and for this reason the results from two dwellings of the same period with dates that do not match are hardly surprising. This could be explained as an example of the impact of tree roots mentioned earlier, or regarding the probability that the space in the depressions had been used on more than one occasion, bearing in mind their arrangement in a compact group.

The following example shows how archaeologists can be selective in publishing dates. In our practice, we know about one example – dating results from the dwelling of settlement Choinovty 1. Several dates were obtained from a reliable homogenous context, and two of them (Tab. 3.18,19; Fig. 6.b) were initially published (*Stokolos 1986.100*). Due to these results, the Final Neolithic age of the early period of the Chuzhyayolskaya culture was substantiated (*Stokolos 1997.219*). Later the whole series of dates obtained for that site was published (Tab. 3.17–20; Fig. 6.b; *Timofeev* et al. *2004.103*). The duration of the whole age range is with *c.* 1000 years considerable, and the rationale for the very early age of this archaeological phenomenon is no longer convincing.

Evaluation of the radiocarbon sequences

As a result of the evaluation of radiocarbon sampling and dating experience in our supraregion, we classify the chronological data based on the reliability of provided information: reference = reliable; ambiguous; unreliable.

The background for our further speculations is as follows:

- the system for evaluating the ^{14}C data in archaeology should depend on the peculiarities of the geography and historical context of the studied region, as well as the accumulated experience of instrumental dating in the region;
- this system should be based on the cooperation of an archaeologist and a geochronologist in order to adequately estimate the chronological information at all stages of its accumulation, from the prehistoric person to the chronometric data.
- the use of instrumental dating methods in archaeology, in particular radiocarbon dating, is part of a process in which the initial conditions are sometimes ambiguous and site-dependent: prehistoric individuals create samples, and various natural conditions constantly influence them. Therefore, the criteria for the reliability of ^{14}C dating results, like in any experiment, are simple and clear to everyone: repeatable accuracy and testability. Reliable age estimation of an archaeological event should ideally be obtained based on analysis of different materials and (or) different areas of archaeological objects and layers. These data can be recommended to the scientific community as trustworthy.

The main problem is that the experience of developing such a system for assessing regions that are identical to those we are studying in terms of geography, chronology and historical context is extremely small. We know the ^{14}C databases for the Neolithic and Chalcolithic of Northern Eurasia within Russia (*e.g., Timofeev* et al. *2004; Chernykh* et al. *2011; Dubovtseva, Kosinskaya 2021*), but only one study offers an integral system of their critical analysis. It is the study of the area closest to the FNE and the period of interest – Karelian Isthmus (northwest Russia), Mesolithic-Early Metal Age (*Seitsonen* et al. *2012.103, 104, Tab. 1*). To assess the reliability of the database, researchers use a rating system to determine the probability of matching radiocarbon ages with archaeological events. Paul Pettitt *et al.* (*2003*) proposed the basis of this system, while Graf and her followers then expanded it with new criteria and adapted the parameters to regional peculiarities (*i.e. Graf 2009. 699–701, Tab. 3; Seitsonen* et al. *2012.Tab. 1*).

The score (from 0 to 4) in the offered system increases with the researchers' confidence in the following conditions: "*(1) certainty of association of dated sample with human activity; (2) relevance of dated sample to the specific archaeological entity of concern; (3) quantity and reliability of dates for a specific archaeological horizon; (4) stratigraphic position; (5) sample type choice and the own age of the material; (6) standard deviation; (7) fittingness with the archaeological material and stratigraphy*" (*Seitsonen* et al. *2012.103, 104, Tab. 1*).

As Kelly Graf (*2009.699*) rightly points out, these criteria are only effective if we have complete information on all the items in this system. But we consider that the probability rankings proposed are artificial and the points awarded are the researchers' desire for a beautiful system that does not take into account that attributes may have different weights and hence different numbers of points (see detail critique of Graf' approach in *Kuzmin 2009*). Therefore, when assessing small databases, incomplete data, or apparent situations, such systems are excessive. For example, the argument that there is no information about a particular sampling location is sufficient to define the data as unreliable. Repeatedly proven erroneous dating of carbon in pottery makes redundant the further search for arguments why such dates are unreliable. Researchers have repeatedly been convinced of the validity of the 'one date is no date' principle, which allows such data to be defined as ambiguous. However, the estimation systems are of significant guidance for critically analysing databases and resolving disputed situations, resulting in determining the most significant probability of each date on a single basis.

Only a few definitions of FNE archaeological sites satisfy our requirements: Vylys-Tom 2 (Mesolithic) (Fig. 4.a), Pezmog 4 and Vadniur 1/7A (Neolithic) (Fig. 5.a), Vadniur 1/5, Yumizh 1 and Pavshino 2/3 (Chalcolithic) (Fig. 6.a).

Some of the ^{14}C data may not match for various reasons. Therefore, we characterize them as ambiguous dates. The criteria for their determination are as follows:

- the principle "*one date is no date*": to confirm/refute single dates, additional measurements are needed since the correspondence of the ^{14}C definition and the desired age of an archaeological event may be an accidental coincidence of numbers (Tabs. 1.1,6,9,19,22,23,29; 2.11,16,22,25; 3.1,2,7,8,22);
- significant difference in the series of dates, when it is impossible to determine which of the results corresponds to the time of the archaeological event, and which documents the negative impact on the sample based on other data (archaeological, paleogeographic or stratigraphic); the validation by additional data is required (Tabs. 1.3–5; 2.26,27; 3.11–14,17–20,32,33);
- measurements with a large standard deviation (Tab. 3.26,27);
- uncertainty between the archaeological material and event of interest allows us to offer different relative-chronological interpretations (Tabs. 1.20; 3.9,10).

If the sampling and dating were done in a methodologically correct manner, then we must not ignore the ambiguous dates. ^{14}C results that do not correspond to modern archaeological models should also not be excluded from the databases. Additional measurements may prove that some of them do indeed date archaeological events. Other determinations can possibly define temporally not well understood impacts on cultural remains and their geoarchaeological context. We thus propose a more flexible approach to the existing ambiguous data: after all, archaeological concepts are changing, and technologies for extracting dated substances are developing at a pace that was previously unthinkable (*Casanova* et al. *2020*).

Inaccurate or unreliable data are often obtained by incorrect methods, such as direct dating of pottery (Tab. 2.3,4,12,17,18,23,24,28,29). In addition, there are data with a lack of detailed sample information, and which cannot currently be correlated with specific archaeological contexts (Tab. 3.21,23–25,31,37). If nothing can be done with the first set of dates, then dates in the second set can become reliable if more information is found in the archives and subsequent dating episodes can substantiate them.

The evaluation of the reliable data and their significance for a supraregional chronological scheme in the FNE archaeology

The dating of the multilayered site Vylys-Tom 2 allowed us to obtain the first reliable sequence of the Mesolithic FNE layers. Previous datings were based on relative-chronological correlations of the materials from adjacent territories and on single ^{14}C dates or measurements with a broad standard deviation. It now can be securely stated that the older phase of that site dates to *c.* 7500 cal BC and the younger to *c.* 6500 cal BC or, alternatively, both phases belong to the 8th millennium BC (Figs. 4.a, 10.A).

Comprehensive analysis of the archaeological context of Pezmog 4 (*Karmanov* et al. *2013; 2014*) made it possible to move back in time the age of the early stage of the Kama Neolithic culture from the 4th millennium BC to second quarter of the 6th millennium BC, or to 5760–5615 cal BC. In addition, these data (Tabs. 2.1,2, 5.a, 8) allow us to reliably date the oldest pottery in the studied region and identify the earliest appearance of the combed tradition in the ornamentation of early pottery in this part of Europe (Fig. 10.A,C). Unfortunately, another type of ancient pottery (Dutovo 1) is currently associated with only one date (Tab. 2.25; Figs. 5.b; 10.B).

The study of the Vadniur 1 assemblages more convincingly confirms the results of previous studies of settlements with multiple dwellings (*Stokolos 1986. 54–88, 113–166; 1988.27; Kosinskaya 1990; Semenov, Nesanelene 1997.19–60*). It was established that these sites existed not simultaneously as a settlement but sequentially due to multiple occupations of attractive places by small groups. For example, the dwellings no. 5 and no. 7 of Vadniur 1 settlement were located only 13m from each other, had the exact same orientation of the long axis, unique features of construction, and similar flint knapping technology, yet the most probable periods of their existence are separated by an interval of about 400–500 years (Tabs. 2.19,20; 3.3–6).

The dating of Vadniur 1/7A (Tab. 2.19,20) and Vadniur 1/5 (Tab. 3.19–21) assemblages presented the first series of reliable age determinations of the late Neolithic and Chalcolithic sites. As a result, archaeologists have the opportunity to revise the established views on the development of the Chuzhjajolskaya culture. In addition, it was determined that Vadniur 1/7A is the oldest forager's dwelling in Northern Eurasia with a complex heating and ventilation system (*Karmanov 2020*). Such a structure is similar to the *gresbakken* type in Norway (*Seitsonen 2006*) and on the Kola Peninsula (*Kolpakov* et al. *2020*).

The dating of the Chalcolithic complexes of the Garino culture (Yumizh 1 and Pavshino 2/3) are also significant. First, however, it is essential to clarify their age and some other dates of the complexes of this culture. So far, the age of sites with the oldest metal in northeastern Europe has been determined very roughly – within the 3rd millennium BC (Fig. 10.A,C).

In this regard, we pay attention to the problem of the different resolutions of methods. Every experienced archaeologist can assess how long a particular site was inhabited or frequented based on the collections' quantitative and qualitative characteristics, the nature of the deposits containing traces of cultural remains, planography and stratigraphy. For mobile foragers in the northern taiga, such places cannot be long term settlements: spending short periods in one place is the defining feature of such households with their appropriating economy. The creation of a burial pit, as a rule, is the work of a single day. Instrumental dating methods are inadequate for reliably assessing the precise age of such objects. According to calculations based on the sets of dates described here, the standard deviation intervals for uncalibrated dates are, on average, 140 radiocarbon years. Thus, even for simple conclusions regarding the chronological correlations between mobile foragers in various territories, age estimations based on these data are still only very roughly sketched.

Conclusions

The FNE chronological database consists of valid dates (22), ambiguous dates (60), and unreliable or

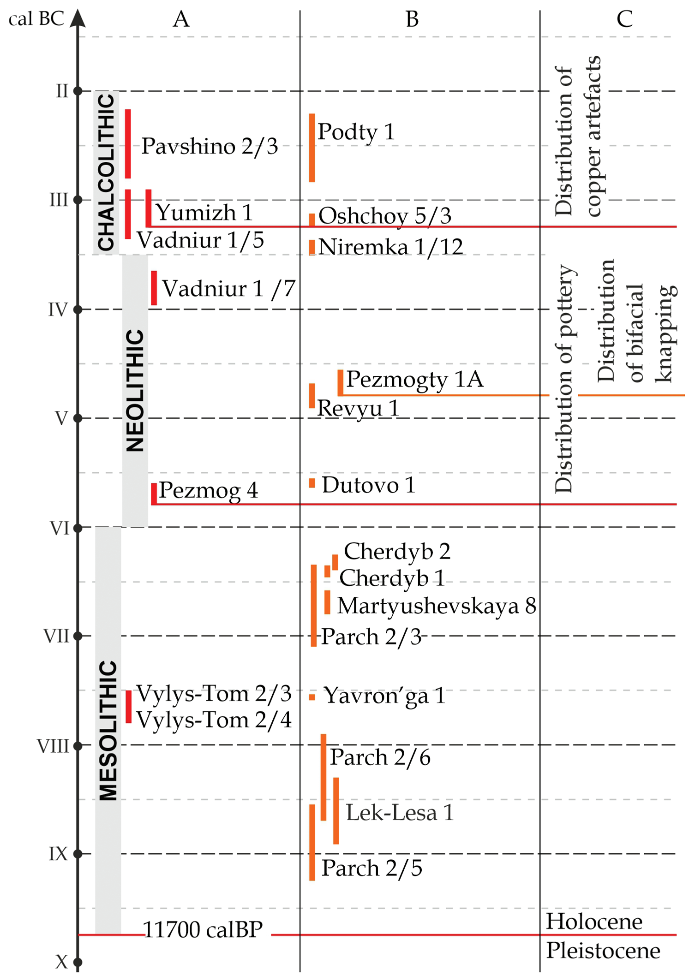

Fig. 10. Archaeological periodization of FNE: a model.* A *reliable dates;* B *single dates corresponding to periodization model, but requiring confirmation;* C *important events.

uncertain dates (15). Among the radiocarbon dates obtained for Holocene sites of the Stone Age and the Chalcolithic in the FNE, only 18 dates from the seven assemblages (Figs. 4.a; 5.a; 6.a; 10.A) can be defined as reliable and with the highest probability associated with prehistoric events. Therefore, they can be used in regional research. In addition, four other dates provide contextual reliability, illustrating the absence of stratigraphic inversion (Tab. 2.6, 7,9,10).

Sixty determinations are considered from an archaeological viewpoint as presenting ambiguous results (Figs. 2.b, 3.b, 4.b). There are 14 single dates that correspond to modern archaeological periodisation, but require confirmation (Fig. 10.B). At the very least, other measurements document the uncertain impacts on the materials or contexts in which the dated samples were found. We hope that future research can better determine their significance, which would require the dating of other materials from the assemblages they derived from or determining the age of similar complexes. Eventually, some of them may be confirmed, and we can identify them as reliable.

The next group of 15 dates (Figs. 5.c, 6.c) is here considered as unreliable and should not be used for the chronological determination of archaeological sites or events associated with this evidence.

The number of reliable age determinations of Mesolithic, Neolithic and Chalcolithic archaeological complexes is insufficient to elaborate even a tentative chronology of those periods. So far, they define only single events of mobile foragers' residence in the FNE in the Early and Middle Holocene. Nevertheless, they offer us the possibility to synchronize these events with those from adjacent territories, and thus they do provide some insights into the diversity of the ancient traditions of pottery making and building dwellings. They also point out possible directions for the search for the origins of these skills. In addition, they provide new arguments for the claim that the studied dwelling complexes were the result of multiple occupations of attractive places rather than the founding of large settlements. Further work will be concerned with the enrichment of the database and an increase in the responsibility for sample selection, in order to enhance the reliability and accuracy of dating. A first step could be a more detailed investigation of informative complexes, such as Vadniur 1, Pezmog 4 and Vylys-Tom 2.

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Tab. 1 Radiocarbon dating results. Mesolithic assemblages.

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
			Vychegda river basin (Komi Republic)			
1	Cherdyb 1	Charcoal; unit 1	GIN-13357	7520±90	6460–6340	*Volokitin, Zaretskaya 2006*
2	Cherdyb 2	Charcoal; unit 2	GIN-13358	7460±70	6400–6250	
3	Parch 2/5	Charcoal, fireplace	GIN-11912	9500±250	9250–8550	*Volokitin 2006*
4	Parch 2/6	Charcoal, fireplace	GIN-11913	9100±250	8700–7900	
5	Parch 2/3	Charcoal, fireplace	GIN-11911	7800±300	7100–6350	
6	Parch 1	Charcoal cluster	Le-4033	7165±300	6400–5700	
7	Chertas 2	Charcoal, depth 1m	TA-1547	Modern	–	Slip card, E. S. Loginova archive (1981)
8		Charcoal with sand, depth 1m	Le-1932	3910±40	2470–2340	Slip card , E.S. Loginova archive (1985); *Timofeev* et al. *2004.100*
9	Pezmogty 6	Charcoal cluster	GIN-13944	5070±100	3970–3760	This paper
10	Vis 1 peat bog; river Vis	Wood, processed log, depth 1.7m	Le-776(478)	8080±90	7180–6900	*Burov* et al. *1972*
11		Wood, log, depth 1.75m	RUL-616	7820±80	6780–6560	
12		Wood, bow, depth 1.9m	Le-684	7150±60	6070–5980	
13		Wood, stick with ledge at the end, depth 1.2m	Le-685	7090±80	6050–5890	
14		Wood, processed plank, depth 1.9m	Le -713	7090±70	6030–5890	
15		Diatom gyttja; depth 0.4m	GIN-13345	1500±70	440–640 AD	*Zaretskaya* et al. *2014*
16		Gyttja; depth 0.7m	GIN-13346	2530±40	790–550	
17		Gyttja; depth 1.34m	GIN-13347	7330±40	6240–6090	
18		Gyttja; depth 2.3m	GIN-13348	8480±50	7580–7520	
19	Yovdino II/4; river Vym	Charcoal, fire pit in dwelling	TA-1546	4590±50	3500–3330	*Kosinskaya 1987.93*
			Pechora river basin (Komi Republic)			
20	Topyd-nyur 7a	Charcoal	Le-2739	6450±60	5480–5370	*Volokitin 1997.116*
21		Charcoal	Le-2740	4640±150	3650–3100	
22	Matiushevskaya 8; river Severnaya Mylva	Charcoal	GIN-14609	7850±60	6780–6600	This paper
23	Lek-lesa 1; river Izhma	Charcoal	Le-3607	9010±70	8300–8190	*Volokitin 2005*
24	Vylys-Tom 2, cultural horizon no. 3 (humous loam/sandy loam); river Izhma	Charcoal, fireplace	GIN-15331	7720±100	6640–6465	*Volokitin, Volokitina 2019.396*
25		Charcoal, fireplace	GIN-14593	7800±90	6760–6490	*Volokitin* et al. *2014*
26		Charcoal, fireplace	LU-7289	8510±70	7595–7520	
27	Vylys-Tom 2, cultural horizon no. 4 (humous loam/sandy loam)	Charcoal, fireplace	LU-7288	8690±90	7830–7590	
28		Charcoal, fireplace	GIN-14594	8540±70	7605–7520	
			Pinega river basin (Arkhangelsk region)			
29	Yavronga 1	Charcoal, bottom of fire pit	Le-853 (547)	8530±60	7595–7535	*Burov 1974.86*

Tab. 2. Radiocarbon dating results. Neolithic assemblages.

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
		Vychegda river basin (Komi Republic)				
1	Pezmog 4, excavation of 1999	Food crust, inner part of the ceramic vessel; depth 3.66–3.75m	GIN–11915	6820±70	5760–5630	*Karmanov* et al. *2012*
2		Charcoal, cultural-bearing deposits; depth 3.6–3.7m	GIN–12324	6760±50	5710–5630	
3		Total organic carbon content (TOCC) of potsherds	Ki–15428-2	6130±100	5220–4950	
4		TOCC	Ki–15428-1	6410±90	5480–5310	
5	Pezmog 4, sampling of 2002	Silty peat (cultural-bearing deposits); depth 3.6-3.8 m	GIN–12322	6730±50	5710–5615	
6		Gyttja; depth 3.2m	GIN-12325	4570±40	3380–3120	
7		Peat; depth 1.8m	GIN-12326	3230±40	1530–1440	
8	Pezmog 4, sampling of 2009	Silty peat; depth 3.58–3.90m	GIN–14202	6870±40	5800–5710	
9		Silty peat; depth 3.25–3.28m	GIN–14201	6200±40	5180–5060	
10		Silty peat; depth 2.54–2.57m	GIN–14200	4610±20	3490–3360	
11	Pezmogty 1A	Charcoal, fireplace	GIN–11914	5840±100	4800–4550	
12		Potsherd, direct dating	Ki–16657	5690±80	4620–4450	
13	Pezmogty 4B	Charcoal, small fragments	GIN-12983	4200±300	3350–2350	This paper
14		Charcoal, small fragments among the sherds of broken pot	GIN-12979	3560±100	2030–1750	
15		Charcoal, small fragments	GIN-12980	1830±70	80–260 AD	
16	Ugdym 1A	Charcoal, small fragments, utility pit	GIN-14353	5300±100	4250–4030	
17	Enty 1A	TOCC	Ki–16032	4930±80	3800–3630	*Karmanov* et al. *2012*
18		TOCC	Ki–15534	5625±80	4530–4360	
19	Vadniur 1/7A	Charcoal, horizontal chimney no. 1 infill	IGANAMS–6107	5090±20	3870–3810	*Karmanov 2020*
20		Charcoal, horizontal chimney no. 2 infill	GIN-15616	4950±100	3810–3640	
21		Charcoal	GIN-15615	1690±30	256–416AD	
22	Revyu 1	Charred bones, pit no. 5	GIN–15746	5910±90	4910–4680	
23	Vis 2, river Vis	TOCC	Ki-16034-2	4840±90	3720–3510	*Karmanov* et al. *2012*
24		TOCC	Ki-16034-1	5370±90	4330–4220	
		Pechora river basin (Komi Republic)				
25	Dutovo 1	Charred bones	GIN–14009a	6680±50	5645–5555	*Karmanov* et al. *2012*
		Severnaya Dvina river valley (Arkhangelsk region)				
26	Prilukskaya; excavation pit 2, 1988	Charcoal, fireplace	Le–4814	6350±60	5380–5290	*Timofeev, Zaitseva 1996.52*
27		Charcoal, fireplace	Le–4813	6680±70	5660–5530	
28	Prilukskaya; excavation pit 1, 1974	TOCC	Ki–16207	6220±90	5300–5050	*Karmanov* et al. *2012*
29		TOCC	Ki–16174-1	6170±90	5230–4990	

Tab. 3. Radiocarbon dating results. Chalcolithic assemblages.

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
Vychegda river basin (Komi Republic)						
1	Podty 1, construction no. 1	Charcoal from the bottom of cultural layer	GIN-15334	3970±70	2839–2210	This paper
2	Ugdym 1D	Charred birch bark in the broken pot	GIN-14592	3480±190	2040–1600	
3	Vadniur 1/5	Charcoal, infill of horizontal chimney no. 1	GIN-15191	4530±40	3240–3110	*Karmanov* et al. *2017*
4		Charcoal, infill of horizontal chimney no. 3	GIN-15193	4520±80	3360–3090	
5		Charcoal, infill of horizontal chimney no. 1	GIN-15190	4480±100	3350–3080	
6		Charcoal, infill of horizontal chimney no. 3	GIN-15192	4400±70	3110–2910	
7	Niremka 1/12, river Vym	Charcoal, infill of exit ditch	TA-1545	4650±60	3520–3360	*Kosinskaya 1987.119*
8	Niremka 1/5	Charcoal, unknown context	TA-1544	3880±60	2559–2149	
9	Niremka 1/2	Charcoal, unknown context	Le-1356	3015±40	1395–1126	
10		Charcoal, unknown context	Le-1357	2970±40	1371–1051	
Pechora river basin (Komi Republic)						
11	Shihovskoe 2/2, river Pechora	Charcoal, remains of burnt roof	Le-7477	3950±100	2580–2280	*Vaskul 2011.5*
12		Charcoal, remains of burnt roof	Le-7478	4360±140	3130–2870	
13	Lasta 8/1, river Izhma	Charcoal; square 53-5G	Le-6204	4130±90	2780–2580	*Timofeev* et al. *2004.102*
14		Charcoal; square 4G	Le-6205	4770±300	3950–3100	
15	Martiushevskoe 2/1,	Charcoal; pit no. 2	GIN-15928	3790±40	2401-2046	This paper
16	river Severnaya Mylva	Charcoal; uprooted tree pit, under pit no. 2	GIN-15929	4680±60	3634-3358	This paper
Mezen river basin (Komi Republic)						
17	Choinovty 1	Charcoal; depth 0.4m	Le-4495	5750±70	4690–4520	*Timofeev* et al. *2004.45, 103*
18		Charcoal; depth 0.3m	Le-1729	5320±60	4240–4050	*Stokolos 1986.100; Timofeev* et al. *2004.45, 103*
19		Charcoal	Le-2168	5210±60	4070–3950	*Stokolos 1986.100*
20		Charcoal; depth 0.4m	Le-5164	4640±25	3500–3440	*Timofeev* et al. *2004.45, 103*
21	Choinovty 2	Charcoal, fireplace out of dwellings	Le-6050	4880±20	3665–3640	*Timofeev* et al. *2004.103*
22	Oshchoy 5/3	Charcoal; depth 0.8m	Le-1730	4530±40	3240–3110	*Stokolos 1986.101; Timofeev* et al. *2004.102*
23	Muchkas	Charcoal, dwelling ?; depth 0.3m	Le-5162	3610±20	1980–1935	*Timofeev* et al. *2004.43, 102*
24		Charcoal, dwelling ?; depth 0.12m	Le-5161	3470±20	1780–1740	*Timofeev* et al. *2004.102*
25		Charcoal, dwelling ?; depth 0.4m	Le-5163	3330±110	1750–1490	
Severnaya Dvina river valley (Arkhangelsk region)						
26	Chornaya Rechka 1	Charcoal, the cultural layer	Le-4001	4370±240	3400–2650	*Vereshagina 2008.128*
27		Charcoal, the cultural layer	Le-4002	4360±370	3600–2400	
28	Yumizh 1	Charcoal; square 25	Le-2597	4220±40	2900–2750	
29		Charcoal, the fireplace 1; depth 0.45m	Le-2599	4320±40	2960–2890	
30		Charcoal, the fireplace 1; depth 0.2-0.4m	Le-2598	4530±40	3240–3110	

No.	Archaeological site	Dating materials	Laboratory index and number	^{14}C age, BP	Calibrated age, BC, 1σ	Reference
		Yug river valley (Vologda region)				
31	Pavshino 2	Charcoal buried with podzol dump; 10m from the destroyed dwelling no. 1	GIN-8179	3970±50	2573–2457	*Vasiliev, Suvorov 2000.21*
32	Pavshino 2/2	Charcoal, passage between two chambers	GIN-8181	4020±50	2580–2470	
33		Scattered charcoal fragments, cultural layer in the pit-house	GIN-8178	3320±100	1740–1490	
34	Pavshino 2/3	Charcoal, fireplace (?)	GIN-8607	4180±120	2900–2580	
35		Charcoal, fireplace (?)	GIN-8608	4000±100	2670–2340	
36		Charcoal, fireplace (?)	GIN-8609	3920±110	2500–2270	
37	Pavshino 2/4	Charcoal fragments from the dwelling pit, sampled from the area destroyed by a lair	GIN-8180	3900±80	2480–2280	
38	Marmugino peat bog	Wood, fishing trap no. 1	Le-711	4700±60	3470–3370	*Timofeev* et al. *2004.99*
39		Wood, fishing trap no. 2	Le-703	4510±50	3240–3100	*Timofeev* et al. *2004.98*

Tab. 4. Synopsis of dated materials and availability of results.

Materials available for dating	Frequency	Number of dates available for publication
Charcoal	Common	68 (Tabs. 1.1–9,19–29; 2.2,11,13–16,19–21, 26,27; 3.1,3–37)
Calcinated or charred bones	67 of 158 reference assemblages	2 (Tab. 2.22,45)
Total organic carbon content in sherds	765 pots	9 (Tab. 2.3,4,12,17,18,23,24,28,29)
Undefined glue (bitumen, resin or tar) for pots repairing	46 of 765 pots	0
Food crust	1 of 765 pots	1 (Tab. 2.1)
Wood	2 sites	7 (Tabs. 1.10–14; 3.38,39)
Charred bark	2 cases	1 (Tab. 3.2)
Total organic carbon content in the sediments, containing archaeological materials	3 sites	4 (Tabs.1.17,18; 2.5,8)
Total organic carbon content in the sediments, overlying the cultural layers	6 sites	6 (Tabs. 1.15,16; 2.6,7,9,10)