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Scope: The journal publishes papers and reviews on the chronology of different archaeological cultures and sites, based mainly on the measurements of the residual content of radiocarbon (^{14}C). A special attention will be paid to the results obtained by both traditional methods and modern accelerator mass-spectrometry technique, to reliability and the precision of radiocarbon measurements. Researchers are welcomed from all the countries over the world. The journal is issued twice a year, total about 150 pages.

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Radiocarbon and Archaeology

14C

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From the Editors

The radiocarbon method is today widely used for chronological research in Archaeology. The first radiocarbon dates for archaeological sites were produced in the 1950's. A large number of dates were gathered during this time because nearly all radiocarbon laboratories were involved in the dating of archaeological objects that could also be dated by archaeological and geological means. One can say that the radiocarbon dates from archaeological sites provided an important means for calibration of the radiocarbon method. In this way radiocarbon dating developed into a scientific method for dating of archaeological material independent of the classical archaeological methods but depending on a close collaboration between natural scientists and archaeologists.

The radiocarbon dating of archaeological objects allows a comparison of the chronological positions of archaeological cultures from different parts of the world. This extends the possibilities for the archaeological research. Most radiocarbon laboratories have now their own databases for radiocarbon dates including those from Archaeology. However, from the 1960's, the journal Radiocarbon published lists of radiocarbon dates produced by the different laboratories. At present these lists are published in journals including "Archaeometry" and "Antiquity". The problems of radiocarbon chronology in archaeology are occasionally discussed at different conferences and published in their proceedings. If one takes the importance of the radiocarbon chronology into account there is an obvious demand for a special journal encouraging regular publication of the date lists and for methodological discussions.

The appearance of such a journal in Russia is not accidental. Earlier, more than 30 radiocarbon laboratories dating archaeological objects existed in the former USSR. The radiocarbon laboratory of the Institute for the History of Material Culture of the Russian Academy of Sciences was founded at the end of the 1950's solely for archaeological dating. Today seven radiocarbon laboratories remain in NIS (one in Kiev, one in Minsk, two in St.Petersburg, two in Moscow and one in Novosibirsk) are dating archaeological samples. Most of the radiocarbon dates from these laboratories are only published in different local publications that are difficult to access for researchers unacquainted with the Russian language.

By publishing the Journal "Radiocarbon and Archaeology" we intend to present the full lists of radiocarbon dates made by NIS laboratories with archaeological interpretations and comments. We hope this will make these radiocarbon dates more accessible internationally. Special attention will be given to the achievements in traditional radiocarbon methods (proportional and liquid scintillation techniques) and accelerator mass-spectrometry, as well as to the reliability and precision of the radiocarbon measurements. The journal will be published twice a year. We think that such a Journal will be of international interest for specialists studying chronology. We would like to invite all specialists to participate in this Journal.

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Radiocarbon intercomparisons

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Abstract

In this paper, some past ^{14}C inter-comparisons are reviewed and a new experimental programme described. New developments in dating technology are identified and the importance of quality assurance procedures stressed.

Keywords: Radiocarbon dating, laboratory inter-comparison, quality assurance.

Introduction

Inter-laboratory comparisons have been widely used in analytical chemistry and radio-chemistry as an important part of ongoing quality assurance programmes. The C-14 community has been no exception in this respect, and in just under 20 years, there have been a number of significant and very extensive inter-laboratory trials organised by individual laboratories and the International Atomic Energy Agency to the benefit of the ^{14}C community (both laboratories and users) (Otlet et al, 1980; ISG, 1982; Scott et al, 1990; Rozanski et al, 1992; Scott et al, 1992; Gulliksen &Scott, 1995).

The inter-comparisons have varied widely in terms of sample type and preparation, but all have had as their primary goal the investigation of the comparability of results produced under possibly quite different laboratory protocols.

Such inter-comparisons form an important part of a laboratory quality assurance programme, the other components of which include documented in-house laboratory procedures and the provision of suitable and well-referenced standards or reference materials.

General objectives

Participation in inter-laboratory comparisons has a number of benefits: for an individual laboratory, it provides an opportunity to verify analytical performance, to identify any problems, their source and magnitude; for new laboratories in particular, such organised inter-comparisons provide an invaluable opportunity to test procedures and equipment and for the user, they provide an opportunity to be assured of the reliability and traceability of the ^{14}C results and to have confidence in the quality of the laboratory.

There are a number of objectives of an inter-laboratory comparison, in the first instance and for the user and laboratory, it provides direct evidence of the comparability or otherwise of the results from different laboratories. Other objectives include to describe the pattern of variation and to identify laboratories producing discrepant results. Commonly, inter-laboratory trials are summarised by the properties of repeatability and reproducibility. They are defined as follows: *repeatability* refers to the variability of results performed in a single laboratory, under as near identical conditions as possible while *reproducibility* refers to the variation in results under widely varying conditions in different laboratories. In effect, they represent two extremes of variation. Typically, the focus of the trial is the laboratory and laboratory performance, but in the case of characterisation of reference materials, the trial can also be used to define the qualities of the test specimens.

The study material

The choice of sample materials is crucial: the first decision is whether to use natural materials or artificially create them; the second is whether all samples are of a single class of material (e.g. only shell or peat or wood), which of course limits the generalisability of the results are varied. The third choice concerns the age span, whether the activity or age of the test samples should cover the ^{14}C timescale or focus on a limited time period. Most commonly for ^{14}C dating, the materials used have been representative of routinely dated material, natural and spanned the ^{14}C timescale. A key question when using natural samples is the homogeneity of the material. Obviously, as sample requirements in terms of weight may vary quite widely (through differences in pretreatment procedure, counting and technique), it is necessary that the sample should be demonstrably homogeneous at the finest level required. This is an important issue as there is ever growing requests for dates from smaller and smaller samples and is one which is returned to in later sections.

The number of samples is balanced between the needs of the statistical analysis of the data and of course the practical commitments of the participating laboratories. Preferably, numbers of test samples should be greater than four, and there should be replication. The presence of replicate (commonly duplicate) samples allows a direct assessment of a laboratory's repeatability, or the within-lab variation.

Summary of recent inter-comparisons

In this section, several ^{14}C inter-comparisons are reviewed and their findings summarized.

International Collaborative Study (1990)

This study extended the work undertaken in earlier trials, and introduced a more complex design, to allow the quantitative assessment of the between-laboratory variation previously reported. The study had three stages, with different test materials in each stage, but also included known age material. The study was sequential, since at each stage, an additional procedure was introduced, bringing an additional contribution to the overall variation. Each stage also included duplicate samples to allow assessment of within-lab variation and its relation to the quoted uncertainties. The study ran for 4 years, with over 50 participating laboratories. Results were summarised at an international workshop (Radiocarbon, 32(3), 1990). From the duplicate results, it was concluded that the within-laboratory variation was adequately described by the quoted uncertainties, but that the between-laboratory variation (both systematic and random) was, in many cases, larger than anticipated. One conclusion was that some of the variation observed reflected the difficulties in maintaining suitable and sufficient laboratory standards and reference materials for calibration, and following this study, international efforts were made to extend the suite of reference materials available.

IAEA- reference materials (Rozanski et al, 1992)

Six new reference materials were distributed in 1990 to over 130 laboratories for characterisation. This study was less concerned with laboratory performance but more with the suitability of the test materials and their future use. The materials had already undergone homogeneity testing before distribution, they ranged in age from modern to background and included a number of different sample classes (wood, cellulose, sucrose and carbonate). The main aim of the analysis was to characterise the samples by providing consensus values. The analysis highlighted problems with some of the reference samples (C-1 (Carrera marble) which indicated some problems at or near background level with contamination) and C-4 (Kauri wood)), where some contamination occurred as a result of the milling process). These reference materials are available on request from IAEA headquarters in Vienna.

TIRI (Scott et al, 1992, Gulliksen and Scott, 1995)

TIRI (the Third International Radiocarbon Intercomparison) was begun in 1991, and again involved a large number of labs (over 70). TIRI involved two stages (in the first stage, a core set of samples for all laboratories, in the second stage, an optional set of materials were available), all the test materials were natural. TIRI was designed to provide an independent assessment of laboratory performance, following the recently completed IAEA study and hence the materials were designed to test the full laboratory procedure.

In TIRI as in the other studies, the results pointed to variation in the results beyond that described by the quoted uncertainties.

Historical Conclusions

All of the studies cited above have provided valuable information to laboratories and hence to users. In all cases where natural samples have been used, there has been evidence of additional variation in the results. In all studies, anomalous observations have been found, although there is no evidence that they occur on a frequent basis. By the nature of the radiocarbon conventional dating technique (random decay process), by the natural variation of ^{14}C in the environment, it is clear that there will always be variation in the determinations, this cannot be reduced to zero, but what can be done however is to eliminate systematic biases and to ensure that the uncertainties quoted by the laboratories are realistic. As a result, it is clear that such checks as TIRI and others are and will continue to be necessary and that they must operate in addition to any within-laboratory procedures. Increasing the scope of reference materials and standards is important, since by their inclusion, the dating determinations can be better constrained but only if laboratories make regular use of them in routine operation. Since the 1980's when these large-scale studies began there have been significant changes in the mode of operation of many laboratories. More and more requests are being made for ^{14}C determinations which cannot be classed as strictly routine. There is still a need for routine dating, where intermittent checks are necessary and which can be satisfied by materials such as the IAEA reference materials and by programmes such as TIRI which were directed more at large sample dating, but there is clearly also a need for further exploration of comparability and variation at the limits of the technique (very small or very old samples).

Future developments

There have been a number of key developments: there is increasing pressure to date smaller (even to the compound specific level) and older samples; more radiometric laboratories are forming close collaborations with accelerator labs which has meant developing in-house techniques for target preparation. Thus an accelerator lab may have a number of target preparation labs providing it with targets presenting new issues of comparability. Perhaps, however the most significant factor is that as we strive to measure smaller and smaller samples, the issue of sample homogeneity becomes more and more important, indeed the definition of a sample becomes critical. In some of the studies already completed in which AMS labs have participated, some evidence of sample inhomogeneity has been reported, which the conventional laboratories were not able to detect. There are difficulties in taking a representative sub-sample from the bulk of material, indeed how do we know it is representative? We do not fully know the potential scale of natural ^{14}C variation in sample matrices.

^{14}C dating still remains a key tool for the archaeologist, but its applications are widening, with increasing focus on past environments and climate and anthropogenic enhancements. Small samples are increasingly becoming the norm rather than the exception and the move toward compound specific analyses simply reflects the increased sensitivity required to answer the scientific questions being posed.

These developments in how the scientific question is phrased when linked to the technological developments introduce practical issues of what should be sampled, and how that sample relates to the event being investigated. This shift in scientific direction has also raised awareness of some of the measurement issues. For users, sample size has become an important issue, as a result for interpretation of the measurement, an understanding of the nature of the sample becomes crucial (not least the magnitude of any natural in-homogeneity in that material).

A new ^{14}C inter-comparison (FIRI)

A new ^{14}C inter-comparison has been designed at least in part to reflect these scientific priorities. However, as its first objective it still has answering the fundamental measurement questions of how accurate and how precise are the analyses, questions which are still equally appropriate for both radiometric and AMS laboratories.

Aims and objectives

The fundamental aims and objectives of FIRI (the Fourth International Radiocarbon Intercomparison) reflect a continuing commitment to the issues of accuracy and precision in basic ^{14}C research and can be simply summarized:

- Demonstration of the comparability of routine analyses of both AMS and radiometric laboratories;
- Quantification of the extent of and sources for any variation;
- Investigation of the effects of sample size, precision and pre-treatment on the results.

The study therefore was conceived with a number of design and sample selection criteria (Scott et al, 1997).

The design structure is rather simple: the intercomparison will include core (which all laboratories will measure) and optional samples all representing 'typical' materials.

The sample selection criteria are relatively simple to express but more difficult to satisfy due to the quantity of material required. They are that all samples should be natural and several should be dendro-dated wood; the samples' activity should span modern to close to background and some duplicates should be incorporated. Further some of the samples should form a link to past exercises; samples should be retained for archiving and most materials should be suitable for measurement by both AMS and radiometric laboratories. Finally, a fundamental property of any sample is that of homogeneity in ^{14}C activity either as a natural property or artificially induced. This has translated into dendro-dated wood with a limited number of rings or drawn from a plateau on the calibration curve; samples with only a short growing period or samples which have been physically homogenized and chemically treated in bulk. This inter-comparison began in 1998, with the samples being dispatched to all laboratories in October 1999. Results are expected by August 2000, shortly after which a workshop will be held to discuss the results and the way forward.

Conclusions

The inter-comparison programme and its overwhelming support by the ^{14}C community over the years reflects the clear and continuing commitment to ensuring the quality of the basic ^{14}C measurement as used in every field of application. The programme has evolved as the ^{14}C field has evolved and it will continue to do so. Assuring the quality of the measurement remains an essential laboratory function and the ^{14}C inter-comparison is and will continue to be an important part of laboratory quality assurance procedures, providing an independent check on measurement capabilities.

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A 2400-year cycle in some natural processes during the Holocene: geophysical and archaeological evidences

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Abstract

The radiocarbon calibration curve is extended now into the Late Glacial. The most outstanding shape of calibration curve is around 300, 2400, 4500, 7500 and 9500 BP. Most of these "wiggles" in the calibration curve are caused by the anomalously high values of the ^{14}C concentration that recur to the period of 2300-2400 years. The highest amplitudes of the ^{14}C concentration seem to correspond to the colder conditions during the Holocene. The different duration cycles observed in the ^{14}C concentration can be connected with the changes of the solar activity, climate and the magnetic field of the Earth. The main aim of this paper is the examination of the ~ 2400-year cycle during the Holocene in various natural records: reconstruction of the temperature and precipitation in some of regions of Northern Eurasia on the basis of data from lake and bog sediments, transgressions and regressions in the basin of the Baltic and Caspian seas, historical records of valley and mountain glacier advances and retreats, ice core data, the appearance of prehistoric man etc. In general, the observed variations in these data are in agreement with the 2400-year cycle observed in the variations of the ^{14}C concentration.

Key worlds: Holocene, climate, cyclicity, radiocarbon chronology, cosmogenic isotopes, archaeological data

Introduction

It was shown by the International Workshop on Intercomparison of Radiocarbon Laboratories (Proceedings, 1990) that the accurate radiocarbon dating is a very complex process. The main result of that intercomparison is the development of high-precision laboratories for radiocarbon calibration work and the demonstration of possibility to improve the precise in all laboratories.

The radiocarbon calibration curve is based on the ^{14}C activity measurements in tree-rings with the calendar age determined exactly by dendrochronological method. There is the possibility to measure the ^{14}C content both in different archaeological and historical samples. But, without a calibration curve there is no possibility to interpret these measurements as dates. If there is a series of samples with known time interval, it is possible to obtain a very accurate estimation of calendar age by using the wiggle matching (the short-term variations in the calendar curve). At present, this calibration extends back for more than 10,000 years.

The accuracy of the ^{14}C dating depends both on the accuracy of the ^{14}C activity measurements and the fluctuations of the ^{14}C content in the Earth's atmosphere. These fluctuations complicate the conversion of radiocarbon ages into calendar ages. The most outstanding shape of calibration curve is around 300, 2400, 4500, 7500 and 9500 BP. For these radiocarbon ages, precise radiocarbon measurements not always result in a higher accuracy in radiocarbon dating. The wiggles in the calibration curve are caused by fluctuations of the ^{14}C content in the Earth's atmosphere, connected with large-scale changes in solar activity, climate or the magnetic field of the Earth. Over a very long time scale the evolution of the Sun has not only fundamentally controlled the physical and chemical processes in the formation of our planet but has controlled its surface physical characteristics and the climatic system. The

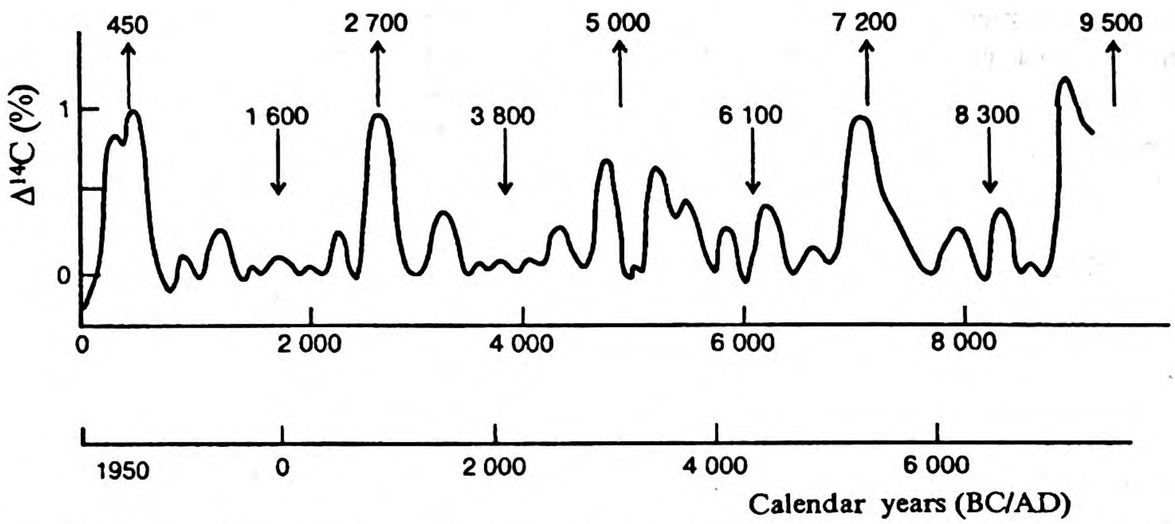

Fig. 1. Large-scale variations of the radiocarbon content during the past 10,000 years smoothed by the band-pass filtering. The arrows show the vicinity of extrema of the ~ 2400-year periods.

climate depends upon the solar activity. The climate system is made up of many components which have significantly different physical processes and time scales of response. The key to many component is the natural variations of the climate. The evidence for significant changes in climate comes from a variety of indirect and proxy data. During such time, the human civilisation and conditions of human life is very sensitive to change in climatic conditions. Therefore, our understanding of natural processes is necessary to predict them. The aim of this paper is to find millennium-scale cycles in various natural processes during the Holocene and to try to connect them with human prehistory and climate fluctuations, as the course of human prehistory in the northern hemisphere is likely influenced by climatic conditions.

2400-year cycle in cosmogenic isotope content during the Holocene

Beyond doubt, the study of natural cyclical processes is a very complex problem. This task is complex in particular in the case of lack of well-defined causal mechanisms of the studied natural processes. In this case, one of the first step is to reveal such cycles in time series that are especially pronounced in the sequence studied.

A large number of publications is dealing with the spectral analysis of the radiocarbon time series (e.g., Stuiver et al., 1991; Damon and Sonett, 1992). Three types of variations are detected in the long-time series of atmospheric ^{14}C content during the last about 11, 400 years: 1) a long-term slow trend, 2) short-term (~11, ~22 years) and medium-term (~90, ~ 210 years) periodicities, 3) a longer, millennium-scale (~2400 year) cycle. Heliomagnetic modulation of the cosmic ray flux causes variations in the ^{14}C-production rate on time scales from decades to hundreds of years. Akhmetkereev and Dergachev (1981) showed that ocean-related ^{14}C redistribution between carbon reservoirs as a result of long-term climatic change plays a minor role in the atmospheric ^{14}C variations compared with the geomagnetic field intensity during the Holocene. The 2300–2400 cycle shows more pronounced in the ^{14}C record after filtering of the raw data (Fig. 1) (Dergachev et al., 1996). Fig. 1 shows that such long-term variations recur 4–5 times in the ^{14}C time series after subtracting the long-term trend.

While the medium-term periods (up to approximately 210 years) can be related to changes in the radiocarbon production rate due to solar activity changes, at present, an unambiguous quantitative interpretation of ~2400-year cycle can not be made. It is possible that these changes occurring in atmospheric ^{14}C content are due to the complicated climatic processes and solar variability (Damon and Jirikowic, 1992). There are a number of references in which the 2400-year cycle both in the cosmogenic ^{14}C and climate is studied. Dergachev and Chistyakov (1993) showed that for the 2400-year cycle, the high amplitude of the ^{14}C content in the tree-ring series correlates with a cooler climate, and the low amplitude with a warmer climate. In general, there is an inverse relation between the large-scale changes of solar activity and ^{14}C content and a direct proportionality between such changes of solar activity and global temperature. Furthermore, 2400-year periodicity in the ^{14}C data strongly modulates the known solar-related 210-year cycle (Damon et al., 1989; Vasiliev et al., 1997) evidence.

A new and nearly continuos record of ^{10}Be data from the GISP2 Greenland ice core (Finkel and Nishiizumi, 1997) demostrates that a good correlation exists between observed millennial-scale ^{14}C and ^{10}Be variations during the Holocene. Fig. 2 shows an expanded plot of the ^{10}Be content for the period 5000–8000 cal BP (calibrated years before 1950 AD), which the authors interpret as a climatic effect. In the bottom of Fig. 2 the ^{14}C content is shown (Stuiver and Reimer, 1993), expressed in ^{14}C concentration. We note two rather large events in the ^{10}Be content at 5200–5600 and at 7100–7600 cal BP. The wiggles persist in both ^{10}Be and ^{14}C curves. These variations correlate well with Fig. 1 and could indicate that they correspond to a cooler climate. Since ^{14}C is affected by biological and ocean circulation processes whereas ^{10}Be is not, the observed ^{14}C and ^{10}Be variations might imply that the variations reflect real changes in solar activity and climate.

Patterns of Holocene climatic fluctuations

The reconstruction of details of climatic changes has been greatly aided by historical documents, tree-ring width changes, pollen records, ice cores, glacier fluctuations, lake level records and so on. In the northern hemisphere, climatic data of high resolution for the Holocene exist in documentary record tree rings, lake and peat sediments. A sequence of synchronous Holocene cooling events has been defined in sediment cores from the Northwest and Northeast Atlantic region. Detailed AMS radiocarbon chronologies for two North Atlantic cores indicate these cooling events recur on millennial time scales (Bond et al., 1993).

Until recently, the Holocene climate was thought to be extremely stable with none of the abrupt variations that are characteristic of the cold climates of glacial times (Dansgaard et al., 1993; Stuiver et al., 1995). The most prominent events, rapid transitions from periods of cold stadials to warmer interstadials, reveal major changes only before the Holocene (Bond and Lotti, 1995). They found in marine sediments older than 10,000 years that the abundance of ice-rafted debris in sediment cores increase every 2000 to 3000 years. If these oscillations were result from possible global climatic changes, they would also be expected in the Holocene. Such millennium-scale fluctuations have been sometimes observed in separate studies before, but the latest work shows their reliable presence in the Holocene as well (Bond et al., 1997).

Pollen data are the main source of quantitative climatic information (estimates of precipitation and temperature changes) in vegetated areas. Any pollen diagram contains the integrated information of local character as well as regional vegetation changes in vast territories. Numerous data indicate that some significant changes of duration with millennia and hundred years are superimposed on the long-term fluctuation of climate. Klimanov and Klimenko (1995) have reconstructed the rate of the temperature and the precipitation in the different regions of Northern Eurasia during the Holocene on the basis

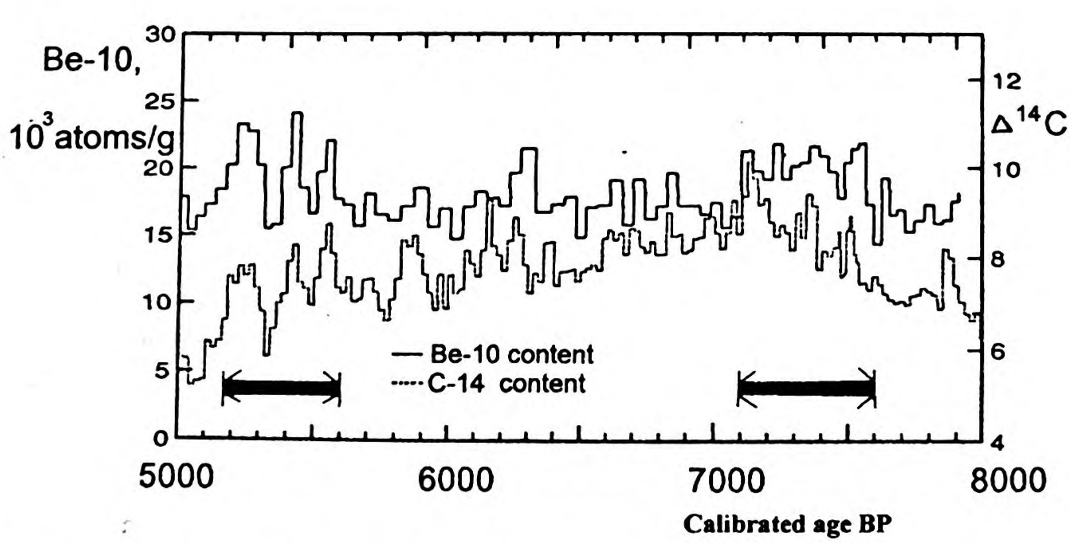

Fig. 2. Beryllium-10 content (atoms per gram of ice) in the GISP2 ice core compared with radiocarbon content (percent) in tree-rings for the time between 5000 and 8000 cal BP. Data from Finkel and Nishiizumi (1997). In the bottom part of the figure two intervals of increased content of cosmogenic isotopes are marked.

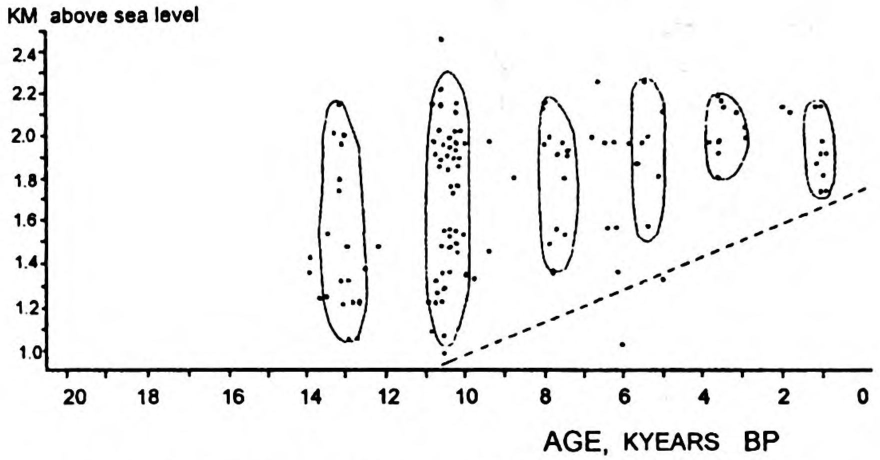

Fig. 3. Records of non-arboreal pollen (NAP) phases for Swiss Central Alps and Prealps during the Holocene. The extended intervals of NAP phases are displayed. The dotted line is the boundary for climatic fluctuations.

of data from lake and bog sediments. They deduced four warming maxima during the intervals: 6700–5700, 4500–3200, 2300–1600 BP and during the 12th–13th centuries (the Medieval Climatic Optimum). These warm periods are separated by cold stages. It was also established that the largest amplitudes for both cooling and warming are found in the northern regions of Eurasia. Substantial global climatic changes are generally more pronounced at higher latitudes. The comparison of the series of main palaeoclimatic curves for the Holocene based on the study of sediments from Karelia (Klimanov and Klimenko, 1995) and the temperature curve for the centre of the Russian Plain (Velichko, 1989) allows us to see that the warming periods in generally correspond to the minima of the ~2400-year cycle in the tree-ring radiocarbon content. It is clear now that much information can be learned about overall detailed pattern of climatic changes during the Holocene and of crucial importance is the dating of events, accurately and precisely.

Palaeoclimatic indicators give an evidence of regional and local weather parameters. Pollen evidence from a number of high-latitude localities indicates that mid-to-late Holocene temperature variations were generally less than 2°C, whereas ice core evidence indicates that the sharp early Holocene cooling event may have been up to 6°C cooler in Greenland (Alley et al., 1997).

Oscillations of the polar and alpine tree-ring limits and changes in the width and density of the annual rings of the long-living trees in these boundary regions contain a wealth of palaeoclimatological information. There are several indications that temperature plays an essential role in the upper limit of the distribution of the forest. Changes in temperature can also lead to movements of the timberline. However, the effect of temperature changes is very complicated due to the influence on numerous physiological processes. The present state of palaeoclimatological knowledge is based mainly on qualitative information. It is necessary to the study of the fluctuations in the arboreal and non-arboreal pollen analyses in sensitive areas, both local and regional. Burga (1993) used for palynological palaeoclimate research non-arboreal pollen analysis as evidence for Holocene climatic fluctuations in the European Central Alps. Fig. 3 shows the relation between records of non-arboreal pollen phases at different altitudes and during different times. The areas located at a higher altitude show cyclic palaeoclimatic changes. The magnitude of climatic oscillations during the Holo cene was different and decreased from the Early Holocene to the present time.

Numerous ^{14}C dates obtained for subfossil pines found above the present pine limit in Swedish Lapland and Southern Sweden indicate that the favourable conditions for the pines were in sequence of cyclical climate changes at about 4000, 6000 and 8000 BP (Karlen, 1976; Kullman, 1990b). The climatic evidence from Northern Fennoscandia (Eronen and Hyvarinen, 1982) and Southern Sweden (Kullman, 1990a) indicates a long-term cyclical climatic deterioration at about 7000, 5000 and 3000 BP. However, there is always the danger that a certain element of anthropogenic "noise" has been introduced into the palynological record. Therefore archaeological information has to be taken into account as well.

There seems to be some correlation in timing of millennia scale fluctuations in different regions of the globe. Rothlisberger (1986) published the record of glacial fluctuations in both the northern and southern hemispheres from 12 regions for the past 10,000 years. Apparently, glaciers behave very similarly near-synchronous word-wide in their reaction to major climatic changes, leading to the belief that they represent global climatic effects. A comparison of these glacial fluctuations with secular changes in cosmogenic radiocarbon content has shown that glacial retreats occur at times when ^{14}C content is decreased and glacial advances occur at times when the ^{14}C content is high. As a consequence, the radiocarbon millennium-scale content fluctuations seem to be able to serve as indicator of glacial oscillations.

Dergachev and Chistyakov (1993; 1995) examined the appearance of the ~2400-year cycle in different solar-terrestrial phenomena: reconstructed the temperature and precipitation in a number of regions of Northern Eurasia based on data from lake and bog sediments, transgressions and regressions in the basins of the Baltic and Caspian seas, historical records of valley and mountain glacier advanced and retreats, ice core data, settlements of the ancient man and so on. Most of the observed variability in these numerous natural records is in agreement with a 2400-year cycle in the variations of the ^{14}C concentration.

Owing to the fact that during the past few years an abundant and various set of proxy data had become available in a continuous time series, for the Holocene appeared a possibility for palaeoenvironmental reconstruction at a level of precision unavailable for earlier before. Related to the need in improvement of our understanding of global palaeoclimate patterns and their forcing, there has been a growing interest in linking marine, lake and terrestrial records.

Several recent studies have attempted to derive palaeoclimate information from the Chinese loess-palaeosol sequences affected both depositional and source areas. Such factors include the wetness and temperature of the soil, as well as the wind velocity and aridity in the source regions. The results drawn from studies of glacial episodes (An et al., 1991; Maher et al., 1994) were characterized by less rainfall than at present, 2) higher rainfall than at present is indicated in the early part of the Holocene, about 9000 BP, that is consistent with evidence from studies of lake-level and pollen, 3) the east Asian monsoon intensified during the early Holocene to suppress the rain shadow effect of the intervening mountain range. It will be noted that the record of high-resolution loess section in Lanzhou on the western Chinese Loess Plateau (Xiao-Min Fang et al., 1999) shows that Asian summer monsoons during the past 60 thousand years have rapid episodic pulse enhancements spanning around 1–2 thousands of years. Both the pattern and timing of the summer monsoon enhancements show that they can be correlated to most major warm episodes and long-term cooling cycles of the North Atlantic climatic system.

The past variations in Asian monsoons were deduced by Chi-Yue Huang et al. (1997) from high-resolution palaeoceanographic data records covering the past 25,000 years in a deep-sea core in the northern South China Sea and palynogical records in a lake core in central Taiwan. They discovered that a summer monsoon in the two records has fluctuated from a moderate one during the deglaciation to a stronger summer monsoon in the Holocene. Both the deep-sea core and lake data is in agreement with climatic records of Chinese Loess Plateau. Zonnefeld et al. (1997) showed that the strength of the monsoon intensity in all areas of Africa at the Younger Dryas was similar to what it had been during the general period of the Last Glacial Maximum and climate led to a cold arid phase. At the same time as a cold, dry period affected Europe, Africa also seems to have undergone a relatively arid phase. Pollen indicators from central Africa suggest that temperatures similar to the present had been reached by about 11,000 BP (Hamilton, 1988).

Lake sediments offer many advantages for palaeoclimatic reconstructions, they provide archives for a large range of climate-related proxies, including pollen, diatoms, stable and cosmogenic isotopes, magnetic properties, organic geochemistry. Recently published materials of palaeoclimatic parameters from lake sediments in the Himalayan region include pollen data and lake-level data used to determine Holocene fluctuations of monsoon rainfall in India and investigations of lake-level variations in China and Tibet (e.g., Fang, 1991). Proxy data from lakes in the western Tibet (Fontes at al., 1993) show a major climate change at 10,000–9500 BP, attributed to a rapid increase of the summer monsoon circulation, which led to wet-warm conditions. The phase of aridity culminates around 4000–3000 BP. Maximum monsoon rainfall seems to have occurred from 9500 BP to 8700 BP and from 7200 BP to 6300 BP, as two pulses separated a reversal event centred at 8000–7700 BP.

Using data on lithological and water levels in different strata in sediments from Lunkaransar and Didwana lakes in north-western India, (Enzel et al., 1999; Wasson et al., 1999) showed that regional water and lake level fluctuations over decades to centuries during the Holocene at each lake were very similar. It indicates that regional climate change was responsible for the vegetation changes recorded. Lacustrine history change in this part of India these authors attributed to changes in the southwestern Indian monsoon rains. The lake levels were very shallow and fluctuated often in the early Holocene and then rose abruptly around 6300 BP. The Lunkaransar lake completely desiccated around 4800 BP.

The climatic history of Africa and the Near East during the past thousands of years remains one of the major challenges in palaeoclimate research, and sedimentary records from the lakes are among the most valuable sources of information. Unfortunately, a small number of lakes without outflow across Africa and the Near East are likely to have accumulated a continuous high-resolution record of Holocene hydro-climatic variability. The levels of east African lakes fell during the Younger Dryas (Williamson et al., 1993) and there was a reduction in forest pollen in the mountains. Using late Quaternary sediments from two sites in tropical Africa, Gasse and Van Campo (1994) reconstructed hydrological balance (Fig. 4) of lake Abyata (Ethiopia) and lake Bosumtwi (Ghana). One can observe the manifestation of the large-scale cycle in the palaeohydrological changes of these lakes. The minimum level of the large-scale arid oscillations of climate occurs in the vicinity of about 400, 3000, 5800, 7500, 10,000 BP. Also, Gasse and Van Campo (1994) found evidence from lakes in Tibet and Rajasthan of major dry phase around 8000 and 7000 BP. The observed climatic changes suggest that dramatic abrupt shifts in hydrological balance can have an impact on human population in the past.

New terrestrial, marine and ice core data document abrupt changes during the warm interglacial climate of the last 12,000 years. These Holocene palaeoclimate records indicate that the Holocene was punctuated by a series of millennia-scale cooling events. Glaciochemical time series developed from Summit, central Greenland document extended periods of winter-like conditions during the periods AD 1900–1420, 450–1150 BC, 3050–4150 BC, 5850–6850 BC and 11,300 to 12,900 years ago (O'Brien et al., 1995). The most recent increase, and also the most abrupt one, coincides with Little Ice Age (LIA). These events may correlate with glacial ice advances during the Holocene in Greenland and mountain glaciers.

Using several independent spectral analysis techniques for study of ice cores from both hemispheres Yiou et al. (1997) found recurrent common patterns between Greenland and Antarctica. They also established the significant oscillations during the Holocene and concluded that these oscillations hardly can be associated with glacial events or ice sheet oscillations.

These new results document significant climate instabilities during "our time".

The impact of large-scale and sharp climatic fluctuations on man

Apparently the more complete picture of former climatic variation may be obtained only for the last 2000 years. This time interval includes both the more detailed instrumental data on different climatic characteristics for last some hundreds of years and historical evidences of more considered climatic variations at different regions of the Earth for thousands and more years (China, Japan, the most part of Europe and Middle East), as well as a set of natural archives which contain data of high resolution. Detailed analysis of all data within time interval makes it possible to get the detailed picture of climatic variations and to get numerical relations of them. This may be used as a base for selection of the similar climatic variations in the more distant past.

The availability of precise dating by tree rings and particularly the many historical data in Europe, suggests that during the LIA glacial fluctuations were nearly synchronous in the European Alps and in all mountainous regions of world (Grove, 1988). Archaeological evidence for climate change in the Mediterranean and Aegean archaeology is discussed by Kuniholm (1990). This oscillation mode of 2400 years runs through the Holocene.

On a base of tree-ring data in work of Hughes and Graumlich (1996) was done attempt to make reconstruction of the precipitation intensity at Great Lakes Basin in USA for period from 1979 AD to 6000 BC. The authors note that during these 8000 years they clearly selected long periods of low precipitation. These periods the authors connect with extended droughts. The most detailed investigation on precipitation history was performed for last the

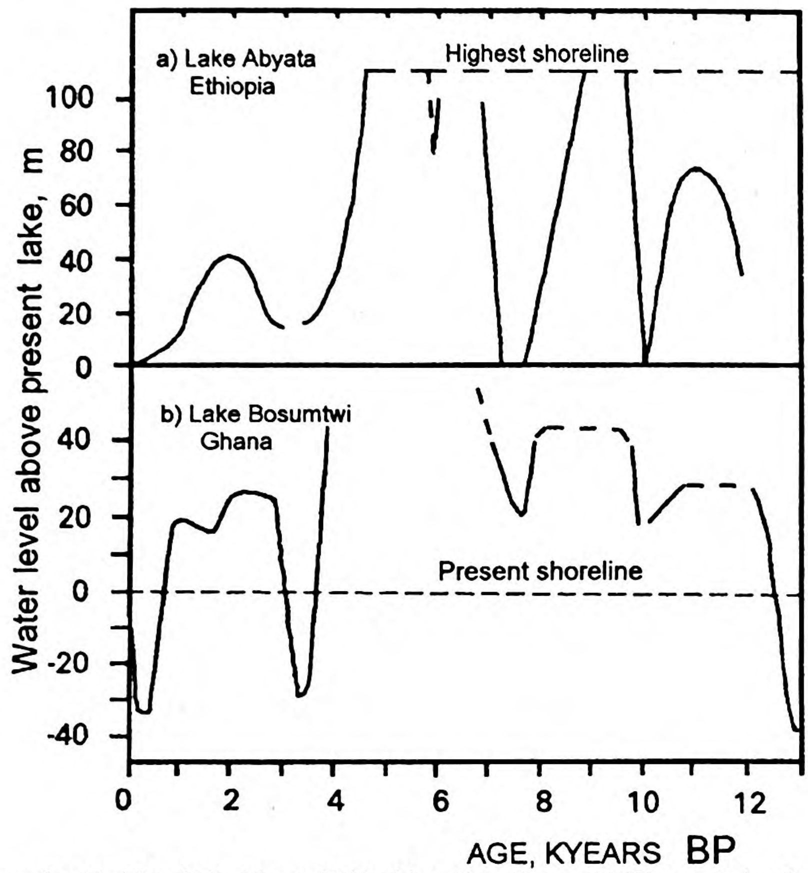

Fig. 4. Changes of the water-level height of lake Abyata (Ethiopia) and lake Bosumtwi (Ghana) during the Holocene, reconstructed by Gasse and Van Campo (1994) from lake core sediments.

2000 years (Fig. 5b). Reconstruction on mountain pine data permits to conclude that the centres of the more considerable dry periods were in 924 AD and 1299 AD which rather well coincide with main trend of ~2400-year solar-climatic cycle, in accordance with it the most activity of the Sun was from ~1500 AD to ~700 AD. Note also that the authors selected as well the other events with prolonged precipitation variations. Results of the work of Hughes and Graumlich (1996) rather well agree with that of Stine (1994), where in the dates determined by radiocarbon methods on data of sink stumps around Mono Lake two prolonged droughts were selected about 900–1100 AD and 1200–1350 AD, error equalled to 100 years (Fig. 5b).

It is possible to restore the picture of atmospheric conditions in the past by dust layers at ice caps in mountains of South America and China. The special interest is connected with glaciers at high altitudes in Tibet which can give climatic history for this region. Vast ice plateau at the altitude about 5 km is subjected to intensive regional monsoon circulation influence and to global circulation influence. In work of Thompson (1996) ice-core (38°06 'N; 96°24 'E, 5325 masl) was investigated. Visible annual dust layers were used for the last 2000 years to make reconstruction of ice accumulation. In Fig. 5c one can select some prolonged periods: the most moist ones (0–400 AD, 1400–1800 AD) and dry period from 400 AD till 1400 AD with the most dry interval around 1075 and 1375 AD, that quite well again agree with the previous picture of ~2400 cycle. The similar picture of main dry and moist periods was demonstrated on data from ice cap in Southern Andes (Peru) (Thompson, 1992). It is surprising that these regions are separated by 20000 km that testifies to global climatic variations.

Historical evidence indicates that the estimated ~ 1°–2 °C Little Ice Age cooling (from about 1400 to about 1900 AD) was sufficient to choke European ports with sea ice, freeze European rivers, force abandonment of Viking colonies in Greenland and cause glaciers to overrun alpine village (Bond et al., 1993; Dansgaard et al., 1993). The LIA coincides with the Maunder minimum in sunspot activity and with an increase of the ^{14}C content amplitude (Fig. 1). Because the LIA happened relatively recent, it has the best geographic monitoring. This allows us make some generalisations that may be applicable to other such oscillations. The examination of these oscillations may contribute to a greater understanding of the

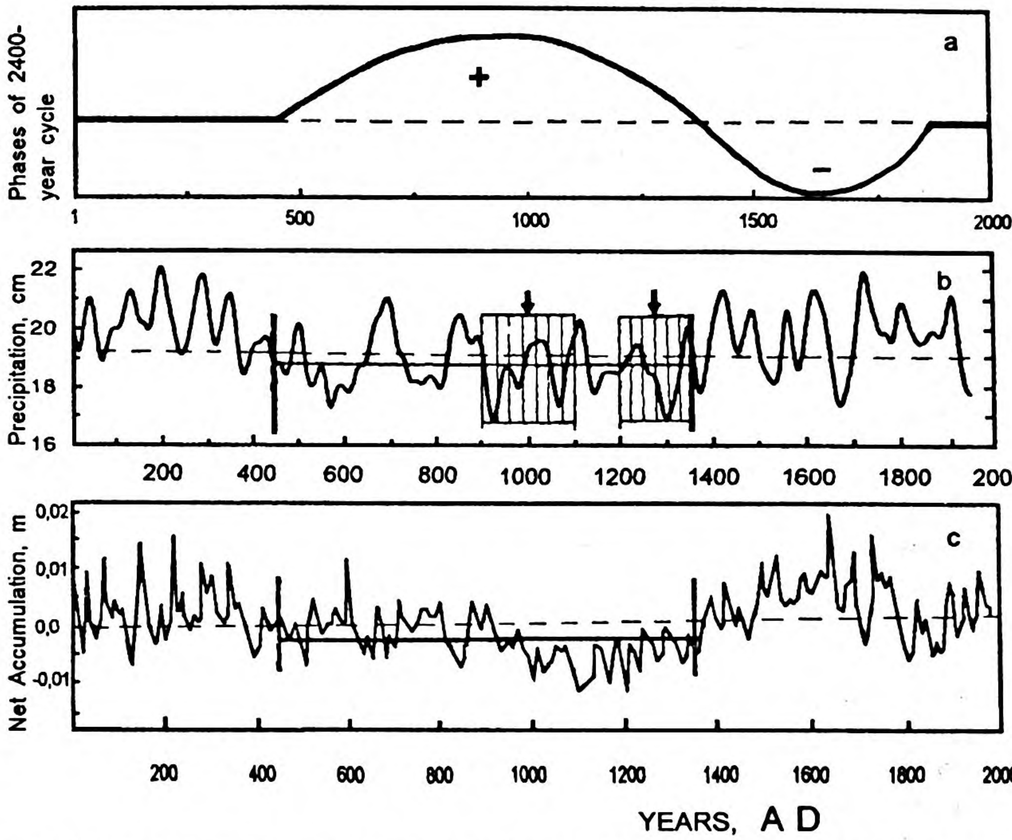

Fig. 5. Comparison of different climate parameter changes in different Earth's regions at *a*) different phases of 2400-year solar-climatic wave (Dergachev V.A. and Chistyakov V.F., 1995); *b*) calibrated reconstruction of precipitation variations (Hughes and Graumlich, 1960) from data of bristlecone pine growing in White Mountain (California) smoothed by 20-year Gauss filter; shaded rectangles — intervals of more long droughts (according to Stine, 1994); the horisontal line shows extreme low levels Mono Lake; *c*) reconstructed rate of ice accumulation (Thompson, 1996) from data of annual layers of dust in tropic ice cap located in South Andes mountains.

climate of cold epoch and possible climatic influence on human migrations.

The following increase in the level of ^{14}C content back in time had happened at 750–850 BC (Fig. 1). In addition, an increase of the ^{10}Be content (Beer et al., 1991) in ice cores, and climatic cooling is observed at this time interval (Kilian et al., 1995). Based on archaeological, palaeoecological and geomorphological data, van Geel et al. (1997) showed evidence for global climate change near 800 BC in both hemispheres.

To assess the role of climate change in three cultural transformations taking place in northwestern Alaska during the mid-to-late Holocene, Mason and Gerlach (1995) examined existing palaeoenvironmental evidence from Alaska. They investigated which environmental and ecological parameters influenced organizational processes of stability and changes of these cultural transformations. The authors concluded that coastal sites were more intensively occupied during warmer periods before 1200 BP (the short-term warmer weather prevailing during 4000–3000 and from 1700–1200 BP), while inland areas were occupied more intensively during the short-term cooled periods prevailed at 3300–3000, 2000–1700, 1200–800 and 600 200 BP. The archaeological record shows that climatic changes caused the migration of peoples. However, in spite of many correlations at the appropriate temporal and spatial scales between various cultures and climate change, archaeological evidence for climate change is still disputable. Concerning the relation of migration of peoples to climatic changes it is necessary to stress that multiple factors may take place: catastrophic, epidemic, economic and so on.

Strong contradictions occur in the next 2400-year interval (around 4500 BP), and therefore it is not possibility to conclude unambiguously that climatic change is followed by regular events such as indicated above. Furthermore, the pattern of the 2400-year interval in the radiocarbon content is strong jagged. It means that the short cold sawtooth-like pulses can be possible during the warmer period in the Holocene. Rothlisberger (1986) shown that between

3500 and 4500 BP there was the widespread "Neoglacial" cooling. This cold period in Europe, lasting from at about 4500 BP to 2500 BP, superimposes on the development of civilization and it is called the Iron Age cold epoch. On the base of analysis of high freshwater levels in the lakes of northwestern India and settlement sites of Harrapan-Indus civilization (Enzel et al., 1999) it is possible to conclude that the changes in climatic conditions were perhaps the principal causes for the abandonment of the ancient settlements of the civilization in the banks of rivers between around 3900 to 3500 BP after desiccation of the lake during arid climate phase.

The natural evolution in the sandy region of the Near-Caspian Lowland as well as settling of tribes and peoples within this territory during the Holocene was considered by Ivanov and Vasiliev (1995). This sandy region is very sensitive to sharp climatic changes. The authors noted that during the interval 5000–6000 years ago (Neolithic epoch) the atmospheric precipitation was higher compared with present times, and a population of the steppes was settled. During the interval 2700–1700 BC (Early and Middle Bronze Age) the climate became more continental, causing migrations of tribes. In the time interval 1300–600 BC humidification took place and the density of population is the highest. Permanent population was absent during the epoch of aridization over 300–1200 AD. In the last epoch of 1300–2000 AD, the humidification increased. In general, there is evidence for co-evolution of nature and society in this region, connected with climatic changes. It is necessary to search new detailed data from different locations for this time interval.

Thus, the late Glacial and Holocene data of vegetation and climate suggests that dramatic climate oscillations can result in changes in human population density as the resource base shifted. Episodes of relatively low population density during intense cold or dry phases would have been followed by recoil periods in which human population could expand in range and in number across the region.

Conclusion

Millennia scale fluctuations of cooler climate occur during the Holocene, and in some cases there is archaeological evidence for climate changes. It is necessary to re-evaluate archaeological data, especially from sites and regions that can provide high-resolution records and good chronologies.

The most prominent events re-occurred about every 2300–2400 years and may correlate with Holocene glacial ice advances in Greenland, Scandinavia and northern Europe. It is also important to correlate data from different areas in order to determine the levels of global or regional variability of climate. This may allow us to evaluate the role of environmental change on past, present, and future human civilizations.

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Radiocarbon dating of fossil bone micro-samples

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ABSTRACT

The peculiarities of bone micro-sample radiocarbon dating and progressive techniques of obtaining radiocarbon counting media worked out at our laboratory are discussed in the present paper. A universal technique — the direct chemisorption into a lithium alloy of carbonaceous gases produced by the controlled thermal degradation of organic materials under vacuum — "vacuum pyrolysis" allowed successful dating of several deteriorated and carbonized bone samples. The ability of hydrofluoric acid to rupture calcium carbonate by its transformation into totally water-insoluble calcium fluoride makes it possible to preserve the initial bone structure simultaneously with effective extraction of the admixed carbon. Collagen or the product of its thermal decomposition finely dispersed remains in a solid matrix with calcium fluoride. The collagen is subsequently transformed into lithium carbide. Comparative dating of the same samples was conducted both by the traditional method and the newly carried out technique. The results obtained from micro-samples and their micro-fragments were also compared. In the all cases the new technique proved to be very effective. Micro-samples were contained in low- background high-performance teflon micro-vials developed at our laboratory. The new technique allows a decrease in the minimum carbon quantity required for radiocarbon liquid scintillation conting, where 0.3-0.5 g is adequate.

Key words: radiocarbon, liquid scintillation technique, reactor construction, bone material, archaeology.

Introduction

Samples of bone from archeological excavations are reliable and often an exclusive material for radiocarbon dating. At the same time radiocarbon dating of fossil bones is associated with some difficulties. The porous structure of bone absorbs water soluble organic substances under burial, which have a different age than the collagen of bone. Besides, bone collagen when buried is subjected to bacteria and micro-fungus deterioration. The influence of micro-biota destroys the carbon isotopes' primary correlation, the so-called "isotopic fractionating".

The factors mentioned above have an influence particularly on bone micro-sample dating, in which the total carbon content does not exceed one gram. The amount of micro-samples can reach about 50% from all archeological material available for radiocarbon dating. Often, the micro-samples of bone material are the only possibility in determination of absolute age by isotopic methods for many archeological monuments and sites. Therefore, the primary chemical processing bone samples should be given special attention. An important and inconsistent problem is decided at this stage: removing as much as possible of the introduced organic substances and various admixtures while keeping simultaneously as much as possible of the bone collagen, and the bone coal, in the case of burnt bones. For samples with significant biological deterioration of collagen (more than 50%), it is important that stable isotopic correlation with subsequent correction of radiocarbon age, should be determined by the mass-spectrometric method.

Methods and strategies

A new complex technique has been is designed in our laboratory for the primary chemical processing of bone micro-samples and its subsequent conversion into benzene for ^{14}C dating.

Primary processing

The traditional strategy of bone sample primary processing comprises of collagen deposition in a pure substance type (Arslanov, 1987). For this aim the sample reduced to fragments is processed by a 0.5% –2% solution of hydrochloric acid at room temperature. The mineral part of bone consisting of phosphates and calcium and magnesium carbonates is dissolved in hydrochloric acid, but collagen stays as a jelly-like material. It is important to note that a certain portion of the bone organic material is also dissolved and, moreover, it disappears forever. Subsequent processing of collagen is difficult impeded and requires much time. The hydrated form of collagen is extremely difficult to wash, centrifuge and dry. A great amount of phosphorus and sulphur compounds is abundant in the end product - dry collagen. Phosphorus and sulphur are the most harmful admixtures in lithium carbide production, and that is why it is necessary to oxidize collagen beforehand to carbon dioxide with subsequent gas purification. The multiple stages of the traditional technique lead to inevitable loss of carbonaceous substances, which is undesirable particularly for microsamples. It is impossible to select a datable carbon fraction from some types of bone material by the traditional technique. For instance, burnt bones contain semi-destroyed collagen and finely dispersed bone coal. Both components are completely available for the purpose of undistorted radiocarbon age determination, but semi-destroyed collagen is almost completely dissolved in acids, and finely dispersed bone coal can be deposited only with the help of super-speed and low-efficiency centrifuges.

The new technique developed makes possible lithium carbide production from collagen or bone coal without their preliminary deposition in a pure state (Skripkin & Kovaliukh, 1998). The bones for this purpose are reduced to fragments, and after washing with trisodium phosphate solution they are processed by 1–3% hydrofluoric acid. This acid transforms carbonates and partly transforms calcium phosphate into fluoride. Calcium fluoride does not dissolve in weak acids, but a change of large CO_3^{-2} and PO_4^{-3} anions for compact F^{-1} generates a mineral matrix which is porous and easily cleaned of organo-silicate complexes. Collagen in this case exists in a semi-bound non-hydrated state. The essential advantage of hydrofluoric acid is its ability to dissolve silicates and humic acids as well as the products of bacterial activity absorbed by the bone. It makes it possible to remove recent organic substances and carbonic carbon, and to wash and dry the processed sample easily and qualitatively. The losses of bone organic substances or bone coal are minimal under such processing (Kovaliukh et al., 1996).

The sample is subsequently reduced to fragments and mixed with manganese dioxide for lithium carbide production by the technique of "vacuum pyrolysis" — (the direct chemisorption of carbonaceous gases into a lithium alloy, produced by the controlled thermal degradation of organic materials under vacuum).

This technique is based on a combination of two processes: thermal breakdown of the organic sample and chemical absorption of gaseous products by lithium. Reactor construction is shown in Fig. 1. Lithium carbide synthesis is carried out within the reactor, which is made of stainless steel with metallic lithium placed on the bottom. The sample is seated inside the titanium glass. The glass with the sample is held at the optimum height in the tubular holder, which directs a gas flow to the melted lithium. Such location of lithium and carbonized sample permits temperature regulation to be made within the area of thermal breakdown (and consequently gassing velocity) without temperature change within the melted lithium area. The reactor is inserted into the stove at optimum depth and is fixed into such position. When temperature conditions are properly chosen the velocity of chemical absorption of thermal breakdown gaseous products by metallic lithium slightly exceeds the sample thermal breakdown velocity. The reactor pressure is stabilized at 0.1–0.2 atm. This promotes evaporation of volatile thermal breakdown products and prevents their condensation into the reactor walls.

As a result of reactor processes the collagen is converted into volatile organic compounds and into bone coal. Addition of manganese dioxide plays an important role. When the temperature is above 550^0 C the manganese dioxide disintegrates, liberating the active oxygen throughout the volume of mixture. Oxygen liberation runs (quietly) under a broad range of temperatures (550^0-940^0 C). Finely dispersed bone coal therewith is oxidized to carbon monoxide and dioxide, and in such a state it is absorbed by melted metallic lithium. An essential feature of manganese oxides is their ability to link phos-

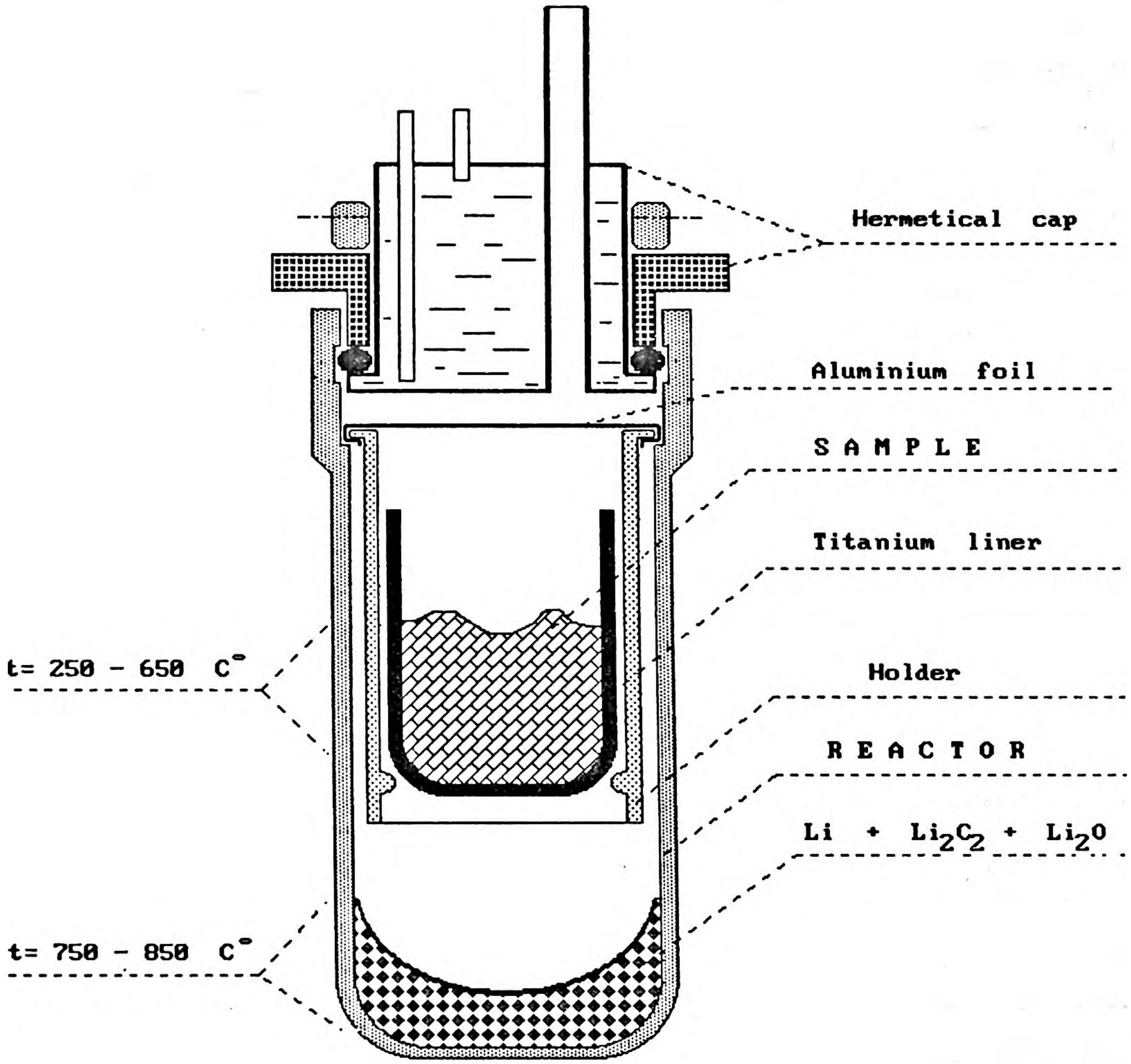

Fig. 1. Reactor construction and elements of technique

phorus and sulphur in thermally stable combinations. This gives lithium carbide of high quality, and what is more — from practically the whole carbon content of bone organic substances. Formation of lithium carbide runs without complications with high output. Lithium oxide, hydride and nitride are also formed in parallel with carbide. Lithium hydride and nitride are completely decomposed under short reaction volume vacuuming at the end of the process. The reactor of reduced volume (400 ml) was designed for fossil bone micro-samples which has made it possible to reduce greatly the losses at this stage.

Lithium carbide is subjected to hydrolysis, and gaseous acetylene is converted into benzene on a vanadium catalyst. The vacuum system for benzene synthesis is made from materials, which do not absorb acetylene or benzene. The internal volume of the vacuum line is insignificant. Construction particularities mentioned above allow 95–97% benzene output to the total exclusion of the memory effect. Because of the advantages presented, it appears possible to date bone from samples as low as 250-300 mg.

The complex chemical technique of lithium carbide production from fossil bone samples had been tested comprehensively. The samples of different types of bone as well as of their different states of preservation after their reduction to fragments and quartering were processed in parallel by both traditional and new methods. The results obtained were compared and analyzed. The samples' ages in parallel series coincided within the limits of instrumental error under practical measurement in an overwhelming majority of cases. Moreover there was success

Table 1

Comparative dating of fossil bone samples by the traditional technique and by the "vacuum pyrolysis" method

№	Sites		Lab. index	^{14}C age, BP
1	Ordzhonikidze-1997,	Traditional method	Ki-6827a	3890±50
	b.11, g.8	Vacuum pyrolysis	Ki-6827b	3910±45
2	V.Holovkovka, b.3, g.1	Traditional method	Ki-6718a	3905±55
		Vacuum pyrolysis	Ki-6718b	3920±60
3	Ordzhonikidze-1980, gr.	Traditional method	Ki-6553a	3710±60
	Chorna Mogila, b.3, g.17	Vacuum pyrolysis	Ki-6553b	3745±50
4	Semionovka 1990-91,	Traditional method	Ki-6688a	6800±60
	2 bones №1	Vacuum pyrolysis	Ki-6688b	6980±65
5	O. Surskoy b.II 1946,	Traditional method	Ki-6691a	7230±55
	Bone, sq.7	Vacuum pyrolysis	Ki-6691b	7245±60
6	Solionoe Ozero IV,	Traditional method	Ki-6202a	12805±95
	Excavations, 1990.	Vacuum pyrolysis	Ki-6202b	12890±100
7	Novovladimirovka II,	Traditional method	Ki-6203a	19290±85
	Bones	Vacuum pyrolysis	Ki-6203b	19340±95
8	Dmitrievka,	Traditional method	Ki-5826a	16495±100
	Upper late Paleolithic layer of seat	Vacuum pyrolysis	Ki-5826b	16520±95

in dating some samples by using only the new method of chemical bone processing. Samples containing significant amounts of the interfering humic acids were well cleaned of the latter both by washing out with alkali or trisodium phosphate and by the action of hydrofluoric acid.

The new complex technique was found to be 5–10 times more efficient than the traditional method of preparation of bone for radiocarbon analysis in terms of both time and labour. The most typical results comparing the methods are shown in Table 1.

The traditional technique of collagen precipitation uses 0.1% NaOH to remove humic substances. As a rule, humic substances are of a younger age with respect to collagen, and they are present within the bone samples in conglomerates of silicon oxide and organic material derived from the soil. When using the new technique the humic substances are removed from the bone samples together with silicates at the processing stage by hydrofluoric acid. Silicon oxide is completely dissolved in hydrofluoric acid, and humic substances precipitated on silicates form a pseudo-solution.

One can see from comparative experiments carried out that the new technique completely satisfies the requirements for the samples' purification from humic substances. Comparison was carried out for samples in different states of preservation and archeological age. When the age of samples approaches the range of 12000–19000 BP, the "vacuum pyrolysis" method gives more ancient results, which points out the fact of more complete and selective removal of recent organic substances. The collagen losses are likely to be reduced considerably when using hydrofluoric acid to dissolve the humic substances.

Measurement of benzene micro-samples is carried out in the specially developed micro-vials with the help of "Quantulus"-low-background spectrometer (Buzinny & Skripkin, 1995). Micro-vials are made of high density non-porous teflon. Holders for micro-vials are made of high purity titanium, and they are provided with a screen to prevent "cross-talk" effects. Construction particulars, as well as the chosen materials enable high counting features to be obtained (Table 2).

As a result of biological processes occuring during burial between bone samples and soil microorganisms, the natural relationship between the three main carbon isotopes (^{13}C and ^{14}C) experiences certain changes. These changes can be enhanced during the processing of collagen and its chemical transformation into benzene.

In evaluating radiocarbon age the correction for biological isotopic fractionation is taken into ac-

Table 2

Counting features

Vial volume (ml)	Benzene loss per 24 hour (mg)	Bg (cmp)	^{14}C efficiency (%)	FM	FM (E2/BG)	t_{max} (year)	t_{min} (year)
0.85	less than 0.10	0.11	82	23.2	61127	48050	80

count. Undertaking such an operation is possible due to a well-defined relationship between the deflection of ^{13}C isotope concentration and the degree of ^{14}C isotope fractionation, practically defined as $\Delta\,^{14}C=(\delta\,^{13}C)^2$. For this purpose the determination is made on variation in concentrations of ^{13}C isotope in the ready benzene by mass-spectrometry. This factor usually falls within the limits $-18.5 < \delta\,^{13}C < -20.7$ per mille. For samples, which had been considerably affected by soil microorganisms, this factor can reach –16 per mille, whereas together with chemical fractionation it may even come to –14 pm. This means in practice that sample misrepresents by age in something like BP=5000 years can reach 250 years. Correction for the isotopic fractionation is central for micro-samples, since such samples usually have a fine bone layer, which is easily permeable to natural deteriorating agents.

The work carried out in our laboratory on Pit-grave culture archaeological monument dating is an inherent example of the radiocarbon method application to fossil bone micro-samples.

As one can see from the results given in Table 3, the age derived from the bone micro-samples falls within the limits of error of measurement of the age derived from the same samples using macro amounts. The slightly younger dates for the micro-samples are caused by a relatively higher background effect due to cosmic radiation. These deviations can be taken into account subsequently to complex comparative checking including mathematical statistics.

Conclusions

A complex technique has been designed with the purpose of fossil bone micro-sample dating, which has shown a high degree of reliability for dating. All the stages of the new technique have passed an all-round inspection regarding agreement of results with respect to the traditional methods. The presented technique allows for reliable results to be obtained for those samples which could be not dated earlier by the traditional method.

Table 3

Comparative dating of fossil bone samples macro and micro increments (Pit-grave culture)

№	Sites		Lab. index	^{14}C age, BP
9	V. Protopopovka, b.1, g.4	Macro	Ki-6733a	3945±50
		Micro	Ki-7130	3920±70
10	V. Protopopovka, b.2, g.3	Macro	Ki-6734a	3925±55
		Micro	Ki-7131	3910±60
11	Ordzhonikidze-1997, Shakhta 22, b.2 g.6	Macro	Ki-6833	3900±55
		Micro	Ki-7132	3930±70
12	V. Holovkovka, b.6, g.8	Macro	Ki-6719	3970±55
		Micro	Ki-7133	3960±60
13	V. Holovkovka, b.11, g.5.	Macro	Ki-6723a	4030±60
		Micro	Ki-7134	4035±60
14	V. Holovkovka, b.5, g.5	Macro	Ki-6731	4005±55
		Micro	Ki-7135	4020±70
15	V. Holovkovka, b.7, g.4	Macro	Ki-6722	3980±60
		Micro	Ki-7136	3940±70

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Radiocarbon chronology as a basis for the reconstruction of the historical landscape of Moscow.

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Abstract

The medieval prehistory of Moscow is investigated. Radiocarbon dating (both conventional and AMS) establishes the chronology. In addition, environmental maps are constructed for both the urban and suburban environments of Moscow. Ecological changes are investigated through soil pollution in the past and its influence on the present situation.

Key words: Moscow, environment, radiocarbon dating, pollen-analysis.

Introduction

Traditionally, Medieval prehistoric studies consider mainly "pure archaeological" or historic arguments for constructing chronologies. In the Moscow context, this approach is valid for the period after the 15th century, but not so for earlier times. The dates for the best datable ceramic types and ornaments shifted for more than 100 years from the 14th century (publications in the 1930–1950's) to the mid 12–13th century (publications since the 1970's) because of reassesment of archaeological arguments for the dates. This shows that early medieval archaeology can not ignore the radiocarbon dating method.

Our main goal is to put the prehistory of Moscow into a more reliable chronological frame and to compose detailed maps, characterizing the urban and suburban environments of Moscow and their evolution from the 12th century AD to the present time. In particular, we tried to assess the changes in ecological conditions of Moscow and to trace the effect of soil pollution in the past on modern distribution of contaminants in urban soils of Moscow. While evaluating environmental and ecotoxicological conditions of medieval Moscow, we took into account that in many places the city had sprawled over the previous farmland, so that urban soils can be influenced by some features inherited from the previous agrarian stages. The aim of our study is to obtain a systematic comparison of historical data and environmental characteristics for the excavation of archaeological monuments in Moscow.

The method of multiple investigations

The essence of our study is the analysis of soils (both surface and its buried contents) in order to reveal the evolution of urban Moscow and the impact on its population. We performed our investigation by using two approaches. First, key sites located in the historical center of Moscow were investigated in cooperation with archaeologists excavating modern construction sites. However, the number of these key sites was not sufficient for making detailed paleoenvironmental maps of Moscow. Moreover, the location of these key sites was determined by the planning of the modern construction works rather than science.

For this reason, we used a second approach: extrapolating results from the nearest suburbs of medieval Moscow which are not affected by modern urbanization and therefore are more suitable for studying medieval land use.

The description of the cultural layers of Moscow from a pedological point of view proved to be the most efficient tool for paleoenvironmental reconstructions. Soil scientists are able to distinguish the horizons of buried soils in the cultural layer and thus determine the surface topography of the past. Specific features preserved in buried soil horizons allow the characterisation of paleoenvironment and land use in the past. Buried plow horizons (Ap) are of special interest, since they yield information on the tilling tools used in the past.

Paleobotanical methods (the pollen analysis was performed by V.S. Gunova and Ye.A. Spiridonova and the phytolith analysis by A.A. Gol'eva) can support the conclusions based on pedology (Boytsov, Gunova , Krenke, 1993). For instance, ancient plow horizons contain abundant phytoliths and pollen of cereal crops. In addition, valuable information on the character of the past vegetation can be obtained; phytoliths indicate the species that grow near the key sites, whereas pollen indicate the species composition of vegetation covering larger areas. Changes in the composition of pollen and phytoliths in the layers of buried soils, enable the reconstruction of changes in past vegetation patterns. These changes are caused by either human impacts on the environment or by climatic fluctuations.

We also studied the geochemical composition of the cultural layer. Concentrations of microelements (including toxic materials such as arsenic, copper, lead, and zinc) in buried soils and cultural layers were determined by X-ray fluorescent analysis.

These data allow assessing paleoenvironmental conditions from the ecological point of view.

Based on archaeological data, the development of ancient Moscow before the 14th century AD was mainly confined to the left bank of the Moskva River from the mouth of the Chertoryi Creek to the boundary of Kitai-gorod in the center of the modern city.

Several local building sites existed along the right bank of the Neglinnaya River. Archaeological data for this ancient period are scarce and do not allow us to distinguish between typical rural and urban settlements. In general we can say that the character of land use in ancient Moscow (the Neglinnaya River basin) for the 12th–14th centuries AD did not differ much from that in the basins of other small rivers in the Moscow area. The latter has been determined from ancient settlements and burial mounds in the Yazvenka River basin (the Tsaritsyno Historical Reserve). Paleosol- and paleobotanical methods were used to investigate plow horizons under burial mounds, eroded soils in the upper part of their slopes, and the deposition of eroded material in depressions and hollows.

In addition, we also used landscape analysis for reconstruction of the paleoenvironment. First, we determined the characteristic features of the modern environment for every particular site. Next, we reconstructed initial (paleo)landscapes and assessed their potential for various kinds of land use, taking into account the geological structures of the territory, such as relief, soil fertility, lithological composition of parent material, hydrological and microclimatic parameters, etc. Such features indicate the land use for different purposes (grazing, cropping, housing, etc.). Thus, we constructed land-use maps for ancient periods and compared our results with the results obtained by other methods.

Our study shows that there are certain regularities in the spatial distribution of settlements, croplands, and burial places of past epochs. The results obtained for these suburbs were then transformed to the historical center of Moscow. Crucial for paleoenvironmental and archaeological studies of urban environments is the dating of cultural layers and artifacts. The chronological scale used by archaeologists is based on ceramic artifacts found in different horizons of the cultural layer of Moscow. Recent findings of "old-Russian" ceramics from excavations near the Kazanskii Cathedral and some other archaeological places in Moscow were dated from the beginning of the 12th century AD to the end of the 12th century/beginning of the 13th century. Radiocarbon dating was performed by the laboratories of the institutes of Geology and Geography in Moscow and in Kiev using liquid scintillation spectrometry. Several samples were dated in Groningen (the Netherlands) using either proportional counters or Accelerator Mass Spectrometry (AMS). The results are shown in Table 1. Some of these results have been published previously (Alexandrovskiy, van der Plicht, et al, 1997; Alexandrovskiy & van der Plicht , 1998). The use of AMS (Van der Plicht, Lanting, 1994) enabled us to obtain radiocarbon dates for small samples (<0.01 g) of charcoal. The ^{14}C dates were calibrated using the software developed by the Groningen laboratory (Van der Plicht, 1993).

Table 1

Radiocarbon dates for cultural layers of Moscow

Horizon, depth (cm)	^{14}C age, BP	Lab. code	Calibrated age, 1σ
		Kremlin	
CL	<u>870±40</u>	GrA-13653	1063-1219 calAD
CL (Iron age)	2210±40	GrA-13656	359-203 calBC
CL (Iron age)	2220±40	GrA-13657	361-205 calBC
CL (Iron age)	2240±40	GrA-13658	381-207 calBC
		Il'inka, 1	
CL 290	640±60	Ki-6078	1281-1392 calAD
CL 290	660±50	GrA-6089	1277-1386 calAD
CL 300	620±35	GrN-22469	1292-1390 calAD
CL 315	810±35	GrN-22470	1213-1262 calAD
CL 315	825±95	IGAN-1650	1050-1271 calAD
CL, pit 320	515±30	GrN-22472	1404-1430 calAD
CL, pit 320	550±35	Ki-5892	1318-1418 calAD
CL 325	<u>875±60</u>	GrA-6282	1044-1223 calAD
CL 325	<u>860±40</u>	Ki-5917	1054-1230 calAD
Ap 340	850±35	Ki-5916	1162-1242 calAD
Ap 340	965±125	IGAN-1720	961-1221 calAD
Ap 340	840±60	IGAN -1713	1058-1262 calAD
Ap 340	830±40	GrN-22471	1172-1250 calAD
Ap 340	1030±95	Ki-5215	890-1156 calAD
	Kazanski cathedral on the Red Square, dwelling 1		
Plank 11 285	820±30	GIN-7179	1181-1257 calAD
Plank 12 287	820±20	GIN-7181	1215-1250 calAD
Log 2 289	830±30	GIN-7183	1175-1239 calAD
Post 2 295	880±160	GIN-7184	1010-1275 calAD
Stove 7 287	930±40	GIN-7180	1032-1160 calAD
Stove 7 287	865±40	Ki-5893	1052-1227 calAD
Stove 7 287	925±25	GrN-22474	1036-1158 calAD
Stove 21 290	890±40	Ki-5894	1043-1212 calAD
Plank 10 289	960±40	GIN-7182	1016-1158 calAD
Ap 295	<u>920±60</u>	GrA-6284	1034-1162 calAD

Table (continued)

Horizon, depth (cm)		^{14}C age, BP	Lab. code	Calibrated age, 1σ
			Romanov, 4	
CL	350	160±40	GIN-8818	1666-1955 calAD
CL	350	290±40	GIN-9026	1519-1651 calAD
CL		350±40	GIN-8819	1467-1633 calAD
CL	335	490±40	GIN-8820	1409-1440 calAD
CL	330	630±40	GIN -8825	1285-1392 calAD
CL		360±110	GIN -8828a	1430-1650 calAD
CL	330	310±40	GIN -9386	1505-1645 calAD
CL	283	280±40	GIN -9389	1523-1654 calAD
Dwell.	335	1000±40	GIN -9575	998-1031 calAD
Dwell.		<u>870±40</u>	GIN -9581	1056-1221 calAD
Dwell.	365	730±40	GIN -9577	1262-1281 calAD
BS	370	2140±40	GIN -9867	341-116 calBC
			Kuzminki, Site 4	
Dwelling pit**		<u>870±40</u>	GIN-9931	1056-1221 calAD
			Kuryanovo,	
Flood plain 150		900±100	GIN-9868	1003-1256 calAD

*Underlined similar dates for the stratigraphy or cultural identical samples/assemblages.

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Note: CL - Cultural layer, Ap - plow horizon, Dwell. – dwelling, BS - buried soil. Laboratory indices: Ki, Kiev; GrA, Groningen (AMS); GrN, Groningen (conventional); IGAN, Institute of Geography,RAS; GIN, Institute of Geology, RAS.

The main key sites: Results

In total, we have investigated 28 key sites in the center of Moscow. In the area of Kitai-gorod, we studied the outer periphery of the Red Square (Razinskii path, the beginning of Il'inka street, Kazanskii Cathedral, and Iverskie vorota (gates). The Staropanskii key site is located northwest of this area (History of Moscow, 1997).

Key sites were studied along the right bank of the Neglinnaya River (the garden in the territory of the old building of Moscow University, Manezhnaya Square, and Teatral'naya Square).

Several sites were investigated in the western (Tverskoi boulevard, Gnezdnikovskii lane), eastern (from Maroseika to Solyanka streets), and northern (the Kuchkovo Field) parts of ancient Belyi gorod (the White City).

We also investigated the areas along the right bank of the Moskva River (Bol'shay Ordynka street and in the area of the ancient oxbow lake (which is presently the water channel).

The outskirts of ancient Moscow were investigated in the so-called Zemlaynoi gorod: Ostozhenka-, Bol'shaya Molchanovka-, Malaya Bronnaya-, and Sretenka streets (the area around the artificial earth wall (rampart) that surrounded the central part of ancient Moscow); one site represents land around ancient Moscow (at present, this is the area of Tishinskaya square).

Important results were obtained for the Moskva-River flood plain, especially for the site of Kur'yanovo (the southeastern part of Moscow). It was shown that deposition of alluvial sediments over the flood plain was not a continuous process. Several stages in the alluvium can be distinguished. These stages are well correlated with paleoclimatic and paleohydrologic events; they are marked by the presence of two buried soils. Ancient settlements found on the surface of the upper buried soil are radiocarbon dated to 900±100 years (GIN-9868), corresponding to a calibrated age range of 1003–1256 AD. The archaeological dating of these settlements (second half of 13th/ beginning of the 14th century) is also available. In contrast to the soils buried in the thickness of the cultural layer, the burying of flood-plain soils was mainly due to natural processes. At the same time, the alluvium deposition process could be connected with human impacts on the environment. Extensive plowing in the catchment area of the Moskva River during the medieval history resulted in active erosion and a more heavy sediment load of river water; the floods were more frequent and higher. As a result, the deposition process of alluvium was very active and no distinct soil horizons could form in this alluvium. In the 20th century, the area of plowed fields in the basin of the river has been reduced; this was caused by measures such as the construction of water reservoirs. The deposition of alluvium on the flood plain has now virtually stopped. These factors favour the development of modern flood-plain soils.

The soils buried under the cultural layer of Moscow belong to the group of soddy-podzolic soils (Alfisols) that originally developed under forests. Usually, these soils contain features showing the character of human impacts on them; the most ancient cultivated soils are found in the central part of Moscow. Garden soils and croplands existed in the area of Moscow Kremlin in the 11th and 12th centuries AD. To the north of this area, soil plowing started somewhat later (in the 14th century). In the periphery of ancient Moscow (Tishinskaya square) natural soils were used for gardening until the end of the 17th century. In some cases, we can definitely say that the soils buried under the cultural layer developed under forests till the time they became buried (the stages of croplands and gardens is not seen in the profile of these soils).

Our investigations allowed us to construct four maps for the historical landscapes of Moscow for the following timespans: i) end of the 12th century-the first half of the 13th century, ii) the first half of the 14th century, iii) the first half of the 15th century, and iv) the beginning of the 16th century.

The areas with different kinds of land use during these periods are shown on the maps in two ways. First, inner boundaries show the areas for which we have sufficient factual data; second, outer boundaries show provisional areas, reconstructed by extrapolation using additional data, such as the analysis of local geographic names, landscape analysis, etc.

At the beginning of the 13th century, the total area of ancient Moscow settlements did not exceed 35 ha. These settlements were located in the basin of the Neglinnaya River and were surrounded by croplands (approximately 140 ha). The flood-plain meadows in front of the Kremlin were used for grazing.

By the middle of the 14th century, the area of settlements and adjacent croplands increased by a factor of 2 (approximately 60 and 260 ha, respectively). Houses were constructed in the territory of the future Kitai-gorod and merged together with the ancient Kremlin settlement. Some small settlements were created on the right bank of Moskva River. The soils of that time are poor in pollen of tree species (not more than 20% of the total amount of pollen), which is an indication for intensive deforestation in the vicinity of the city.

In a century, the area covered by housing increased by a factor of three and reached 250 ha; the area of croplands also enlarged, but not as much as the area of house construction. We can assume that ancient Moscovites did not use only their own foodstuff, but also imported the products of other places.

The spread of the city at the end of the 15th and the beginning of the 16th century was very rapid. The area with houses increased by a factor of three and reached 600 ha. During this period, the outlines of the future radial-circle pattern of Moscow emerged. House construction in the city was regulated by the central authority. It was forbidden to build houses to the Northeast of the Kremlin, where the orchards of Moscow tsars and princes were located. The meadows belonging to the landlords of Moscow were preserved in the centre of the city (the Rachka River mouth); regular house construction with streets and lanes took place in the western part of Moscow.

Judging from paleobotanical records, the structure of farmlands did not change much in spite of the active urban spread in that period. Weed control measures were actively applied. During some periods, also reforestation of the territory took place.

The accumulation of sediments in the cultural layer was larger in depressions, e.g. in the basin of the Neglinnaya River (Manezhnaya Square). This caused the leveling of the initial topography of the city and made drainage conditions worse. As a result, the city suffered from a rising groundwater table and secondary waterlogging. This made it necessary to build special drains and pavements. It is interesting to investigate the ancient gardens of Moscow. Pollen analysis shows that buried garden soils in the center of Moscow contained a significant amount of pollen of cereal crops. It is probable that cereals were still cultivated in the gardens of the ancient Moscovites along with typical garden crops. Some layers dating back to the beginning of the 17th century are very rich in phytoliths of ruderal plants; in many places, the phytolith spectra are rich in phytoliths of meadow- and swamp-plant species.

The interpretation of chemical composition data of surface- and buried-soils, cultural layers, and various archaeological objects requires detailed knowledge on average concentrations of certain elements in local geochemical environments and on the potential migration ability of these elements in specific conditions. Small particles (microelements) are capable to form complex compounds with soil humic substances; therefore, the higher is the humus content in a soil, the higher is the absorption capacity of this soil with respect to microelements. This also applies to the material from cultural layers.

The migration of elements is determined by the amount of precipitation (in Moscow, about 600 mm per year) and the precipitation-to-evaporation ratio. The excess of precipitation over evaporation in combination with the acid reaction of soils (both factors are typical for Moscow) favors the migration of elements and their leaching from soils. Thus, initial (native) soddy-podzolic soils are relatively poor in most microelements.

The increase in the calcium content in the cultural layer of Moscow is related to human activity (construction works and manufacturing). The presence of calcium neutralizes the initially acid soil reaction or even leads to a slightly alkaline reaction. Most of the polluting metals that get into the soil by a slightly alkaline reaction loose their mobility and become fixed in the soil material. By using the composition of these pollutants in particular soil layers of different age, we can reconstruct some aspects of human economic activity.

The most important anthropogenic indicator is phosphorus. The increase in the phosphorus concentration in cultural layers and buried urban soils (in comparison with native conditions) is due to the input of municipal waste. Humans as biological organisms and domestic animals are also important sources of phosphorus in urban soils and cultural layers. The phosphorus content in the body of a person can be about 1%. Nearly 4 g of phosphorus is daily discharged from a human's body with urea. Every ton of manure contains about 3 kg of phosphorus compounds.

Geochemists consider phosphorus a relatively immobile element. However, in certain conditions, phosphorus is capable of migration. The increase in mobility of phosphorus compounds is related to the transformation of tricalcium phosphate into di- and monocalcium phosphates: $Ca_3(PO_4)_2$ – $CaHPO_4$ – $Ca(H_2PO_4)_2$. This reaction proceeds in the presence of free acids that form during the decomposition of organic residues in anaerobic conditions, in particular, in conditions of the secondary waterlogging. Such geochemical transformations are also typical for arsenic.

The geochemical composition of the cultural layer (which may also be called the dirt of the city) of ancient Moscow is characterised by extremely high concentrations of arsenic, lead, copper, and zinc. Apparently, these elements were widely used in manufacturing technologies. For instance, the concentration of arsenic in the cultural layers of the 17th and 18th centuries varies from 8 to 25 mg/kg, exceeding the maximum permissible level by two to five times (Table 2). Anomalously high concentrations of copper and zinc are observed in cultural sediments of the 15th and 16th centuries (Aleksandrovskaya & Aleksandrovskiy, 1997).

Meanwhile, concentrations of copper, zinc, and lead in natural soils around Moscow are lower than the average concentrations of these elements in the Earth's crust, which is conditioned by the percolative water regime of soils and slight acidity of soil solu-

Table 2

Trace elements, mg/kg, Romanov 4 site

Horizon	depth (cm)	century	Cr	Mn	Ni	Cu	Zn	As	Pb	Rb	Sr	Zr
Clark:			122	1060	99	30	76	2	13	70	38	162
A1	20	20th	85	770	25	141	197	8	228	56	176	184
CL	70	19th	63	902	30	312	125	12	51	61	187	229
A1/CL	110	18th	65	1151	30	163	183	25	161	70	192	243
A1/CL	170		44	683	4	58	90	17	24	47	111	165
CL (Cu)	230	17th	55	9329	31	1204	1328	11	57	114	537	358
CL (Cu)	230		90	985	37	1910	125	25	120	74	157	251
CL	290	17th	67	817	29	115	101	46	28	54	100	152
CL charcoal	325	16th	71	700	27	30	84	6	20	45	119	173
A1p	340		66	1255	19	72	135	8	17	69	112	224
A2	360		60	334	3	9	25	8	8	52	81	361

tions causing active leaching of these elements from soils.

The increase in the copper content of the cultural layer is certainly determined by the anthropogenic load on the urban environment. It is known that copper utensils were widely used in the past. Ancient copper-smelters also polluted the environment.

The excess of copper in a human's body leads to severe diseases; liver and germ cells suffer most. This could reduce the lifespan of medieval people. At the same time, a copper deficit (which is typical for the natural environment around Moscow) is also dangerous as it can lead to anaemia. In such cases, a slight increase in the copper concentration could be even favourable for the human health.

The toxicity of zinc is not very high. Zinc is an essential element for the growth and development of plants and animals. A low content of zinc in soils of Smolensk region (30-40 mg/kg versus the normal concentration of 75 mg/kg) could retard the development and growth of local inhabitants. The deficit of zinc could be compensated for by eating fish including skin and fins (the concentration of zinc in fish muscles is relatively low). Again, some additional input of zinc into the urban environment could have a positive effect on human's health. At the same time, excessive concentrations of this element could worsen health conditions and change the behaviour of large groups of people.

The excess or deficit might cause serious malfunctioning of human organisms. Lead contamination leads to disturbances in the nervous system, though data on these disturbances are rather controversial. Experiments conducted by D.M. Ogilvie and A.H. Martin (Ogilvie, Martin, 1982), who added acetate of lead into mice food, showed that excessive lead concentrations increase the motoric activity of animals. Probably, the excess of lead in a human's body increases the feeling of anxiety.

An extremely high concentration of mercury was found in the cultural layer in the area of the Gostinyi Dvor site. Mercury was widely applied in the ancient economy (in jewelry, for gold-plating of cathedral domes, in medicine, etc.). Mercury is toxic because it is volatile. The poisonous effect of mercury on people who worked with this metal was very strong; the inhabitants of nearby houses also suffered from excessive concentrations of mercury. The main symptoms of mercury poisoning are increased anxiety followed by suppression, lowering of blood pressure, and psychic breakdown.

In general, we can say that landscape-geochemical studies of urban soils and cultural layers allow not only to reconstruct some peculiarities of the ancient economy, but also enable to investigate the health and behaviour of ancient people.

The pollution of the urban environment in Moscow was very strong already in the medieval epoch. Hence, the foodstuff obtained from the gardens and orchards of Moscow were far from being "ecologically safe". In this connection, the popular statement that ancient Moscow did not differ much from a rural environment (Moscow is sometimes called "the big village") is absolutely wrong. Already in the 16th century, Moscow was an important industrial city with corresponding environmental problems. Modern urban soils of Moscow inherited the unfavourable geochemical background created in previous epochs. Excavations of ancient soils and cultural layers can lead to a considerable contamination of modern surface soils.

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Radiocarbon dates of the Mesolithic sites of Eastern Europe

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Abstract

The article is presented the list of ^{14}C dates for the Mesolithic sites of Eastern Europe. The map of location of the Mesolithic sites of Eastern Europe is presented too. The histograms of the distribution of the ^{14}C dates of the Mesolithic sites for different Eastern European regions separately (southern, central, northern) were prepared. The radiocarbon dates show coexistence of the Neolithic in the Southern regions and the Mesolithic in the North.

Key words: Mesolithic, radiocarbon age, Eastern Europe.

Introduction

The radiocarbon dates are of especial importance for the chronology of Mesolithic period. The division into periods and relative chronology of Neolithic are in many areas worked out in enough sufficient degree using the typological criteria for the large series of the pottery materials. The synchronization of the Neolithic cultures of the adjacent regions could be stated using the recognizable traces of interconnections and interinfluences and in number of cases especially in Southern areas also by the recognition of imports. These circumstances allow to work out the schemes of the synchronizations of Neolithic cultures in huge areas using the pure archaeological criteria. In these cases the restricted number of ^{14}C dates originated from the key-sites could be enough to reach the real scheme of the absolute chronology. The brilliant example of such construction was created by T.S.Passek when she suggested the chronology of Neolithic and Eneolithic of the former USSR southern area using the very first and not numerous yet radiocarbon dates (Passek, 1962).

The working-out the Mesolithic chronology of the broad area using the typological criteria only is much more complicated task. The Mesolithic materials are represented by stone and bone-antler industries which are more conservative and are depended on natural resources in great degree. The evolution of industries could have different speed even in adjacent regions and changes in industries and innovations appearance could be asynchronous. Factually we can reach absolute chronology schemes and even the real synchronization basing on independent data only, first of all on the radiocarbon evidence. The problem of the Mesolithic radiocarbon chronology preparation became of prime importance now.

Results and discussion

^{14}C evidence can give certain materials for solving some problems which we cannot solve using the traditional typology methodics only. The problems of the upper temporal limits of the Late Mesolithic cultures in different regions and the chronology of the Neolithisation stages are among them. The radiocarbon dates fix relatively fast spread of the pottery production which could be explained most probably by the processes of diffusion (Timofeev & Zaitseva, 1996). The Lists of ^{14}C dates for the Eastern Europe Mesolithic did not appear in archaeological literature during the last 20 years. The List of datings is absent even in the fundamental volume devoted to the former USSR Mesolithic (Koltzov, 1989).

Table

Radiocarbon dates of the Mesolihic sites of Eastern Europe

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
			Russia			
			Komi Republic			
1	Kolovaty, 67°18'/58°40'	Le-4000	6985±250	6110-5585	charcoal	1
2	Lek-Lesa, 64°47'/53°24'	Le-3604	9010±70	8082-8006	charcoal	2
3	Viss peat-1, 63°07'/52°30'	Le-616	7820±80	6702-6478	wood	4
4	Viss peat-1, 63°07'/52°30'	Le-684	7150±60	5992-5836	wood	4
5	Viss peat-1, 63°07'/52°30'	Le-685	7090±80	5992-5836	wood	4
6	Viss peat-1, 63°07'/52°30'	Le-776	8080±90	7246-6774	wood	4
7	Viss peat-1, 63°07'/52°30'	Le-713	7090±70	6600-6420	wood	4
8	Parch-1, 61°36'/54°40'	Le-4033	7165±150	6170-5850	charcoal	14
			Karelia and North-Western regions			
9	Pindushi-19a b, 63°12'/34°51'	Le-1521	7280±80	6170-6026		3
10	Orovnavolok-9, 62°46'/35°05'	Le-1092	7720±100	6600-6420	charcoal	5
11	Pegrema-8, 62°35'/34°26'	Le-677	7140±80	6102-5868	charcoal	7
12	Pegrema-8- 62°35'/34°26'	Le-721	7050±150	6000-5710	charcoal	7
13	Pegrema-8 62°35'/34°26'	Le-672	7050±150	6000-5710	charcoal	7
14	Oleneostrovski cemetery,grave 100, 62°03'/35°22'	GIN-4836	9910±80	9480-9040	bone from skeleton	9
15	Oleneostrovski cemetery,grave 9, 62°03'/35°22'	OxA-1972	9020±450	8840-7530	bone from skeleton	9
16	Oleneostrovski cemetery,grave 108, 62°03'/35°22'	OxA-1973	7750±110	6690-6420	bone from skeleton	9
17	Oleneostrovski cemetery,grave 80, 62°03'/35°22'	OxA-1669	7560±90	6458-6244	bone from skeleton	9
18	Oleneostrovski cemetery,grave 80, 62°03'/35°22'	OxA-1668	7560±90	6458-6244	bone from skeleton	9
19	Oleneostrovski cemetery,grave 85, 62°03'/35°22'	OxA-2125	7510±90	6404-6228	bone from skeleton	9
20	Oleneostrovski cemetery,grave 70, 62°03'/35°22'	GIN-4450	7470±240	6480-6010	bone from skeleton	9

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
21	Oleneostrovski cemetery,grave 57, 62°03'/35°22'	OxA-2266	7350±90	6340-6044	bone from skeleton	9
22	Oleneostrovski cemetery,grave 80, 62°03'/35°22'	OxA-1667	7330±90	6218-6040	bone from skeleton	9
23	Oleneostrovski cemetery,grave 89, 62°03'/35°22'	OxA-2124	7280±90	6172-6016	bone from skeleton	9
24	Oleneostrovski cemetery,grave 57, 62°03'/35°22'	OxA-1665	7280±80	6172-6016	bone from skeleton	9
25	Oleneostrovski cemetery,grave 142, 62°03'/35°22'	GIN-4451	7220±110	6170-5960	bone from skeleton	9
26	Oleneostrovski cemetery,grave 85, 62°03'/35°22'	GIN-4839	7210±50	6108-5982	bone from skeleton	9
27	Oleneostrovski cemetery,grave 153, 62°03'/35°22'	GIN-4452	7140±140	6120-5810	bone from skeleton	9
28	Oleneostrovski cemetery,grave 158, 62°03'/35°22'	GIN-4454	7130±170	6160-5770	bone from skeleton	9
29	Oleneostrovski cemetery,grave 71, 62°03'/35°22'	GIN-4449	7130±170	6160-5770	bone from skeleton	9
30	Oleneostrovski cemetery,grave 118, 62°03'/35°22'	GIN-4840	7080±80	5984-5828	bone from skeleton	9
31	Oleneostrovski cemetery,grave 108, 62°03'/35°22'	GIN-4838	7070±100	5980-5780	bone from skeleton	9
32	Oleneostrovski cemetery,grave 151, 62°03'/35°22'	GIN-4453	6980±200	6000-5610	bone from skeleton	9
33	Oleneostrovski cemetery,grave 73, 62°03'/35°22'	GIN-4841	6960±100	5940-5700	bone from skeleton	9
34	Oleneostrovski cemetery,grave 10, 62°03'/35°22'	GIN-4456	6950±90	5934-5698	bone from skeleton	9
35	Oleneostrovski cemetery,grave 19, 62°03'/35°22'	GIN-4457	6870±200	5950-5530	bone from skeleton	9
36	Oleneostrovski cemetery,grave 3, 62°03'/35°22'	GIN-4459	6830±100	5170-5580	bone from skeleton	9
37	Oleneostrovski cemetery,grave 16, 62°03'/35°22'	GIN-4458	6790±80	5706-5534	bone from skeleton	9
38	Oleneostrovski cemetery,grave 57, 62°03'/35°22'	OxA-1666	6100±90	5204-5174	bone from skeleton	9

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
39	Oleneostrovski cemetery,grave 57, 62⁰03'/35⁰22'	OxA-1664	5700±80	4676-4460	bone from skeleton	9
40	Kladovetz-8, 61⁰56'/35⁰50'	TA-1445	7760±100	6650-6430	charcoal	11
41	Kladovez-4 61⁰56'/35⁰50'	TA-1451	7840±60,	6754-6500	charcoal	10
42	Muromskoe-7 61⁰50'/36⁰17'	TA-1134	7940±120	7000-6630	charcoal	12
43	Muromskoe-7 61⁰50'/36⁰17'	TA-1012	7600±100	6480-6240	charcoal	12
44	Besov Nos-6, 61⁰40'/36⁰03'	TA-1421	8300±80	7478-7104	charcoal	13
45	Besov Nos-6 61⁰40'/36⁰03'	TA-1454	7560±70	6454-6254	charcoal	13
46	Antrea Korpelakhti-(Ozernoe), 60⁰53'/29⁰27'	Hel-269	9230±210	8490-8030	Bark birch	18
		Northern and North-Eastern regions				
47	Yavrongski bog, 62⁰39'/46⁰24'	Le-853	8530±60	7572-7494	charcoal	6
48	Peschanitza, 61⁰14'/38⁰53'	GIN-4858	9890±120	9500-9010	bone from skeleton	16
49	Lower Veretie, 61⁰13'/38⁰58'	GIN-4031	9050±80	8122-7994	charcoal	17
50	Lower Veretie , 61⁰13'/38⁰58'	GIN-4869	8790±100	7935-7690	peat	17
51	Lower Veretie , 61⁰13'/38⁰58'	GIN-2452y	8310±120	7490-7100	wood	17
52	Lower Veretie , 61⁰13'/38⁰58'	GIN-2452d	8270±130	7430-7050	wood	17
53	Lower Veretie , 61⁰13'/38⁰58'	Le-1469	9600±80	8954-8602	charcoal	17
54	Lower Veretie, 1,61⁰13'/38⁰58'	Le-1472	8750±70	7899-7698	wood	17
55	Lower Veretie, 61⁰13'/38⁰58'	Le-1470	8270±100	7430-7090	charcoal	17
56	Lower Veretie, 61⁰13'/38⁰58'	Le-1471	7960±100	7000-6660	charcoal	17
57	Lower Veretie, 61⁰13'/38⁰58'	Le-1473	7700±80	6554-6422	wood	17
58	Kolupaevskaya, 59⁰58'/43⁰01'	Le-1193	4340±50	3030-2888	charcoal	80
59	Kolupaevskaya, 59⁰58'/43⁰01'	Le-1194	5600±150	4670-4260	charcoal	80
60	Popov cemetery grave 8, 61⁰17'/38⁰57'	GIN-4857	7150±160	6160-5810	bone from skeleton	15
61	Popov cemetery grave 9, 61⁰17'/38⁰57'	GIN-4856	9730±110	9050-8660	bone from skeleton	15
62	Popov cemetery, grave 6, 61⁰17'/38⁰57'	GIN-3887	7290±150	6340-5960	bone from skeleton	15

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
63	Popov cemetery, grave 3, 61°17'/38°57'	GIN-4442	9520±130	8930-8440	bone from skeleton	15
64	Popov cemetery, grave 2, 61°17'/38°57'	GIN-4446	5400±300	4550-3810	bone from skeleton	15
65	Popov cemetery, grave 1, 61°17'/38°57'	GIN-4447	9430±150	8920-8260	bone from skeleton	15
66	Kumozero, 59°52'/40°31'	Le-3240	7600±180	6590-6190	charcoal	19
67	Tsareva, 59°17'/38°06'	Le-4903	7610±120	6540-6240	charcoal	22
68	Ustj-Andoga-1, 59°10'/38°00'	Le-4470	6960±100	5940-5700	charcoal	23
69	Ustj-Andoga-1, 59°10'/38°00'	Le-4471	6610±60	5568-5448	charcoal	23
70	Ustj-Andoga-1, 59°10'/38°00'	GIN-5584	8540±100	7690-7440	charcoal	23
71	Ustj-Andoga-1, 59°10'/38°00'	GIN-5583	7850±140	6990-6480	charcoal	23
72	Vodysch, 58°08'/41°32'	Le-1229	7150±70	6044-5882	charcoal	25
		The regions adjoining to the Ural, Udmurtia Republic				
73	Barinka-1, 57°05'/51°39'	Le-1264	7435±170	6420-6060	charcoal	31
74	Barinka-2, 57°05'/51°39'	Le-1288	8265±130	7430-7050	charcoal	32
			Central regions			
75	Vashutinskaya, 57°22'/40°08	Le-2616	10600±100	10700-10475	charcoal	27
76	Ivanovskoe-2, 56°51'/39°02'	Le-2146	8510±90	7584-7434	wood	35
77	Ivanovskoe-3, 56°51'/39°02'	Le-1934	7400±80	6360-6066	wood	36
78	Ivanovskoe-3, 56°51'/39°02'	IGAN-81	8900±100	8040-7720	wood	36
79	Ivanovskoe-3, 56°51'/39°02'	IGAN-80	8370±50	7488-7318	peat	36
80	Ivanovskoe-3, 56°51'/39°02'	Le-3098	8130±80	7258-7006	wood	36
81	Ivanovskoe-3, 56°51'/39°02'	IGAN-161	7500±70	6380-6230	peat	36
82	Ivanovskoe-3, 56°51'/39°02'	IGAN-68	7500±110	6410-6200		36
83	Ivanovskoe-3, 56°51'/39°02'	Le-3095	7310±70	6180-6046	wood	36

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
84	Ivanovskoe-3, 56°51'/39°02'	Le-1980	7630±40	6460-6418	wood	36
85	Ivanovskoe-3, 56°51'/39°02'	Le-1979	7510±80	6392-6230	wood	36
86	Ivanovskoe-3, 56°51'/39°02'	Le-1983	7310±80	6184-6038	charcoal	36
87	Ivanovskoe-3, 56°51'/39°02'	Le-1905	8430±90	7540-7320	wood	36
88	Ivanovskoe-3, 56°51'/39°02'	GIN-242	8859±700	------	charcoal	36
89	Ivanovskoe-3, 56°51'/39°02'	Le-1912	7470±80	6364-6182	wood	36
90	Ivanovskoe-3, 56°51'/39°02'	Le-3096	10100±100	9950-9190	wood	36
91	Ivanovskoe-3, 56°51'/39°02'	Le-3099	10210±100	10275-9390	wood	36
92	Ivanovskoe-7, 56°50'/39°02'	Le-1260	7490±120	6410-6190	peat	37
93	Ivanovskoe-7 56°50'/39°02'	Le-1261	7375±170	6370-6050	peat	37
94	Berendeevo-3, 56°34'/39°10'	Le-1556	7770±100	6690-6450	wood	49
95	Berendeevo-2a, 56°34'/39°10'	Le-1572	7860±80	6992-6546	charcoal	48
96	Berendeevo-2a, 56°34'/39°10'	Le-1571	7430±80	6364-6178	wood	48
97	Berendeevo-2a, 56°34'/39°10'	Le-1570	6990±80	5940-5742	wood	48
98	Berendeevo-1, 56°34'/39°10'	Le-1577	7830±80	6758-6480	wood	47
99	Lanino, 57°11'/33°00	Le-3772	8630±290	8020-7320	charcoal	30
100	Podol-3, 56°53'/33°19'	Le-5029	9180±75	8334-8088	charcoal	33
101	Podol-3, 56°53'/33°19'	Le-3772	8630±290	8020-7310	charcoal	33
102	Ozerki-5, 56°42'/36°41'	GIN-7216	6930±70	5840-5692	wood, artefact	41
103	Ozerki-5, 56°42'/36°41'	GIN-6659	7410±90	6364-6070	charcoal	41
104	Ozerki-5, 56°42'/36°41'	GIN-6660	7190±180	6180-5820	charcoal	41
105	Ozerki-5, 56°42'/36°41'	GIN-7217	7120±50	5992-5882	wood	41

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
106	Ozerki-5, 56°42'/36°41'	GIN-7218	7310±120	6220-5990	wood	41
107	Ozerki-5, 56°42'/36°41'	GIN-6662	6970±120	5950-5700	wood	41
108	Ozerki-5, 56°42'/36°41'	NGU-133	8050±450	7480-6470	peat	41
109	Ozerki-5, 56°42'/36°41'	GIN-6654	8770±40	7899-7708	wood, artefact	41
110	Ozerki -17, 56°42'/36°41'	GIN-6655	8830±40	7953-7732	wood	44
111	Sukontzevo-7, 56°28'/34°50'	GIN-4950	8870±70	8024-7732	wood	51
112	Sukontzevo-7, 56°28'/34°50'	GIN-4734	8900±110	8050-7710	wood	51
113	Sukontzevo-7, 56°28'/34°50'	GIN-4733	8710±50	7880-7592	wood	51
114	Sukontzevo-7, 56°28'/34°50'	Le-3015	9650±100	9010-8630	wood	51
115	Sukontzevo-7, 56°28'/34°50'	GIN-3902	9220±50	8336-8100	charcoal	51
116	Butovo, 56°43'/35°21'	GIN-5441	9310±110	8440-8140	charcoal	39
117	Kultino-2, 56°38'/35°22'	Tln-1406	8850±200	8040-7600	charcoal	46
118	Ustj-Tudovka-4, 56°25'/33°48'	GIN-4864	8770±200	7980-7570	charcoal	52
119	Malaya Lamna, 56°34'/41°55'	Le-2610	8800±90	7953-7700	charcoal	50
120	Nushpoly-2, 56°38'/37°43'	GIN-6657	7310±40	6170-6058	wood, artefact	45
121	Okaemovo-5, 56°20'/38°08'	GIN-6191	7910±80	6994-6612	gyttja	54
122	Okaemovo-5, 56°20'/38°08'	GIN-6192	7730±60	6950-6492	gyttja	54
123	Okaemovo-5, 56°20'/38°08'	GIN-6193	7360±40	6210-6064	gyttja	54
124	Okaemovo-5, 56°20'/38°08'	GIN-6194	6800±140	5790-5565	gyttja	54
125	Okaemovo-18a, 56°20'/38°08'	GIN-6656a	7420±50	6354-6178	wood artefact	55
126	Okaemovo-18a, 56°20'/38°08'	GIN-6656	7060±50	5958-5850	wood	55
127	Okaemovo-4, 56°20'/38°08'	GIN-6204	7490±50	6372-6232	wood	53

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
128	Belivo-4a, 55°47'/39°02'	GIN-3897	9940±300	10075- 8950	charcoal	58
129	Belivo-4a, 55°47'/39°02'	GIN-3898	9550±100	8940-8530	charcoal	58
130	Belivo-4a, 55°47'/39°02'	GIN-3899	8840±110	8020-7700	charcoal	58
131	Belivo-4a, 55°47'/39°02'	GIN-4728	9130±150	8340-8030	charcoal	58
132	Belivo-4a, 55°47'/39°02'	GIN-4732	8770±180	7935-7590	charcoal	58
133	Zhabki-3, 55°33'/39°38'	GIN-3211	7420±90	6368-6170	charcoal	59
134	Zhabki-3, 55°33'/39°38'	GIN-2767	6870±100	5810-5600	charcoal	59
135	Zhabki-3, 55°33'/39°38'	GIN-3212	8750±120	7935-7630	charcoal	59
136	Zhabki-3, 55°33'/39°38'	GIN-3213	8520±300	7935-7150	charcoal	59
137	Chernaya-1, 55°25'/39°15'	GIN-3895	9110±50	8134-8038	charcoal	60
138	Chernaya-1, 55°25'/39°15'	GIN-3551	8730±300	8080-7430	charcoal	60
139	Chernaya-1, 55°25'/39°15'	GIN-3894	8630±40	7690-7548	charcoal	60
140	Chernaya-1, 55°25'/39°15'	GIN-3891	8270±200	7490-7030	charcoal	60
141	Chernaya-1, 55°25'/39°15'	GIN-3893	8190±120	7410-7030	charcoal	60
142	Chernaya-1, 55°25'/39°15'	GIN-3547	8060±100	7240-6720	charcoal	60
143	Chernaya-1, 55°25'/39°15'	GIN-3892	7300±500	6650-5585	charcoal	60
144	Bezvodnoe-1, 56°12'/43°25'	GIN-5442	6920±380	6120-5440	charcoal	56
			Southern regions of Russia			
145	Satanaj, horizon 1 44°19'/40°39'	Le-4981	7950±140	7000-6620	bone	77
146	Satanaj, horizon 2 44°19'/40°39'	Le-4982	7780±200	7000-6410	bone	77

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
			Baltic region			
			Estonia			
147	Kunda, 59°36'/26°32'	TA-14	8340±280	7690-6820	wood	20
148	Kunda, 59°36'/26°32'	TA-12	9780±260	9525-8540	bone	20
149	Kunda, 59°36'/26°32'	TA-16	6015±210	5210-4700	wood	20
150	Kunda, 59°36'/26°32'	Ua-3000	8280±90	7430-7098	bone	20
151	Kunda, 59°36'/26°32'	Ua-3001	8485±90	7572-7432	bone	20
152	Kunda, 59°36'/26°32'	Ua-3002	8515±100	7680-7430	bone	20
153	Kunda, 59°36'/26°32'	Ua-3052	8040±75	7044-6726	bone	20
154	Kunda, 59°36'/26°32'	Ua-3003	9085±100	8330-8020	bone	20
155	Kunda, 59°36'/26°32'	Ua-3005	9330±120	8520-8190	bone	20
156	Kunda, 59°36'/26°32'	Tln-552	7950±60	6998-6704	bone	20
157	Narva, layer 2, 59°17'/28°07'	TA-52	7375±190	6370-6020	charcoal	21
158	Narva, layer, 59°17'/28°07'	TA-176	6020±120	5070-4280	charcoal	21
159	Narva, layer 2, 59°17'/28°07'	TA-254	7580±300	6760-6040	charcoal	21
160	Narva, layer 2, lowe, 59°17'/28°07'	TA-52	7375±190	6370-6020	charcoal	21
161	Narva, layer 2, 59°17'/28°07'	TA-40	6740±250	6230-5980	charcoal	21
162	Narva, layer 2 59°17'/28°07'	TA-17	6020±120	5070-4780	charcoal	21
163	Narva, layer 3, 59°17'/28°07'	TA-25	7580±300	6760-6040	wood	21
164	Narva, layer 3, 59°17'/28°07'	TA-41	7090±230	6160-5690	charcoal	21
165	Narva, layer 3, 59°17'/28°07'	TA-53	7640±180	6610-6210	charcoal	21
166	Kypu-4, 58°55'/22°15'	TA- 2553	6640±60	5578-5452	charcoal	29
167	Kypu-4, 58°55'/22°15'	Tln-2016	6157±51	5210-4998	charcoal	29

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
168	Kypu-8, 58°55'/22°15'	Tln-2024	6172±50	5214-5052	nut	29
169	Vykhma-1, 58°31'/22°21'	TA-2650	6950±100	6000-5600	charcoal	78
171	Vykhma-1, 58°31'/22°21'	TA-2652	6245±200	5420-4940	charcoal	78
172	Vykhma-1, 58°31'/22°21'	TA-2649	6330±100	5450-5000	charcoal	78
173	Pulli, 58°19'/24°35'	TA-949	9350±60	8432-8266	wood	24
174	Pulli, 58°19'/24°35'	TA-245	9600±120	8990-8540	wood	24
175	Pulli, 58°19'/24°35'	TA-175	9300±75	8414-8202	Huminic acid	24
176	Pulli, 58°19'/24°35'	TA-176	9575±115	8960-8530	charcoal	24
177	Pulli, 58°19'/24°35'	TA-284	9285±120	8420-8100	charcoal	24
178	Pulli, 58°19'/24°35'	Hel-2206A	9620±120	9010-8600	charcoal	24
			Latvia			
179	Osa, under the layer 56° 51'/24°35'	MGU-1748	8790±80	7935-7702	wood	34
180	Osa, 56° 51'/24°35'	Le-812	6760±80	5684-5529	wood	34
181	Osa, 56° 51'/24°35'	Le-810	6580±70	5567-5440	peat	34
182	Osa, 56° 51'/24°35'	Le-811	6960±80	5934-5712	wood	34
183	Osa, 56° 51'/24°35'	TA-1820	6710±80	5660-5504		34
184	Osa 56° 51'/24°35'	Bln-770	7186±160	6180-5850	wood	34
185	Osa, 56° 51'/24°35'	MGU-1009	6560±440	5850-5010	charcoal	34
186	Zvidze, 56° 47'/26°59'	TA-856	6760±60	5672-5534	charcoal	38
187	Zvidze, 56° 47'/26°59'	TA-862	6535±60	5330-5222	wood	38
188	Zvidze, 56° 47'/26°59'	Le-2795	7340±80	6220-6046	charcoal	38
189	Zvidze, 56° 47'/26°59'	TA-1722	7650±100	6560-6370		38

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
190	Zvidze, 56⁰ 47'/26⁰59'	TA-1723	7180±100	6160-5880		38
191	Zvidze, 56⁰ 47'/26⁰59'	TA-1745	7480±80	6378-6116		38
192	Zvidze, 56⁰ 47'/26⁰59'	TA-1611	7240±100	6170-5980		38
193	Zvidze, 56⁰ 47'/26⁰59'	TA-863	7110±60	5994-5868	peat	38
194	Zvidze, 56⁰ 47'/26⁰59'	TA-1632	7060±80	5958-5812		38
195	Zvidze, 56⁰ 47'/26⁰59'	TA-864	7020±60	5946-5788	wood	38
196	Zvidze, 56⁰ 47'/26⁰59'	TA-851	7020±60	5946-5788	charcoal	38
197	Zvidze, 56⁰ 47'/26⁰59'	TA-861	6780±60	5682-5590	wood	38
198	Zvidze, 56⁰ 47'/26⁰59'	TA-857	7370±90	6352-6054	wood	38
199	Zvidze, 56⁰ 47'/26⁰59'	TA-1607	6630±80	5576-5448		38
200	Zvidze, 56⁰ 47'/26⁰59'	TA-1612	6610±80	5572-5444		38
201	Zvidze,, 56⁰ 47'/26⁰59'	Vs-518	6530±140	5575-5320		38
202	Zvejnieki cemetery, grave 305, 57⁰49'/25⁰10'	Ua-3634	8240±70	7414-7360	bone	26
203	Zvejnieki cemetery, grave 39, 57⁰49'/25⁰10'	Ua-3635	6775±55	5675-5590	bone	26
204	Zvejnieki cemetery, grave 57 57⁰49'/25⁰10'	Ua-3636	6825±60	5702-5604	bone	26
205	Zvejnieki cemetery, grave 85 57⁰49'/25⁰10'	Ua-3637	6460±60	5434-5332	bone	26
206	Zvejnieki cemetery, grave 2 57⁰49'/25⁰10'	Ua-3638	6900±65	5806-5670	bone	26
207	Zvejnieki cemetery, grave 154 57⁰49'/25⁰10'	Ua-3644	7730±70	6594-6460	bone	26

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
209	Zvejnieki cemetery grave 170 57°49'/25°10'	OxA-5969	8150±80	7260-7034	bone	26
210	Zvejnieki, settlement, 57°49'/25°10'	Tln-296	8500±460	8030-6810	bone	26
211	Sulyagals, 56°43'/26°40'	TA-1317	9575±80	8942-8538	Wood under cultural layer	40
			Lithuania			
212	Spiginas, grave 4 56°01'/21°51'	GIN-5571	7470±60	6366- 6222	Bone from skeleton	57
213	Keblyalaj-2, middle layer 53°56'/24°17'	TA-2600	9100±180	8340-7980	charcoal	61
214	Keblyalaj-2, middle layer 53°56'/24°17'	TA-2604	8680±90	7884-7574	wood	61
215	Keblyalaj-2, middle layer 53°56'/24°17'	TA-2643	8800 ±100	7980-7700	charcoal	61
216	Keblyalaj-2, upper layer 53°56'/24°17'	TA-2610	7060±150	6010-5720	peat	61
217	Keblyalaj-2, upper layer 53°56'/24°17'	TA-2641	7750±200	7000-6370	charcoal	61
218	Keblyalaj-2, upper layer 53°56'/24°17'	TA-2599	7250±120	6180-5970	wood	61
			Ukraine			
219	Krug, 51°53'/25°50'	Ki-6262	11200±110	11275-11050	mammoth tooth	63
220	Senchitsy-5a, 51°53'/25°50'	Ki-6263	9580±70	8942-8546	bone	62
221	Ryzhi Ostrov, 50°38'/29°44'	Ki-6261	7875±50	6988-6600	charcoal	64
222	Ryzhi Ostrov, 50°38'/29°44'	Ki-6260	7800±60	6622-6476	charcoal	64
223	Vyzyavok-4a, 49°57'/32°56'	Ki-5220	9310±70	8418-8252	charcoal	65
224	Vyzyavok-4a, 49°57'/32°56'	Ki-5221	9530±80	8672-8518	charcoal	65

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
225	Vyzyavok-4a, 49°57'/32°56'	Ki-5222	9600±50	8732-8624	charcoal	65
226	Vizyavok-4a, 49°57'/32°56'	Ki-6255	9260±90	8392-8100	charcoal	65
227	Igrenj-8, 48°24'/34°36'	Ki-956	9290±110	8420-8140	shell	68
228	Igrenj-8, 48°24'/34°36'	Ki-368	8860±470	8460-7300	charcoal	68
229	Igrenj-8, 48°24'/34°36'	Ki-950	8650±100	7870-7540	charcoal	68
230	Igrenj-8, 48°24'/34°36'	Bln-1707-1	8575±70	7688-7498	shell	68
231	Igrenj-8, 48°24'/34°36'	Ki-805	8080±210	7250-6770	charcoal	68
232	Igrenj-8, 48°24'/34°36'	Ki-850	7300±130	6230-5980	shell	68
233	Igrenj-8, 48°24'/34°36'	Ki-806	6930±130	5940-5640	shell	68
234	Igrenj-8, 48°24'/34°36'	Ki-2169	6650±200	5860-5340	shell	68
235	Igrenj-8, 48°24'/34°36'	Ki-2168	6520±95	5562-5334	shell	68
236	Igrenj-8, 48°24'/34°36'	Ki-2170	6820±120	5780-5530	shell	68
237	Igrenj-8, 48°24'/34°36'	Ki-1569	7850±100	6990-6480	shell	68
238	Igrenj-8, 48°24'/34°36'	Ki-2171	6500±200	5580-5260	shell	68
239	Igrenj-8, 48°24'/34°36'	Ki-1206	7120±100	6040-5830	shell	68
240	Igrenj-8, 48°24'/34°36'	Ki-6256	7080±60	5972-5850	bone	68
241	Igrenj-8, 48°24'/34°36'	Ki-6257	6930±50	5808-5702	bone	68
242	Igrenj-8, 48°24'/34°36'	Ki-6258	6910±50	5782-5684	bone	68
243	Igrenj-8, 48°24'/34°36'	Ki-6259	6860±45	5724-5638	bone	68
244	Storunya-1, 48°50'/24°33'	Le-1417	5200±70	4216-3948	charcoal	66
245	Molodova-5, 48°35'/27°05'	GIN-54	10940± 150	11050-10750	charcoal	67
246	Girzhevo, 47°15'/29°42'	Le-1703	7050±60	5958-5832	bone	70
247	Mirnoe, 45°38'/29°32'	Le-1648	7200±80	6120-5958	bone	71
248	Vishennoe-1 (Crimea), 48°08'/34°36'	Ki-6264	9740±60	9044-8962	bone	69
249	Vishennoe-1 (Crimea), 48°08'/34°36'	Ki-6304	9680±70	9024-8670	bone	69

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
250	Buran-Kaya (Crimea), 45°07'/34°36'	Ki-6268	10730±60	10770-10650	bone	72
251	Buran-Kaya (Crimea), 45°07'/34°36'	Ki-6267	10920±65	10955-10840	bone from skeleton	72
252	Buran-Kaya (Crimea), 45°07'/34°36'	Ki-6267a	11460±70	11500-11350	bone from skeleton	72
253	Buran-Kaya (Crimea), 45°07'/34°36'	Ki-6269	10580±60	10625-10459	bone	72
254	Buran-Kaya (Crimea), 45°07'/34°36'	Ki-6267	8750±55	7908-7700	bone	72
255	Mys Troitsy-1 (Crimea), 44°23'/33°57'	Ki-6340	7450±70	6362-6188	shell	76
256	Mys Troitsy-1 (Crimea), 44°23'/33°57'	Ki-6341	7800±60	6618-6480	Bone from skeleton	76
257	Shpan Koba (Crimea), 44°31'/33°50'	Ki-5821	7600±45	6518-6450	bone	74
258	Shpan Koba (Crimea), 44°31'/33°50'	Ki-5822	6780±40	5600-5560	bone	74
259	Shpan Koba (Crimea), 44°31'/33°50'	Ki-5823	10210±80	10220-9485	bone	74
260	Shpan Koba (Crimea), 44°31'/33°50'	Ki-5824	9890±80	9376-9030	bone	74
261	Shpan Koba (Crimea), 44°31'/33°50'	GIN-6277	8240+/-150	7420-6990	charcoal	74
262	Kukrek (Crimea), 44°59'/33°55'	Ki-954	9600±150	9000-8530	charcoal	73
263	Kukrek (Crimea),- 44°59'/33°55'	Bln-1799-1	7320±65	6182-6048	charcoal	73
264	Kukrek (Crimea),- 44°59'/33°55'	Bln-1799-2	7285±70	6170-6042	charcoal	73
265	Laspi-7(Crimea),- 44°25'/33°44'	Ki-951	9100±130	8340-8050	shell	75

Table (continued)

No	Site, geographical coordinates (NL/EL)	Lab. Index	^{14}C age, BP	Calibrated age, calBC, (1σ)	Material for dating	No position of site on the map
266	Laspi-7, 44°25'/33°44'	Bln-1921	9085±100	8330-8020	charcoal	75
267	Laspi-7, 44°25'/33°44'	Ki-953	8930±100	8080-7740	charcoal	75
268	Laspi-7, 44°25'/33°44'	Ki-952	8870±120	8030-7700	charcoal	75
269	Laspi-7, 44°25'/33°44'	Ki-876	8680±250	8000-7490	shell	75
270	Laspi-7, 44°25'/33°44'	Ki-957	8340±250	7590-7000	charcoal	75
271	Laspi-7, 44°25'/33°44'	Ki-637	8080±210	7290-6700	charcoal	75
272	Laspi-7, 44°25'/33°44'	Ki-704	8030±190	7240-6620	charcoal	75
273	Laspi-7, 44°25'/33°44'	Ki-638	7620±230	6700-6070	shell	75
274	Laspi-7, 44°25'/33°44'	Ki-863	7500±380	6760-5890	charcoal	75
275	Laspi-7, 44°25'/33°44'	Le-1326	6940±140	5950-5660	charcoal	75
			Moldova			
276	Soroki-2, 47°51'/28°11'	Bln-588	7515±120	6429-6200	charcoal	79
277	Soroki-2, 47°51'/28°11'	Bln-587	7420±80	6364-6174	charcoal	79

The Table presents the list of 277 ^{14}C dates from the samples originated from 79 Mesolithic sites of European Russia, Ukraine and the Baltic States, produced by the Radiocarbon Labs of the Institute for the History of Material Culture, Russian Academy of Sciences, Saint-Petersburg (index Le), the Geological Institute of Russian Academy of Sciences, Moscow (index GiN), the Institute of Mineralogy and Geochemistry, Kiev, Ukraine (index Ki), Tartu Radiocarbon Lab, Esthonia (index Ta) and the data of some other Labs, including the accelerator dates of Oxford Lab (index OxA). The dates of St-Petersburg's and Kiev's Labs are taken from the archives of Labs, the other ones are given after the information published in different sources (see the List of literature). The dates which are apparently too young because of the mixed character of the dated samples are excluded. At the same time some dates produced on samples of disputable attribution, originated from the sites with mixed layers or sites with complicated and unclear stratigraphy are included in the List.

The geographical coordinates of the dated sites are presented to be published here at the first time. They were determined using the Licensed computer program GIS Master (of IGNIT firm). The possible errors can be not more then 5-10 minutes. The latitude values of the dated sites are in frames from 67 to 44 degrees of NL and longitude values are between 58 and 28 degrees of EL. The map of the dated sites is represented in Fig. 1. The main concentration of the dated Mesolithic sites is connected with the central part of the Eastern European Forest zone. Many of them are peat-bog sites with excellent conditions for the samples of organic preservation. Dated sites in the North and in the South of the Eastern Europe and also in the eastern regions are not so numerous. The distribution of ^{14}C dates for Mesolithic sites according to temporal intervals is represented in Fig. 2. The largest amount of dates fall on the interval 7000–7400 BP which corresponds to the Late Mesolithic. The histograms of the distribution of ^{14}C dates of the Mesolithic sites for different Eastern European regions separately (southern,

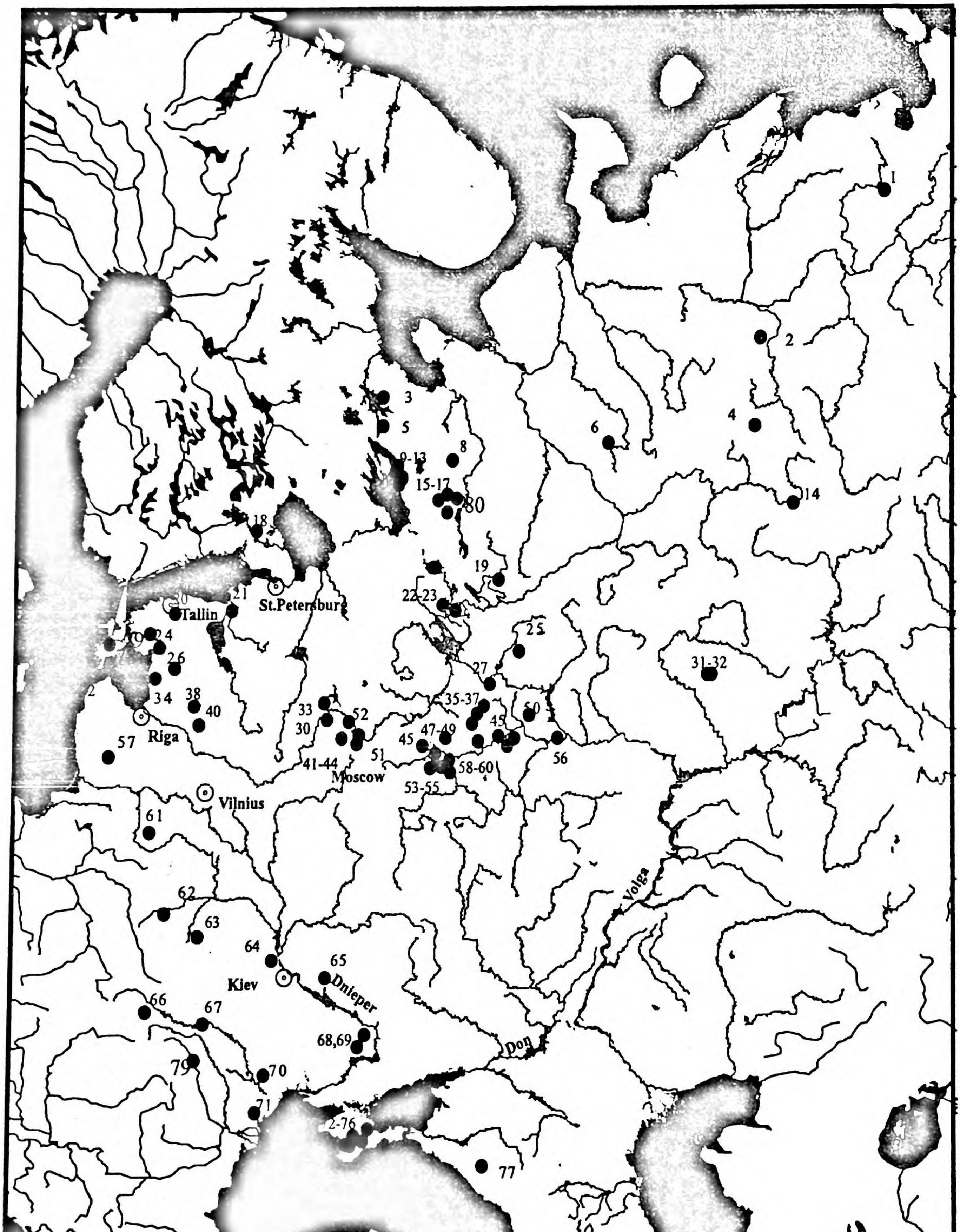

Fig. 1. Location of the Mesolithic sites in the Eastern Europe dated by 14C method

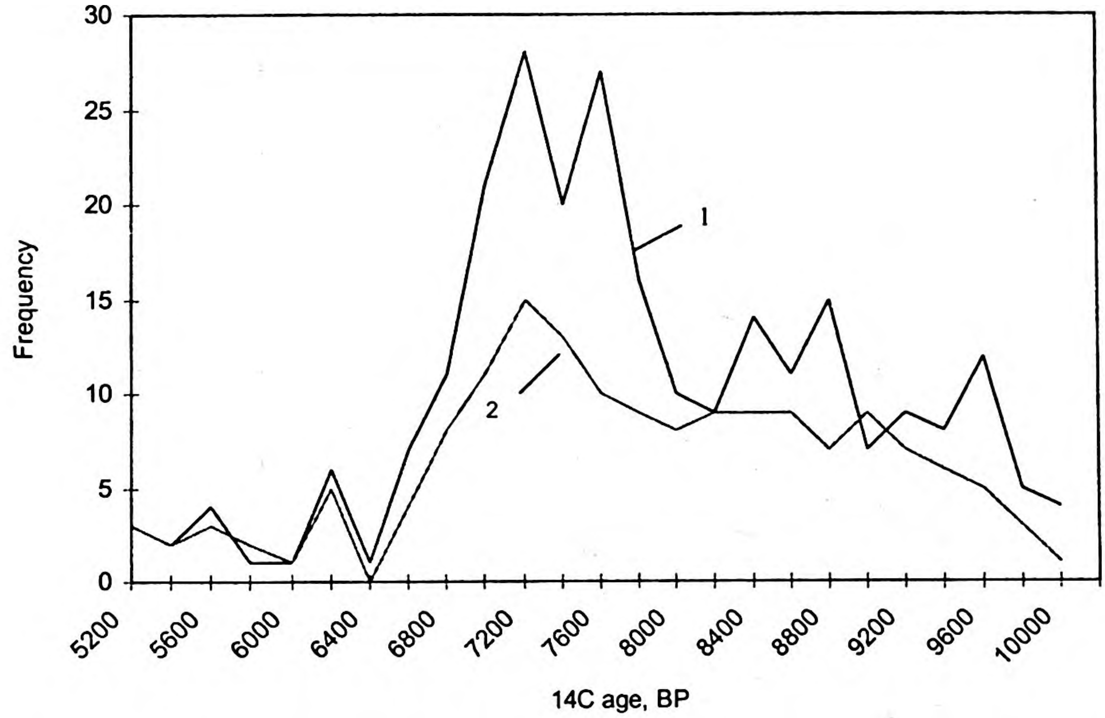

Fig. 2. Histograms of the distribution ^{14}C dates of the Mesolithic sites according to temporal intervals. 1- amount of ^{14}C dates, 2- amount of dated sites.

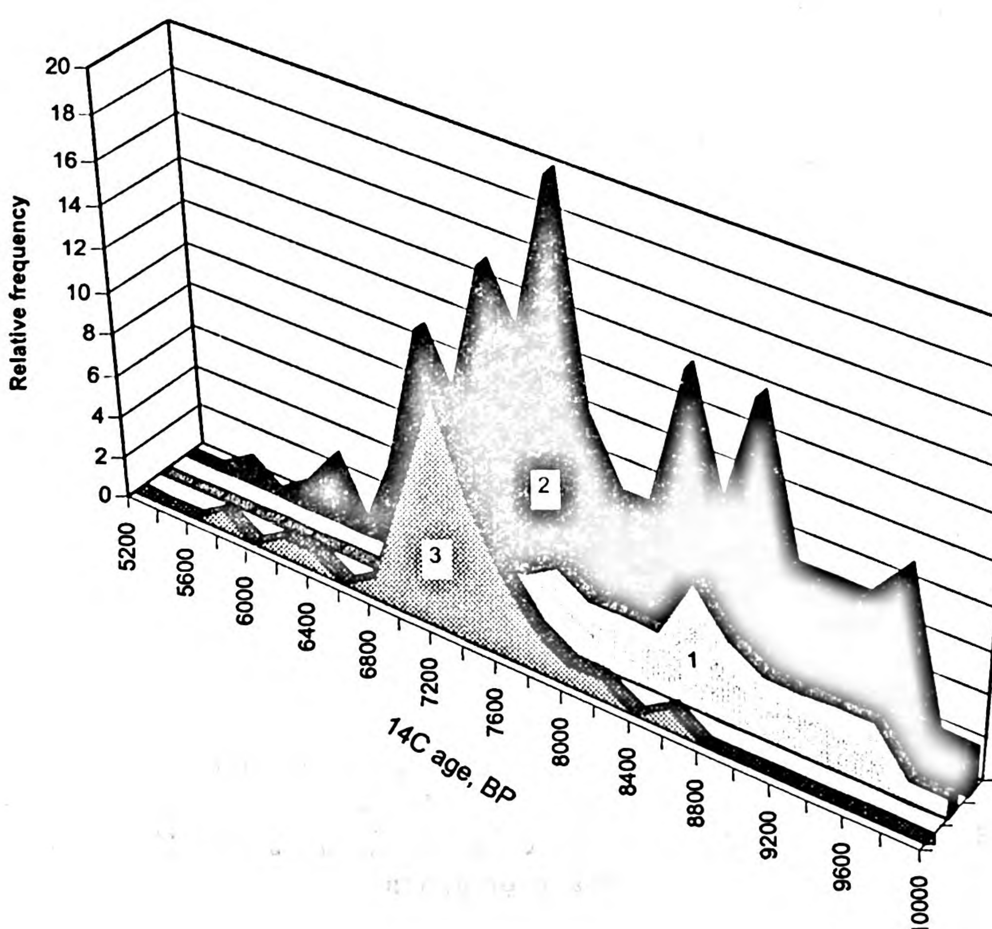

Fig. 3. Histograms of the distribution of ^{14}C age of the Mesolithic sites of different Eastern European regions according to the Northern latitudes (1- South, up to 52 NL, 2- Center, 52-62 NL, 3 – >62 NL).

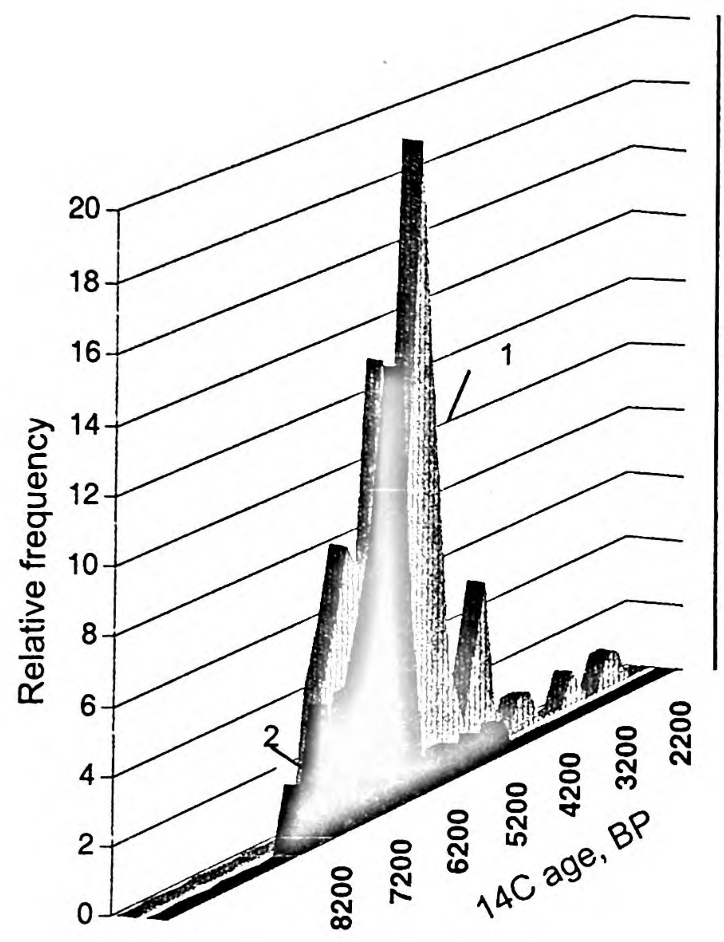

Fig.4. Coexistence of the Mesolithic sites in the Northern regions and the Neolithic sites in the Southern regions of the Eastern Europe. (1 – the Neolithic, 2 – the Mesolithic).

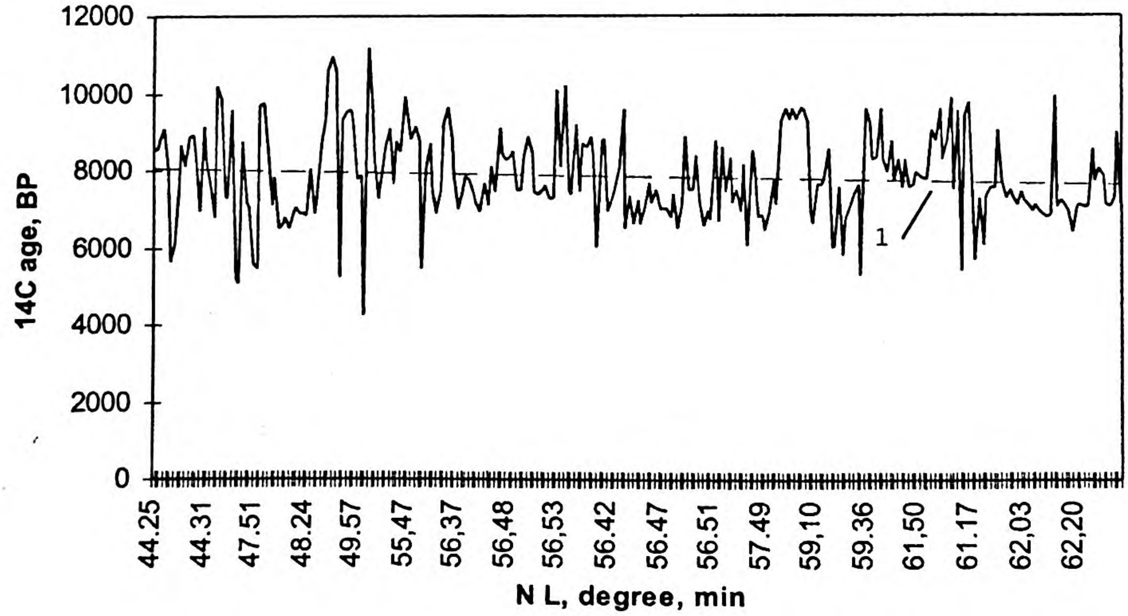

Fig. 5. Distribution of the radiocarbon age for the Eastern European Mesolithic sites following the latitude of the dated sites location. 1 – line of radiocarbon age dates trend.

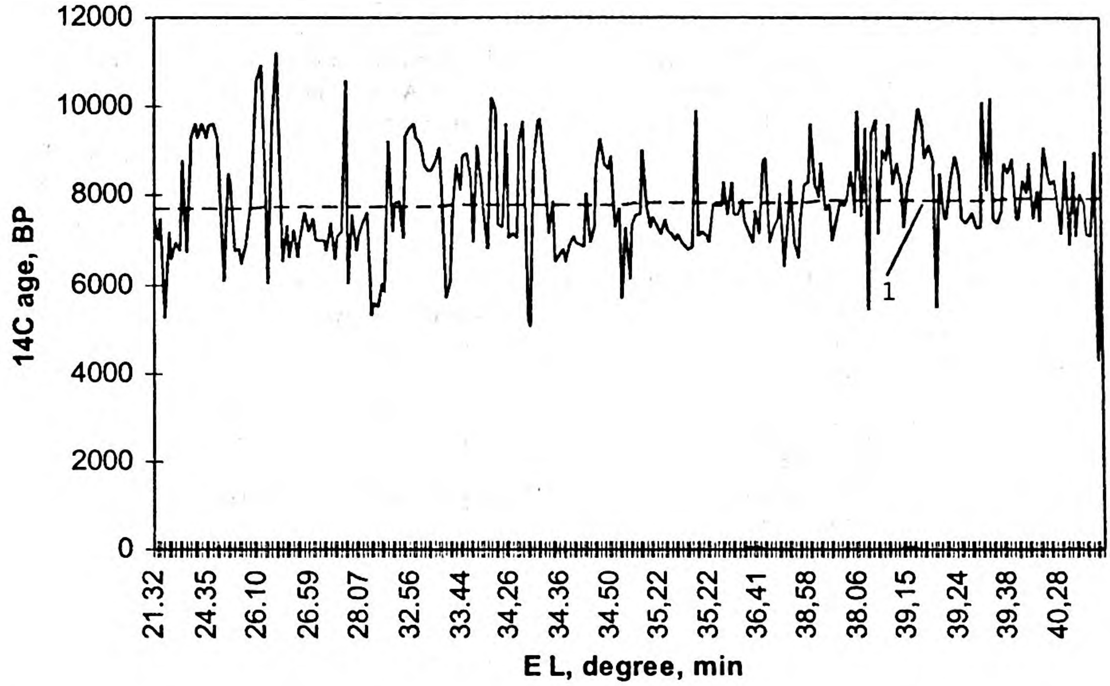

Fig. 6. Distribution of radiocarbon dates of Eastern European Mesolithic sites following the longitudes of the dated sites location. 1 – line of radiocarbon dates trend.

central, northern) are represented at Fig. 3. Some regularities are observable concerns some different periods of duration, concentrations of the largest amounts of the dates in temporal intervals and the dating for the End of Mesolithic in these regions. The radiocarbon dates show coexistence of the Neolithic in the Southern regions and the Mesolithic in the North (Fig. 4). The dates of the Neolithic of Southern part of the Eastern Europe are taken from database created in the Institute for the History of Material culture, Russian Ac. of Sci., St-Petersburg. We considered as the interesting task also to retrace dependence of latitude – longitude positions and the radiocarbon ages of the sites. The graphs were created to show the correlation of ^{14}C ages and values of EL (Fig. 5) and correlation of ^{14}C ages and values of NL (Fig. 6). The possible trends of ^{14}C age to directions S-N and W-E were determined. There are also small trend to decrease of ^{14}C age of dated Mesolithic sites to the direction South – North (Fig. 2) and small trend in distribution of ^{14}C dates to West-East direction which shows some tendency of increase of the Mesolithic sites ^{14}C age to the Eastern direction (Fig. 3). The more detailed conclusions can be done later.

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14C

The Chronolo(g)y of the Neolithisation of Eastern Europe and the position of the South Russian area in this process.

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ABSTRACT

The Radiocarbon datings of the sites from the Steppe and Forest-Steppe zones of Southern Russia demonstrate a very early dating for the Neolithic in the area (the lower layers of Rakushechnyi Yar and the Elshan sites dated to about 8000 BP, uncal.). The numerous datings of Early Neolithic sites in the Eastern European Forest zone are somewhat younger and represent different stages of the Neolithisation of the more Northern areas: in Central Russia pottery appears about 7100—7000 BP at the Early Neolithic sites of the Upper-Volga culture and in the North-Western, Northern Russia as well as in the Eastern Baltic area the sites with the Early pottery are dated to about 6600–6500 BP. The ^{14}C chronology shows that the first pottery in Eastern Europe appeared independently from the influences of the more western centres of early agriculture and probably as the result of diffusion from the cultures of the Steppe and Forest-Steppe zone.

Kee words: *Radiocarbon chronology, Early Neolithic, pottery production, Steppe- and Forest-Steppe zones, Volga basin, Don basin, dispersion of Neolithic, diffusion.*

Introduction

The introduction of the Neolithic in Eastern Europe is in Russian archaeology traditionally connected with the appearance of the first pottery. Food-production appeared in the main part of the area much later than the ceramics. In many territories of the Forest zone it had happened in the Bronze Age or even in the Iron Age.

The radiocarbon chronology of the Eastern European Neolithic has been improved during last two decades. We have now more than 400 datings for the sites of European Russia (Timofeev, Zaitseva, 1996). The main part of them are from the Neolithic cultures of the Forest zone and the work for constructing the chronology of the more southern regions is very urgent.

The Neolithic assemblages in the Steppe and Forest/Steppe zones of Russia were discovered by the field research of T.D. Belanovskaya, L. Ya. Krizhevskaya, V. Ya. Kiyashko and others close to the Azov sea and in the lower Don River basin, by A.T. Sinyuk in the Middle river Don River basin and by I.B. Vasilyev, A.A. Vybornov and others in Lower Volga River basin. An important review of these materials was done by D. Ya. Telegin (Telegin, 1996) in the chapters of the newly published volume "The Neolithic of Northern Eurasia" (1996, ed. S.V. Oshibkina). The dating of the Neolithic in the area has become a topic of prime importance. In this connection the ideas of the outstanding researcher of the Stone Age in the Steppe zone the late prof. V.N. Danilenko (1969) should be mentioned. He considered the Neolithic of the area as very ancient and proposed also, that pottery dispersed from this area to the Early Neolithic cultures situated immediately to the West and to the North.

Discussion

The last years a number of radiocarbon datings of importance for the understanding of the Neolithisation in the area have been obtained from the Forest- Steppe area of the Volga basin. The Early

Table 1
Radiocarbon datings of the Elshan-type Early Neolithic sites.

Lab. Index	^{14}C age, BP	Site	Material for dating
Le-4781	8990±100	Chekalino-IV	Shell
Le-4782	8000±120	Chekalino-IV	Shell
Le-4783	8050±120	Chekalino-IV	Shell
Le-4784	7940±140	Chekalino-IV	Shell
GIN-7085	8680±120	Chekalino-IV	Shell
GIN-7086	7950±130	Chekalino-IV	Shell
GIN-7088	8470±140	Lebyazhinka-IV	shell
Le-2343	8020±90	Ivanovskaya	bone

Neolithic sites were discovered there in 1970's (Vasilyev, Penin, 1977). These sites of the so-called Elshan-type (or of Elshan culture) are mainly excavated in the Samara and Orenburg regions (Vasylyev, Penin, 1977; Vasylyev, Vybornov, 1988; Morgunova, 1980; Mamonov, 1995). The sites yield a flint industry with some Mesolithic traits (including tanged arrowpoints made on blades, of the so-called Episwiderian type) and archaic pointed- bottomed pottery with poor ornamentation. Some authors compare the shape of the Elshan vessels with the early vessels of the Central Asian Neolithic hunters and gatherers (Vasylyev, Vybornov, 1988). During the last years the Lab of the Institute for the History for Material culture, St.-Petersburg, has dated samples from the multilayered site Chekalino IV, excavated by A.E. Mamonov (1995) at the Sok-river, in the Sergiev district of the Samara region. The Elshan materials were discovered in the lower culture layer of the site. Concentrations of "Unio" fresh-water shells were found in this layer (Fig.1). Four samples of shells were dated by ^{14}C Lab of the Institute for the History of Material Culture (Le-index). Three of them produced radiocarbon datings about 8000 BP, and one was even older. A similar dating was obtained by Le on a sample of bones from the other site of Elshan-type: the lower layer of the Ivanovskaya site in the Orenburg region, excavated by N.G. Morgunova (1980, 1988). Similar datings were also produced by the Lab of Geological Institute (GIN, Moscow) on samples from Chekalino IV and from one more site with materials of Elshan-type: Lebyazhinka IV in the Samara region. The main part of the Elshan datings are about 8000 BP or some older. The list of ^{14}C dates for these sites is presented in Table 1.

According to the information published by the author of Chekalino IV about the excavations (Mamonov, 1995) the ^{14}C dates are in good concordance with the pollen-data and the geological investigations done by E.A. Spiridonova and Yu. A. Lavrushin. They date the Elshan layer of Chekalino IV to the Boreal period.

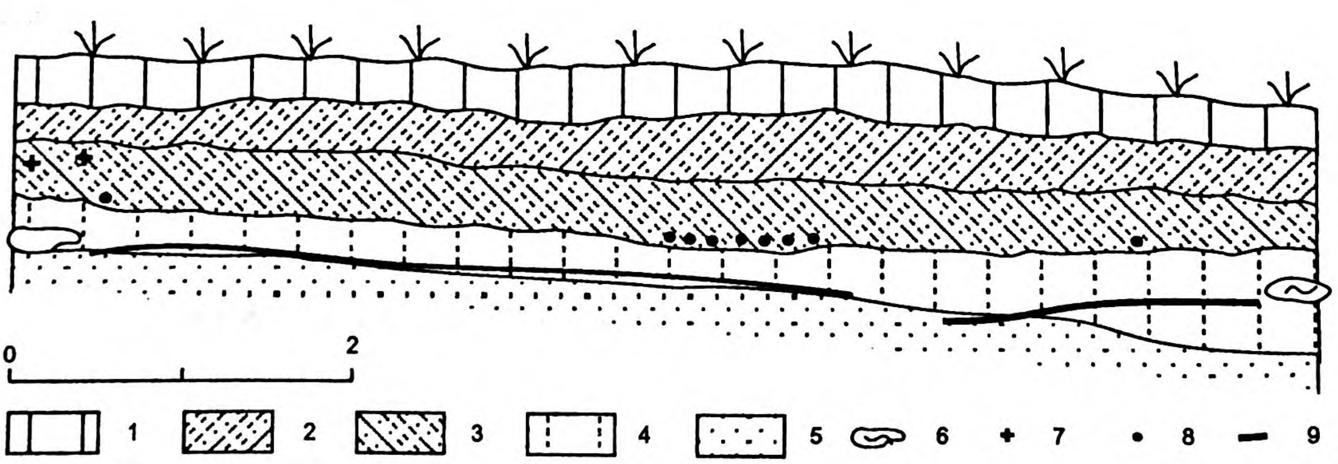

Fig.1. The strarigraphy of the Chekalino IV site.
1- turf, 2-dark-grey humified sandy loam, 3- dark brawn-grey humified sandy loam, 4- light brawn-grey sandy loam, 5- yellow, pale-yellow sandy loam (virgin soil), 6- shells concentration (dated by ^{14}C), 7- finds of Eneolithic, 8- finds of the Late Neolithic, 9- Early Neolithic horizon (after Mamonov (1995) with additions of the samples documentation data).

Table 2

^{14}C datings of the layers of the Rakuschechnyi Yar multilayered site

Number of the position of the dated samples (accordance with Fig.2)	Layers (according to Fig.2)	^{14}C age, BP	Lab. Index	Material for dating
1	XX	7690±110	Ki-6476	Sherds with food crust
		7930±140	Ki-6476	
		7860±130	Ki-6477	
2	XV, XIV-XV	6930±100	Ki-6478	Sherds with food crust
		6825±100	Ki-6479	
		7040±100	Ki-6480	
3	IX	7180±250	Le-5344	Shell
4	VIII	6070±100	Bln-704	Charcoal
5	Under V	6770±450	Le-5481	Bone
6	V	6440±35	Le-5582a	Huminic (cold),
		632035	Le-5582b	Huminic (hot)
		5920±90	Le-5479	Bone
		5890±105	Ki-955	Charcoal
7	IV	5060±230	Le-5340	Bone
		6300±90	Le-5482	Bone
8	III	4360±100	Bln-1177	Charcoal
		5720±180	Le-5480	Bone
9	II	5290±260	Le-5327	Charcoal
		4830±90	Le-5387	Charcoal

The Elshan sites seem to be the earliest manifestations of Neolithic pottery in Eastern Europe. Information about the economy of this culture is almost absent and evidence of food-production is absent. The stone industry and the topography of the sites indicate that the economy was based on hunting, fishing and gathering. The opinion has been expressed that many traits of the Elshan Neolithic excluding the vessels shapes, distinguish it from the southern or south-eastern cultures (Mamonov, 1995). It most be mentioned, that the ^{14}C datings from the Central Asian sites of hunters and food-gatherers (Jebel cave, Uchaschi 131) as well as those from the early food- producers (Jeitun culture of Turkmeniston) are later, than the datings of the Elshan-type materials.

An independent, local origin of the Early pottery in the South-Eastern Russia Forest-Steppe zone, should be considered.

Further important evidence concerning the chronology of the Southern Russia Neolithic has now been obtained for the multilayered settlement Rakushechnyi Yar situated in the lower Don basin (Rostov-on-Don region). The site was excavated in the period 1960–1980's by Dr. T.D. Belanovskaya. More than one thousand square metres was investigated. Detailed stratigraphical studies revealed a succession of 23 separate culture layers and horizons (Belanovskaya, 1995). The lowest layers of the site yielded the material from the local Rakushechnyi Yar culture. The assemblage consist of the Neolithic pottery, flat- and pointed-bottomed, with rather simple ornamentation, the flint industry contain some geometric microliths (trapezes) and tools of bone and antler. The material includes some distinctive elements of food-production. Bones of domesticated animals (cattle and sheep) were found together with bones of the wilds ones (red deer dominating). A series of ^{14}C datings have been produced for the Rakushechnyi Yar layers by the Labs of Le, Ki and Bln. They and are presented in Table 2 (Belanovskaya, Timofeev et al, 1999). The datings of layer XX, one of the lowest, on pottery with preserved food crust, yields an age about 8000-7600 BP and the samples from the upper layers of Rakushechnyi Yar culture (XV, XIV-XV) are about 7000-6800 BP. The datings of the superimposed layers of the Late Rakushechnyi Yar culture and those of the local Eneolithic coincide with the stratigraphical evidence (Fig.2).

The traces of long-distance influences can be recognised in the rich assemblages of the Eneolithic layers of Rakushechnyi Yar (Belanovskaya, 1995). The datings of the Rakushechnyi Yar site can serve as a preliminary basis for the development of a more detailed chronology of the Neolithic and Eneolithic

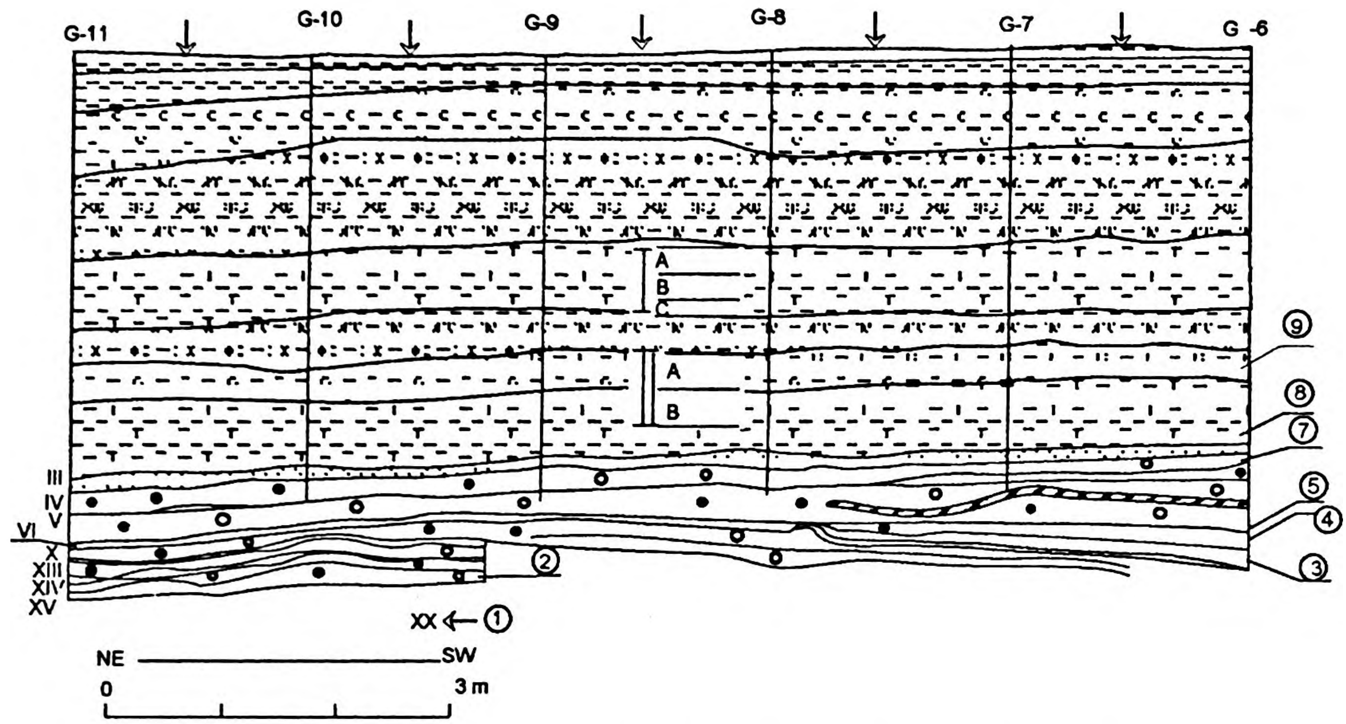

Fig.2. Stratigraphy and the position of the 14C dated samples for the multilayered Rakushechny Yar site.
II- XX – stratigraphical layers (after Belanovskaya, (1995)
1-10 – the position of the dated samples, the NN (III- XX) follow the Table 2.

cultures of a large part of the Eastern European Steppe zone.

Additional evidence exists from another site from the Steppe zone, Matveev Kurgan I in Rostov in the Don region, excavated by L. Ya. Krizhevskaya (1992). There were found traits of food production (including bones of cattle and sheep/goat) and some pieces of badly preserved pottery. The site is dated to 7505±210, 7180±70 (GrN-7199, Le-1217). The ^{14}C datings of the Rakushechnyi Yar's lowest layers, as well as these of Matveev Kurgan I confirms the early appearance of Neolithic culture in the Southern Russian Steppe zone. It should be mentioned, that in the Rakushechnyi Yar under the dated layer XX are three more thin layers, yet undated. The pottery of these layers looks rather developed. It does not look like the first manifestation of ceramic production. There are also a number of datings for Late Neolithic - Eneolithic of the area (Timofeev, Zaitseva, 1997). According to these and to the datings of the Rakushechnyi Yar's upper layers, as well as to the new data for the Ukrainian cemeteries of Mariupol-type (Lillie, 1998), the appearance of the " Eneolithic " elements in the Steppe zone happened not later than 6000 BP, uncal. The chronological position of the more Northern Early Neolithic of the Eastern Europe Forest zone has become clearer during last years (Timofeev, Zaitseva, 1997a). It is clear now that the appearance of the "Forest Neolithic" distinguished by the appearance of the first pottery should not be dated later than 7100–7000 BP. There are about 40 ^{14}C datings for the samples from the Early Neolithic sites of the "Verhnevolzhskaya" (Upper Volgian) culture of the Central Russia area and the earliest of them are from 7200–7000 BP (Op. cit., p.18, Fig. 1). According to these data the first pottery appeared in the Central part of the Eastern European Forest zone before the dispersion of the Linearband pottery in Central Europe. The origin of the first Upper Volgian pottery is connected by the researchers (D.A. Krainov, A.T. Sinyuk, E.L. Kostyleva) to the more southern Early Neolithic culture of the Forest-Steppe zone in the Middle Don area. ^{14}C datings for the Middle Don culture are still absent and the datings of the Elshan sites are the only chronological indications at the moment.

The typological peculiarity of the early pottery in the Steppe and Forest-Steppe zone and the chronological evidence point to an origin of the pottery production that is independent of the more Western centres of the Neolithisation.

Conclusion

The radiocarbon evidence gave a number of authors an opportunity to study the succession and the

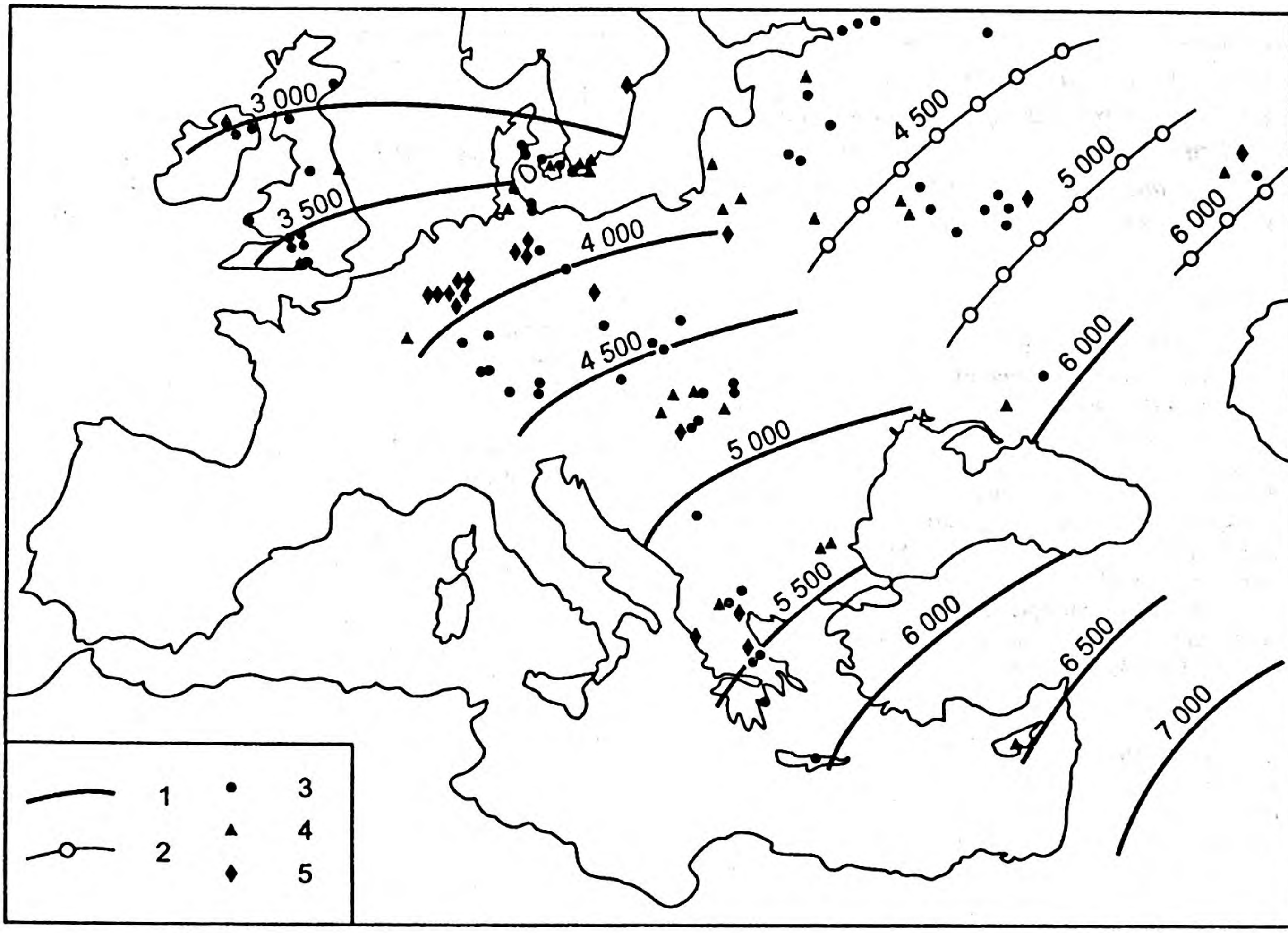

Fig.3. Model of the dispersion of the Neolithic in the main part of Europe, after P. Breunig (1987) with addition of Eastern European data.
1- the chronological boundaries of the area with food-production.
2 - the chronological boundaries for the dispersion of pottery-production in the Forest/Steppe and Forest zones.
3 - sites with datings fitting into the suggested scheme.
4 - sites with datings about 300 ^{14}C-years too young.
5 - sites with datings about 300 ^{14}C- years too old.

chronology of the Neolithisation in the main areas of the Near East and Europe in detail and displayed a quite systematic development from the Earliest position in the Near East to the appearance of the Neolithic in S. Europe (Greece, 7500 BP) and the following dispersion of Neolithic culture to Central Europe about 6700–7000 BP (Clark,1965; Dolukhanov & Timofeev 1972; Breunig et al., 1987). The data which we now have for Eastern Europe allow us to refine the understanding of the Neolithisation in a large area of Eastern Europe. In Fig. 3 we use the model suggested by P. Breunig (1987) to show the parallel process of the dispersion of agriculture to the Greece, Central and NW Europe and the dispersion of the Early pottery production in the Southern part of Eastern Europe and in the Forest zone. It seems as if the ^{14}C datings of the Eastern European Early Neolithic supports an interpretation of the dispersion of pottery in the Forest zone as a result of diffusion. The stone and the bone and antler industries of the Early Neolithic in the Forest zone display many similiarities with the local Late Mesolithic materials where as the first pottery has prototypes in the southern cultures. This was demonstrated in many lectures at the last conference devoted to the introduction of the Neolithic in the area of the former USSR (St-Petersburg, 1990). The archaeological and chronological data from the Southern areas and the typological differences between the earliest dated pottery point to the existence of several centres for the first archaic pottery production in Eastern Europe.

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Chronology of Mariupol type cemeteries and subdivision of the Neolithic – Copper Age Cultures into periods for Ukraine.

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Abstract

In recent years over 200 datings for Neolithic and Copper Age monuments were obtained in Kiev, Oxford and other laboratories. It allowed us to define their age and division into periods more accurately. Basing on these data and taking previous isotope studies into consideration we get the conclusion that, firstly, chronological boundary between Late Mesolithic and beginning of Neolithic age in the area under study is in the middle-beginning of the second half of the 7th millenium BC, secondly, subsequent period up to the beginning of the Early Bronze Age (Pit culture, Corded ware culture) about 3000 years BC is divided into two unequal periods – Neolithic and Neo-Eneolithic. Neolithic (Early Neolithic) period — 6500–5500 BC: this is the period of existence of the Early Neolithic cultures: the Bug-Dniester, Surska, early monuments of Dnieper-Donets community (DDC) as well as the Mariupol type cemeteries of first stage. Linear Pottery culture evolved in the North-West of Ukraine in that period. Neo-eneolithic period — 5500–3000 BC: this is the period of simultaneous evolution of the Neolithic and Eneolithic cultures, the Mariupol type cemeteries from which we began our study appearing, obviously, as early as the very end of the Late Mesolithic period and existed until the A stage of the Neo-Eneolithic period.

Key words: Neolithic, Eneolithic, Bronze Age, archaeological cultures, Ukraine, chronology, radiocarbon dating.

Introduction

The determination of the radiocarbon age of the Mariupol type cemeteries (MTC) is the key problem for the solution of the chronology of Neolithic and Eneolithic monuments in the East European steppe zone. As it generally known, the greater part of the Mariupol type cemeteries is located in the steppe zone of the Dnieper river basin (Nikolskoe, Vilniansk, Vonigsky, Marievka, Lys'a Gora, Yasinovatka, Vasilievka and others). Several similar burial grounds were excavated in the upstream of the Dnieper (Dereivka) and in the Orel' Rivers basin (Osipovka, Hospitalny hill), as well as in the Sea of Azov Littoral (Mariupol) and in the Crimea (Dolinka) (Telegin, 1991). They are also found in the Chir river basin (the Lower Don River region) (Yakovlev, 1901). Judging from the finds of typical Mariupol type adornments, the burial grounds Siezzheie in the Volga river basin (Vasiliev, 1981) as well as some interments in the Northern Caucasus (the Staro-Nizhesteblievskaia village) (Shatalin, 1984) should be assigned to this group of necropolises.

Results

Almost all necropolises of this type located in the Ukrainian steppe zone belong to the Nadporozhsky type of the Dnieper-Donetsk cultural region (DDR) (Telegin&Titova, 1998), whereas the materials from the Siezzheie cemetery served as a basis for recognizing of the Samara culture in the Volga river basin.

The essential feature of the Mariupol type cemeteries is inhumation in supine position with arms straightened and hands near or on the pelvis. The skeletons are usually heavily pressed from the sides; the dead were obviously tightly swaddled or squeezed into narrow holes. The graves contain as individual, double or multiate burials. Collective burial-vaults comprising of several dozen or even more than a hundred graves were also found (Mariupol, Derievka, etc.). The skeletons are usually abundantly covered with red ochre powder. The orientation of bodies varies.

All burial grounds of the Mariupol type are cemeteries. As regards the construction of the graves, there are two types of pits: small rounded-oval and large square multiple tombs.

A rich variety of things were found near both skeletons and the burial site: adornments made of bone, animal teeth, fish, various stones, as well as stone tools, more rarely, bone tools. A large amount of broken pottery and potsherds were also found in some sites of later burial grounds. The ceramic materials are well represented in Nikolskoe and Lys'a Gora cemeteries near the Dnieper River and in Siezzheie burial ground in the Volga river basin. Wide vessels with plain bottoms and characteristic bulges of the rim — "collar" are found most often here.

On a whole the complex of materials from MTC is unique and has no direct analogue. The most characteristic materials for this complex are adornments in a form of various plates cut from wild-boars' tooth enamel. In addition to such adornments, figurines of animals were found in Siezzheie and Mariupol cemeteries.

Based on the stratigraphy of interments (Vilianka, Yasinovatka) one can distinguish two main groups (A and B) in the evolution of MTC which differ in some details of burial customs, composition of finds and correspond to two chronological stages.

The interments of stage A (Vasilievka 2,5; Marievka etc.) were located in oval holes containting from one to 10–11 graves, 2–3 in a row, sometimes on 2–3 levels. Usually the bodies were painted with red ochre, though the holes were filled with dark grey powder. The artefacts in early graves are not numerous — teeth of fish, pendants made from deer teeth and small flint finds — trapeziums, scrapers and from time to time, ring-shaped borers.

The burial grounds of stage B are multiple graves in a form of semi- right-angled pits, comprising, as a rule, of several dozen interments (Mariupol, Nikolskoe, Lys'a Gora, Yasinovatka, Dereivka, etc.). Such pits are filled with red ochre powder. Many finds were found in the pits, such as flint artifacts (knives, scrapers and axes), various adornments, weapons and others. As already noted, a large amount of broken vessels was collected on the sites ofNadporozhie, Lys'a Gora and other late cemeteries as well.

Materials from excavations in the Dnieper river region are the fundamental source for the radiocarbon dating of the MTC and their division into periods. Some cases of the stratigraphy interments of different periods were noted and ceramics imported from other cultures were found on these sites. Over 20 ^{14}C dates were obtained by the Kiev Radiocarbon Laboratory of the State Scientific Centre of Environmental Radiogeochemistry in 1970s–1980s. At that time, the materials of the later stage B in the evolution of these burial grounds were ^{14}C dated, in particular those from Nikolskoe, Yasinovatka, Dereivka and other cemeteries. Radiocarbon age of these monuments lay between the end of the 7th and the middle of the 6th millennum BP, (the 5th –4th millennium BC). These dates of the monuments agree well with an imported Tripolie vessel of Borisov type which is dated to 3250- 3000 (Nikolskoe burial ground).

The foregoing reasoning and conclusions on division of the Dnieper MTC into periods and dating them to the end of the 5th –4th millennia BC became customary in science. Based on these data the Siezzheie burial ground in the Volga river basin and other monuments were dated.

The dating of the B stage MTC mentioned above had been extrapolated to the whole group of these monuments, as well as to the burial grounds of stage A (Vasilievka 2,5 Marievka), for which we had no radiocarbon dates at that time. Such conclusions turned out to be premature.

It became quite obvious recently, after obtaining a new large series of ^{14}C dates for the MTC including 26 dates produced by the Oxford and over 15 dates by the Kiev Radiocarbon laboratories. It was important that all new dates were obtained from human bones, which proved to give more reliable results than samples of coal, shell and other materials dated before.

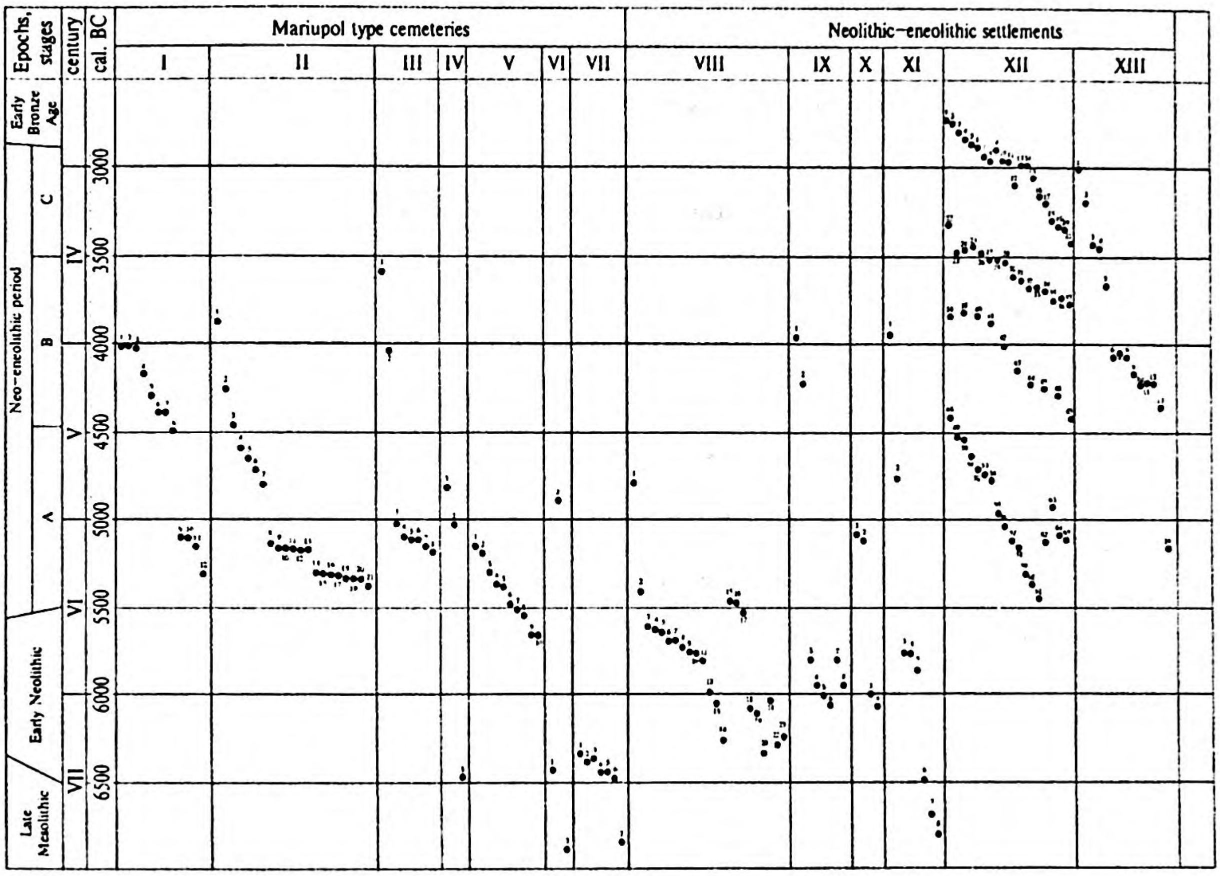

Fig.1. Radiocarbon age of the Mariupol type cemeteries (I-VII) and Neo-Eneolithic settlements (VIII-XIII). (Names of the monuments are given in Table 1)

Thus, to solve the problem of radiocarbon chronology of the MTC we have over 60 radiocarbon dates (Table I), (Fig.1).

According to the data presented the age of most of the sites are between the 5500–4000 BC (Nikolskoe, Yasinovatka, and Dereivka). However, some sites belong to the earlier period — the 7th millennium BC (Vasilievka 2,5 and Marievka).

Let us consider this situation more closely. Typologically later burial grounds (Nikolskoe, Yasinovatka and Derievka) were dated back to 5500–4000 BC. The majority of these interments belong to group B. As mentioned above, the stratigraphy of the interments of these two groups was well traced in Yasinovatka and Vilniansky necropolises, where the older A-type pits were covered by multiple graves of B- type. The radiocarbon data show that the difference in time between the graves of A and B type appears to be rather small in these necropolises. This is attested by radiocarbon dating of the earlier group of MTC, for example, Vasilievka 2 and Marievka necropolises which were dated to the 7th millennium BC, whereas a major part of Vasilievka interments was dated to the middle of the 6th millennium BC.

Thus, taking radiocarbon dates into consideration one can come to recognize that MTC should be dated not to the end of the 5th — first half of the 4th millennia BC as it was suggested before, but to a relatively long period in the 7th–5th millennia BC. So, MTC evolution comprises two main periods — Early-Mariupol (6500–5500 cal BC) and Late-Mariupol (5500–4000 cal BC) ones.

When considering the question of absolute MTC age, judging from available radiocarbon dates, another puzzling circumstance — the lack of any data on creation of the monuments of this type during the period of about 400 years in the middle of the 6th millennium BC was noted. This chronological gap in MTC history still requires explanations. However, it is hard to anticipate that the MTC creators migrated somewhere for this time period and later, judging from the identity of the burial grounds preceding and following this chronological gap, returned to the old places. This fact is likely to be explained by the fact that for the present we have no dates for a number of the already studied burial grounds (Vovniti 1,2, Lys'a Gora, Hospitalny hill, etc.), or, alternatively, the MTC from the end of the 7th–the 5th millennia BC will be found and dated.

Table 1

Radiocarbon age of Mariupol type cemeteries (I-VII) and Neo-Eneolithic settlements (VIII-XIII) assessed from analyses by Kiev (Ki, KIGS), Berlin (Bln), Oxford (OxA), St. Petersburg (Le), California (UCla), Groningan (GrN) and British Museum (BM) laboratories

	Site/ material/position of material in site	Lab. index	^{14}C dates	
			^{14}C age, BP	Intervals of calibrated age, calBC
		I. Nikolskoe		
1.	Skeleton 79a	Ki-3410	5200±30	4016±45
2.	Skeleton 115	Ki-3284	5200±170	4012±195
3.	Pit 3	Ki-3158	5230±40	4027±65
4.	Skeleton 105	Ki-5159	5340±30	4169±68
5.	Skeleton 125	Ki-3283	5460±40	4292±44
6.	Skeleton 1	Ki-3575	5560±30	4390±38
7.	Pit 3	Ki-3125	5560±30	4390±38
8.	Skeleton	Ki-523	5640±400	4492±446
9.	Skeleton 137	OXA-5052	6145±70	5099±96
10.	Skeleton 125	Ki-6603	6160±70	5104±92
11.	Skeleton 94	OXA-6226	6220±75	5153±92
12.	Skeleton 125	OXA-5029	6300±80	5308±109
		II. Yasinovatka		
13.	Skeleton 63,64	Ki-2810	5100±40	3876±63
14.	Skeleton 65	Ki-3580	5390±55	4257±71
15.	Skeleton 36	Ki-1171	5650±70	4461±83
16.	Skeleton 160	Ki-3160	5730±40	4591±71
17.	Skeleton 35	Ki-3162	5810±60	4652±84
18.	Skeleton 39	Ki-6790	5860±75	4714±101
19.	Skeleton 18	Ki-3032	5900±90	4799±116
20.	Skeleton 34	Ki-6786	6195±80	5134±96
21.	Skeleton 41	Ki-6785	6240±95	5162±111
22.	Skeleton 47, 65	Ki-3033	6240±100	5161±116
23.	Skeleton 90	Ki-6786	6245±70	5166±91
24.	Skeleton 18	OXA-6167	6255±65	5175±90
25.	Skeleton 36	OXA-5057	6260±80	5171±103
26.	Skeleton 21	Ki-6789	6295±70	5302±104
27.	Skeleton 45	Ki-6791	6305±80	5307±104
28.	Skeleton 19	Ki-6788	6310±85	5312±104
29.	Skeleton 64	OXA-5030	6330±90	5317±95
30.	Skeleton 17	OXA-6166	6360±75	5335±72
31.	Skeleton 45	OXA-6164	6360±75	5335±72
32.	Skeleton 19	OXA-6165	6370±60	5338±62
33.	Skeleton 5	OXA-6163	6465±60	5380±61
		III. Derievka		
34	Skeleton 11	Ki-3135	4820±40	3591±56
35	Skeleton 41, 42, 43	Ki-2177	5190±90	4038±127
36	Skeleton 109	OXA-5031	6110±12	5023±49

Continuation Table 1

	Site/ material/position of material in site	Lab. index	^{14}C dates	
			^{14}C age, BP	Intervals of calibrated age, calBC
37	Skeleton 11	Ki-6728	6145±55	5098±86
38	Skeleton 49	OXA-6160	6165±55	5113±79
39	Skeleton 73	OXA-6162	6175±60	5112±81
40	Skeleton 42	OXA-6159	6220±60	5151±82
41	Skeleton 84	OXA-6161	6270±110	5183±132
		IV. Osipovka		
42	Skeleton 53	Ki-519	5940±20	4816±35
43	Skeleton 93	Ki-517	6075±125	5027±162
44	Skeleton 20	OXA-6168	7675±70	6470±60
		V. Vasilievka 5		
45	Skeleton 29	Ki-6776	6220±60	5151±82
46	Skeleton 29	OXA-6198	6280±70	5189±103
47	Skeleton 26	Ki-6775	6325±65	5299±80
48	Skeleton 8	Ki-6777	6430±50	5369±50
49	Skeleton 8	OXA-6171	6470±70	5384±70
50	Skeleton 23	Ki-6771	6530±70	5481±68
51	Skeleton 10	Ki-6772	6620±80	5513±56
52	Skeleton 80	Ki-6773	6675±65	5547±49
53	Skeleton 20	OXA-6268	6810±90	5656±75
54	Skeleton 10	OXA-6172	6835±60	5658±54
		VI. Vasilievka 2		
55	Skeleton	OXA-3895	7620±80	6430±76
56	Skeleton	OXA-3804	6005±35	4889±51
57	Skeleton	OXA-3806	8020±90	6886±144
		VII. Marievka		
58	Skeleton 10	Ki-6779	7550±80	6338±85
59	Skeleton 10	Ki-6781	7585±80	6385±84
60	Skeleton 14	Ki-6780	7600±100	6365±105
61	Skeleton 10	OXA-6200	7620±100	6444±104
62	Skeleton 14	OXA-6269	7630±110	6441±114
63	Skeleton 4	Ki-6782	7680±90	6479±77
64	Skeleton 4	OXA-6199	7955±50	6843±121
		VIII. Bug-Dniester culture		
65	Pugach 2	Ki-3030	5920±61	4790±80
66	Soroki 5	Bln-589	6495±100	5409±89
67	Pugach 2	Ki-6648	6740±65	5609±54
68	Pugach 2	Ki-6649	6780±60	5627±44
69	Pugach 2	Ki-6657	6810±60	5644±47
70	Soroki 2	Bln-586	6825±150	5693±134
71	Gard 3	Ki-6650	6865±50	5690±53
72	Pugach 2	Ki-6656	6895±50	5728±57

Continuation Table 1

	Site/ material/position of material in site	Lab. index	^{14}C dates	
			^{14}C age, BP	Intervals of calibrated age, calBC
73	Savran	Ki-6653	6920±70	5755±80
74	Gard 3	Ki-6655	6930±55	5761±68
75	Savran	Ki-6654	6985±60	5806±77
76	Bazkov ostrov	Ki-6652	7160±55	5986±47
77	Bazkov ostrov	Ki-6651	7235±60	6050±64
78	Soroki 2	Bln-587	7420±80	6262±92
79	Pugach-2	Ki-6678	6520±60	5465±62
80	Pugach-2	Ki-6679	6560±50	5473±41
81	Gard 3	Ki-6687	6640±50	5531±41
82	Pechera	Ki-6692	7260±65	6078±64
83	Pechera	Ki-6693	7305±50	6108±53
84	Zan'kovtsi	Ki-6694	7540±65	6336±76
85	Bazkov ostrov	Ki-6696	7215±55	6033±61
86	Sokol'tsy II	Ki-6697	7470±60	6287±68
87	Sokol'tsy II	Ki-6698	7405±55	6242±81
		IX. Surska culture		
88	Stril'chaia skela	Ki-2973	5160±70	3961±111
89	Stril'chaia skela	Ki-2948	5365±70	4224±94
90	Isl. Surskoi	Ki-6688	6980±65	5802±80
91	Isl. Surskoi	Ki-6989	7125±60	5946±60
92	Isl. Surskoi	Ki-6690	7195±55	6005±54
93	Isl. Surskoi	Ki-6691	7245±60	6061±64
94	Semenivka	Ki-6688	6980±65	5802±80
95	Semenivka	Ki-6689	7125±60	5946±60
		X. Dnieper-Donetsk culture (Kamennaya mogila)		
96	Horizon	Ki-4023	6120±80	5083±112
97	Horizon 15	Ki-4024	6180±90	5118±106
98	Horizon 15	Ki-4226	7170±70	5998±70
99	Horizon 15	Ki-4022	7250±95	6068±84
		XI. Rakuschechny Yar		
100	Layer 4	Ki-3545	5150±70	3946±110
101	Layer 5	Ki-955	5890±105	4764±138
102	Layer 14-15	Ki-6479	6925±110	5762±110
103	Layer 15	Ki-6478	6930±100	5767±103
104	Layer 15	Ki-6480	7040±100	5861±98
105	Layer 20	Ki-6475	7690±110	6489±102
106	Layer 20	Ki-6477	7860±130	6688±191
107	Layer 20	Ki-6476	7930±140	6801±188

Continuation Table 1

	Site/ material/position of material in site	Lab. index	^{14}C dates	
			^{14}C age, BP	Intervals of calibrated age, calBC
		XII. Tripolie A culture		
108	Chervony khutor (p.6), CII	Ki-5016	4140±110	2720±144
109	Chervony khutor (p.98), CII	Ki-5039	4160±90	2742±123
110	Zavalivka (10)	Ki-5014	4230±80	2790±110
111	Soficvka, CII	Ki-5013	4270±90	2830±144
112	Chervony khutor (p.2), CII	Ki-5038	4280±110	2859±170
113	Zavalivka (p.6) , CII	Ki-5015	4290±90	2877±146
114	Sofievka	Ki-5029	4300±45	2928±59
115	Sofievka (p.1), CII	Ki-5012	4320±70	2954±87
116	Shkarivka, B1B2	Ki-201	4320±170	2889±268
117	Usatovo, CII	UCLA-1642A	4330±60	2952±68
118	Maiaki, CII	Le-645	4340±60	2957±67
119	Varvarovka, CI	Ki-601	4370±180	3091±262
120	Maiaki, CII	UCLA-1642G	4375±60	2977±76
121	Maiaki, CII	UCLA-1642B	4376±60	2977±76
122	Maiaki, CII	Bln-629	4400±100	3049±159
123	Maiaki, CII	KIGN-281	4475±130	3154±180
124	Gorodsk, CII	GrN-5099	4551±35	3195±96
125	Maiaki, CII	KIGN-282	4580±120	3292±189
126	Maidanetskoe, CI	Ki-1212	4600±80	3326±163
127	Danku 2, CII	Le-1054	4600±60	3341±152
128	Gorodnytsia-Gorodyshche, CII	GrN-5088	4615±35	3420±73
129	Shkarovka, B1B2	Ki-881	4620±100	3327±177
130	Maiaki, CII	Ki-870	4670±100	3484±135
131	Shkarovka, B1B2	Ki-877	4690±80	3469±106
132	Shkarovka, B1B2	Ki-879	4710±30	3450±77
133	Shkarovka, B1	Ki-1204	4700±90	3485±112
134	Evminka-1, CI	UCLA-1466B	4790±100	3525±121
135	Soroki-Ozero, CI	BM-494	4792±105	3525±126
136	Chapaievka, BII	Ki-880	4810±140	3540±164
137	Shkarovka, B1B2	Ki-875	4840±95	3620±113
138	Chapaievka, B2	Bln-631	4870±100	3642±119
139	Evminka-1, CI	UCLA-1671B	4890±60	3687±55
140	Maidanetskoe, CI	Bln-2087	4890±50	3679±43
141	Novo-Rozanivka 2, CI	UCLA-1642F	4904±300	3702±363
142	Soroki-Ozero, CI	BM-495	4940±105	3756±120
143	Shkarovka, B1B2	Ki-2088	4940±95	3741±108
144	Varvarovka 15, CI	Bln-2480	4990±60	3776±89

Continuation Table 1

	Site/ material/position of material in site	Lab. index	^{14}C dates	
			^{14}C age, BP	Intervals of calibrated age, calBC
145	Brinzeni 4	Bln-2430	5020±60	3838±83
146	Shkarovka, B1	Ki-520	5015±105	3815±111
147	Putineshti, B1	Ki-613	5060±120	3836±128
148	Klishchiv yar, B1B2	Le-1060	5100±50	3876±67
149	Tsypleshti, BII	Bln-2431	5165±50	4006±71
150	Krasnostavka, B1	Ki-882	5310±160	4144±167
151	Brinzeni 8, BII	Bln-2429	5360±65	4224±93
152	Stari Kukoneshty, B1	Bln-2428	5390±60	4247±75
153	Polivaniv Yar, B1	GrN-5134	5440±70	4287±74
154	Putineshti, B1	Bln-2447	5595±80	4419±75
155	Ruseshti	Bln-590	5565±100	4415±95
156	Rogozhany	Bln-2426	5700±55	4526±73
157	Timkove	Bln-3191	5700±70	4541±89
158	Grenivka	Ki-6682	5800±50	4636±74
159	Luka Vrublivetska	Ki-6685	5845±50	4711±73
160	Grenivka	Ki-6683	5860±45	4739±56
161	Luka Vrublivetska	Ki-6684	5905±60	4774±76
162	Sobatinovka 2	Ki-6680	6075±60	4962±99
163	Sobatinovka 2	Ki-6737	6100±55	5035±106
164	Voronovitsy	Ki-6677	6180±60	5119±80
165	Korman'	Ki-6225	6225±60	5156±83
166	Okopi	Ki-6671	6330±65	5309±78
167	Bernashovka	Ki-6670	6440±60	5367±56
168	Bernashovka	Ki-6681	6510±55	5450±65
169	Babshin	Ki-6656	6200±55	5126±76
170	Grebenyukuv yar	Ki-6672	6040±65	4925±89
171	Grebenyukuv yar	Ki-6673	6120±50	5086±95
172	Grebenyukuv yar	Ki-6165	6165±55	5113±79
		XIII. Srendy Stog culture		
173	Petrovska balka	Ki-2979	4410±50	3003±83
174	Petrovska balka	Ki-2931	4530±40	3194±93
175	Petrovska balka	Ki-2930	4670±50	3433±70
176	Petrovska balka	Ki-2981	4670±80	3455±113
177	Dereivka settlement	Ucla-1671	4900±100	3665±122
178	Dereivka settlement	Ki-2197	5230±95	4070±116
179	Dereivka settlement	Ki-6965	5210±70	4046±92
180	Dereivka settlement	Ki-6964	5260±75	4071±98
181	Dereivka settlement	Ki-6960	5330±60	4164±88
182	Dereivka settlement	Ki-6966	5370±70	4229±92
183	Dereivka burial ground	OxA-5030	5380±90	4216±106
184	Dereivka settlement	Ki-2193	5400±100	4221±114
185	Dereivka settlement	Ucla-14660	5515±90	4357±88
186	Dereivka settlement	Ki-2195	6240±100	5161±116

Methodological aspects of the radiocarbon dating of the wood and fossil bone samples

Samples of wood and bone from various archaeological monuments described in this work are noted for their high degree of bio-deterioration. Such material presents difficulties for traditional methods of primary chemical treatment. Cellulose as well as collagen with a high degree of bio-deterioration are highly soluble even in low concentration of muriatic acid. For small amounts of samples which were analyzed, even 20% losses of radiocarbon dating fraction are undesirable. The method of highly selective elimination of introduced organic matter from wood and bone samples which was devised in our laboratory, allows dating even in very complicated cases. We use a 2% solution of hydrofluoric acid. A significant advantage of hydrofluoric acid is its ability to dissolve silicates and humic acids and products of the vital functions of bacteria absorbed on to them. Moreover this acid practically does not dissolve collagen or highly deteriorated cellulose. A sample treated in this way is characterized by a minimal amount of introduced organic matter. The fact that calcium carbonate and calcium phosphate do not dissolve in the process of elimination of introduced organic matter, but transform into insoluble fluoride is of great importance for analysis of bone samples. In this case even highly deteriorated molecules of collagen remain in the original non-organic matrix and are not sacrificed. The combination of such a preliminary chemical treatment with obtaining lithium carbide by the technique of direct chemisorption of carbonaceous gases into a lithium alloy produced by the controlled thermal degradation of organic material under vacuum — "vacuum pyrolysis" allowed us to obtain benzene from the most complicated samples from the archaeological monuments being studied.

The highly effective micro-vials developed in our laboratory played an important part in increasing the accuracy of physical measurement. These micro-vials are characterised by an unprecedented combination of useful characteristics. For example, the background count of 1 ml of benzene on Quantulus-1220 m is 0.11 CPM with efficiency of 85%.

Anthropologic analysis of ancient Neolithic cultures of Ukraine

The study of anthropologic materials from MTC and DDR is very important for understanding of the ancient history of Ukraine. Comparative analysis of these materials with craniologic series of the adjoining areas of Europe, Asia and Northern Africa has shown that the Neolithic population of the Dnieper-Donetsk ethnic cultural community falls into Proto-European type of large Europeoid race. Let us note that the quantity of anthropologic finds is quite considerable compared to other series from the Neolithic in Europe; it comprises of over 300 restored crania and of even more postcranial parts of skeletons.

Analysis of these sources allows us to determine not only the anthropologic type of our predecessors, but to make sculptural reconstructions of their faces. The Dnieper-Donetsk population as a whole was tall with massive hypermorphic skeletons, very wide faces, which often exceeded the world maximum of bizygomatic breadth (up to 166 mm). Brachycrany (73,6 mm) and low or very low orbits (orbital index –71,8) enhanced the special appearance of this people (Table 2).

It is interesting and important to outline that the anthropologic composition of the DDR population was not unchangeable over the centuries. It was subjected to epochal changes as well as to various influences of other cultures. Two variants of this type were distinguished (Potekhina, 1999). The first is characterized by dolichocrany, a very large cranial length and height, and moderate cranial breadth. The faces are wide (143,5-147,5 mm), medium-high, and well profiled. The orbits are very low, the nose is medium wide, very extended with a high bridge. The second type is characterized by mesocrany, large cranial breadth. The face is exclusively wide (149-159 mm), with weakened horizontal profiling on the orbital level. The orbits are very low, the nose is medium wide, extended and the bridge of the nose is high.

Based on the stratigraphical observations and radiocarbon dates, it was found that the first anthropologic type was characteristic for early interments in oval pits (Type A), the second one — for square multiple graves completely filled with red ochre (Type B).

It must be emphasised that according to anthropologic features, people from MTC differed considerably from their neighbours, in particular: the Tripolie, Sredny Stog and Kemi-Oba people. These data are of considerable importance in the study of questions of ethnic composition of the ancient population of Ukraine and division of their history into periods. We will now to examine these questions more closely.

Table 2

Comparison of male craniological series from burial grounds of Neolithic and Eneolithic cultures of Southeastern Europe (MTC, DDR – Mariupol type cemeteries of Dnieper-Donets community; SSC – Sredny Stog II culture)

N	Features	MTC DDR (mm)	SSC (mm)	New Danilovka type (mm)	Trypolie culture (mm)	Kemi-Oba culture (mm)
1	Cranial length	193,1/165/	195,0/15/	194,2/5/	183,4/5/	194,7/7/
8	Cranial breadth	144/176/	142,1/15/	145,0/5/	132,6/5/	138,0/8/
8:1	Cranial index	74/91/	72,8/15/	74,4/5/	72,3/5/(mm)	70,0/7/
45	Bizygomatic breadth	146,5/91/	139,5/10/	147,0/4/	127,8/4/	130,2/5/
48	Nasion-alveolar height	73,6/87/	70,3/12/	69,5/2/	69,0/2/	73,2/4/
48:45	Upper facial index	50,2/74/	50,2/10/	47,4/2/	52,1/2/	56,7/4/
52:51	Orbital index	71,8/95/	73,2/12/	74,9/4/	74,0/4/	77.8/4/
54:55	Nasal index	49,2/83/	49,3/10/	49,5/2/	50,2/2/	48,3/4/
77	Nasomalar angle	139,6/87/	140,3/10/	141,2/3/	137,0/3/	132,6/3/
	Zygomaxillary angle	127,1/68/	127,2/10/	134,5/2/	123,1/2/	114,5/2/

The question of assigning a culture to certain historic periods is not, of course, a new one. The problem of division of Neolithic and Mesolithic cultures into periods was raised earlier as well (Telegin, 1993). This question is discussed in the general work "Archaeology of Ukrainian SSR" written by a body of authors (Archaeology of Ukrainian SSR, 1985). A discussion on time of transfer from the Mesolithic up to the Neolithic periods in the Dnieper river basin arose again quite recently (Jacobs, 1993; Potekhina &Telegin, 1997; Telegin, 1992). The MTC dates discussed above as well as the series of calibrated determinations of settlements obtained in the last few years allow us to turn our attention to this problem again. It is worth mentioning that settlement materials are of primary importance for the formulation of the problem of division of cultures into periods because in this case we obtain many data on the level of economic development of a particular community, major forms of economy, etc. This is essential, for example, for solving the problems of transfer from Mesolithic to Neolithic period. It is connected with the so-called "Neolithic revolution" as well as the determination of the beginning of the Copper-Bronze Age.

Discussion

Division of Neolithic and Eneolithic cultures on the territory of Ukraine into periods.

The question of the beginning and development of a productive economy in Ukraine in the primitive epoch is comparatively well studied for many cultures, including Linear Pottery, Bug-Dniester, Surska, Dnieper-Donetsk and other cultures. Many articles are published on the problem of when animal domestication took place and their species composition (Palkin, 1970; Formozov, 1972; Krainov, 1957; Telegin, 1977; Bibikova, 1963). By studying faunal remains, it is recognized that the availability of domesticated bulls and pigs was characteristic for the most ancient periods of the aforesaid Neolithic cultures in Ukraine and Moldova, and in addition for the Linear Pottery culture — sheep and goat.

Sheep are in the list of the fauna found in the Neolithic horizons of Rakushechny Yar near the Don River (Belanovskaya, 1995).

Along with breeding of domestic animals the Bug-Dniester, Liner Pottery and Dnieper-Donets cultures practised agriculture. It is known that the population of these cultures cultivated several species of wheat, barley, millet, oats, vetch and rye (Pnushevich & Markevich, 1970; Kulczycka-Lieciejewicz, 1979; Okhrimenko, 1993).

Among the recent publications on the determination of radiocarbon age of these cultures' monuments in Ukraine, mention should be made of a number of joint publications by Dr. N.N.Kovaliukh, the Head of Kiev Radiocarbon Laboratory, and archaeologists M.Yu.Videiko, N.B. Burdo and others. Over 20 dates were obtained, for example, for the Bug-Dniester culture (Videiko, Kovaliukh, 1998), 8 dates for Surska monuments (Kovaliukh, Tuboltsev, 1998) and about 20 dates for the Early Tripolie culture (Burdo, Kovaliukh, 1998). Analyses for Tripolie B and C stages, a number of monuments of Sredny

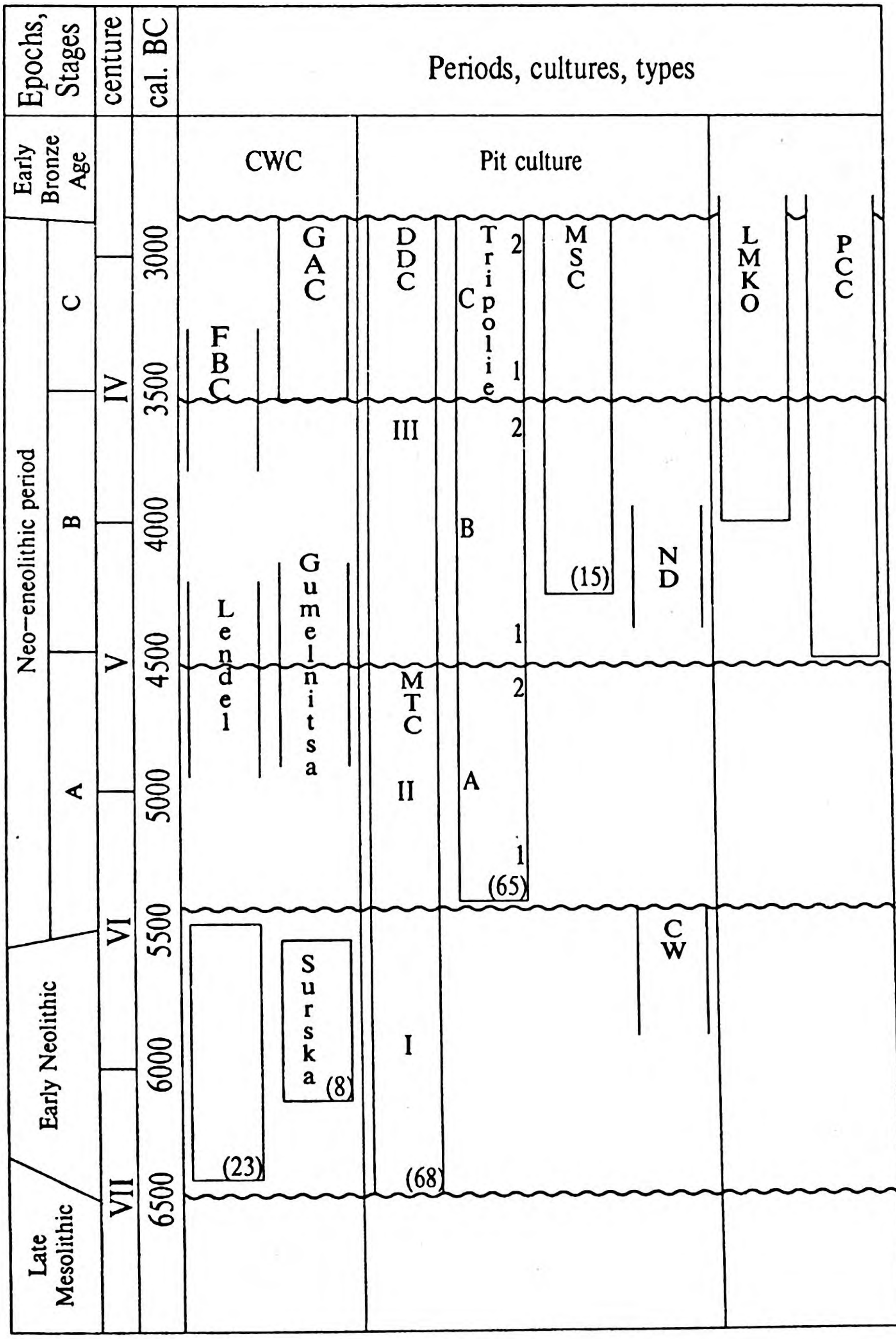

Fig. 2. Periods and stages in development of the Neolithic and the Eneolithic cultures for Ukraine. Cultures: FBC – Funnel Beaker culture; CWC – Corded Ware culture; GAC – Globular Amphora culture; LMKO – Lower-Mykhailivka-Kemi-Oba; PCC – Pitted-Comb culture; DDC – Dnieper-Donets community; MSC – Sredny Stog II culture; ND –Novodanylivka type; BDC –Bug-Dniester culture; MC – Mountain Crimea culture; MTC – Mariupol Type cemeteries. The quantity of radiocarbon dates is shown in brackets.

Stog II culture and Kamenna Mohila multi-layered settlements near the Sea of Azov and Rakushechny Yar near the Don River (Belanovskaia, 1995) were performed in this and other laboratories.

At present we have about 200 radiocarbon dates for the dating and subdivision of the Neolithic and the Eneolithic monuments of this region into periods. About 100 of the dates were obtained from samples from settlements (Table 1).

The general analysis of these studies and the results of the research conducted by other authors (Movsha, 1984; Telegin, 1985; Burdo, Videiko, 1998; Chernysh, 1982) made it possible to clarify certain questions on the chronology of the Post-Mesolithic cultures in Ukraine and to divide them into periods. Based on the settlement materials, it is estimated now that the chronological border between the Mesolithic and Neolithic stages should be placed around 6500 BC , when the first Neolithic cultures had cropped up in the South of Ukraine. The period from 6500-3000 BC may be divided, in our opinion, into two cultural-historic periods: Neolithic (Early Neolithic) and Neo-Eneolithic (Nen). The latter comprises of three sub-periods or stages: Nen-A, Early-Tripolie - Late-Mariupol; Nen-B, Middle-Tripolie - Sredny Stog and Nen-C, Late-Tripolie - Lower-Mykhailivka (Figure 2).

Data on the evolution of material culture of the tribes and periodic ethnic-cultural changes in their composition are used as a basic guideline in the aforementioned division into stages of the historic process of the area under study. As the names of the stages suggest, this division is based on the materials of well-known Neolithic and Eneolithic cultures, such as Tripolie, DDR, Sredny Stog II and others, whose monuments had been developed over about a thousand years or even much longer.

I. Neolithic period (6500–5500 cal BC) begins with the appearance of the Bug-Dniester culture in the North-Western Black Sea Littoral and the Surska culture in the Lower Dnieper area (Archaeology of Ukrainian SSR, 1985). Based on the radiocarbon dates, early stage Mariupol cemeteries (Vasilievka 2 and Marievka) as well as early horizons of the Rakushechny Yar sites in the Lower Don river area and, probably, the monuments of Kaia-Arsy type in the Crimea are dated back to this period.

These cultures developed on the local Mesolithic sub-basis. However they also were subjected to external influence from the South-West and the South as evidenced, for example, by the close cultural contacts of the Bug-Dniester culture with the Krish-Starchevska culture in the Balkans (Gorsdorf & Bajadzier, 1996), as well as the appearance of a considerable amount of stone vessels in the Surska settlements in the Lower Dnieper area which are characteristic for the Neolithic stage in Asia Minor.

In addition to the aforesaid ethnic-cultural phenomenon, mention should be made of the spread of the original Linear Pottery culture (LPC) in the Volyn' and Podolie regions in the Early Neolithic period. The carriers of this culture migrated here through Poland from Central Europe. It was a comparatively highly developed agricultural-cattle-breeding culture, which evolved in this area for 500 years (Archaeology of Ukrainian SSR, 1985).

It is necessary to say that even in the Early Neolithic period the population of Ukraine was not anthropologically uniform. As we stated above, the DDR carriers as judged from MTC materials, were the descendants of Proto-European hypermorphic population whereas the LPC tribes belonged to graceful Mediterranean type.

Development of the Bug-Dniester culture emerged about 6500 BC, continued for about a thousand years — to the middle of the 6th millennium BC (5500), when the area occupied by its carriers was invaded by Early-Tripolie tribes. At about the same time the Surska culture had ceased to exist in the Lower Dnieper area and the Sea of Azov Littoral; it was substituted by the Nadporozhie DDR culture.

II. Neo-Eneolithic period (5500–3000/2800 years BC). Owing to the aforesaid events, namely, the appearance of Eneolithic tribes on the right bank of the Dnieper — Tripolie and then Gumelnitska and Lendelska as well as expansion of Late-Mariupol DDR burial grounds, the Early Neolithic period gave place to the Neo-Eneolithic one, i.e. the period of simultaneous existence of Neolithic and Copper Age cultures. It lasted over two thousand years and was divided into three stages — Nen-A, Nen-B and Nen-C.

Stage Nen-A — Early-Tripolie — Late Mariupol (5500–4400 years BC). There is a great body of literature on the economy and material culture of Tripolie tribes and DDC carriers which were also MTC carriers (Archaeology of Ukrainian SSR, 1985; Chernysh, 1982; Telegin & Titova, 1998). That is why we shall not consider these problems here. It is significant that the Tripolie people had well-developed hoe agriculture and practised cattle-breeding. They used copper and gold whereas DDR tribes were hunters and fishers, though they also bred cattle. The carriers of these cultures differed anthropologically clearly from each other. While DDR people belonged to massive hypermorphic type of large Europeoid race, Tripolie people were shorter and graceful. On a whole, they belonged as LPC carriers, to the western branch of the Mediterranean race. As it is seen from Table 2, the width of their faces (bizygomatic breadth) was only 127,8 mm, nasion-alveolar height — 69,0 mm, orbital index — 74,0 mm, upper facial index — 52,1mm. These sizes and indexes are different for the DDR population (Table 2).

Whilst the carriers of Tripolie and Dnieper-Donets cultures were in various stages of historic development, were of different origin and varied anthropologically, they nevertheless, as had been mentioned, had close cultural contacts. This period in Ukrainian history up to the beginning of the second half of the 5[th] millennium BC was characterized by a certain stability in ethnic-cultural relations. This was the period of flowering of the cultures of Dnieper-Donets community with combed-stroke ceramics, mass appearance of late MTC (Nikolskoe, Mariupol, Dereivka and others) and Early Tripolie monuments. This Nen-A stage lasted for about a thousand years. It ended owing to the appearance of the Sredny Stog II culture and the expiration of MTC in the Podnieprovie region. This event was concurrent with transfer of the Tripolie culture from its early stage to the middle stage.

Stage Nen-B, Middle-Tripolie — Sredny Stog II (4400-3500 years BC). This period is characterized by the prevalence of two Eneolithic cultures in the South of Ukraine — Tripolie of B-C1 stage and Sredny Stog II of Pre-Derievka and Derievka stages (Telegin, 1973). Tribes of Lendelska and Gumelnitska cultures inhabited the territory of Livoberezhna Ukraine. They came here in the end of the previous stage. Forest-steppe Levoberezhie, Volyn', the Middle and Upper Dnieper areas adjacent to those inhabited by Tripolie people were populated, as in earlier periods, by numerous tribes of DDR cultures such as Donetsk, Kyiv-Cherkassy, Volyn' and others (Telegin &Titova, 1998).

An important event in the history of population at this stage was the appearance of Neolithic tribes of pitted-comb culture (PCC) in the North-East of Ukraine. Analogues of this culture were found in the Volga-Oka Rivers area (Archaeology of Ukrainian SSR, 1985).

The appearance of new ethnic-cultural formations in Ukraine at Nen-B stage considerably increased the diversity in composition of the population, which differed in cultural level, religion and anthropologically.

As indicated above, Tripolie people were chiefly agriculturists. The population of Gumelnitska and Lendelska cultures was close to them by their cultural level and occupations. They were of Western and South-Western origin too. Sredny Stog II, DDR and PCC tribes belonged to quite a different world. As a whole they noticeably lagged behind Tripolie people and other agriculturists of the Pravoberezhna Ukraine on a cultural level. Sredny Stog II people were steppe cattle-breeders. They used pointed-bottom vessels, house-building was poorly developed, plastic art was imperfect. But Sredny Stog II people were on a much higher level by armament standards than Tripolie tribes. They made an important impact on the development of world civilization by domesticating and saddling the horse. Unlike Tripolie people and Sredny Stog II, DDR and PCC tribes were hunters and fishers though the carriers of DDR, as already noted, kept domestic animals and cultured crops (barley and wheat), while for PCC carriers it is not characteristic at all.

As in the previous period the anthropologic composition was very heterogeneous. Tripolie people, as stated above, belonged to Mediterranean race, DDR carriers were hypermorphic Europeoids. According to craniologic data, the PCC people having also "softened mongoloid" features, called laponondic, were close to them. As for the Sredny Stog II people's, scull parameters (bizygomatic breadth, orbital index, etc.) occupied an intermediate position, i.e. they were slightly more massive than Tripolie people and notably more graceful then DDR people (Table 2).

Judging from funerary customs, the population of Ukraine of the Nen-B stage differed noticeably in their religious views in early as well as in late Neo-Eneolithic periods. As discussed earlier, DDR carriers buried their dead in supine position. PCC tribes had similar funerary customs. However, the Sredny Stog and Tripolie peoples buried their dead in flexed position with the only difference that in the first case the dead were laid on the back and in the one side with hands near the face — in the so-called position of adoration.

In oder to again a complete understanding of the ethnic-cultural composition of the B-stage population of Ukraine, a number of other cultural types of that time should be also mentioned. We think of the monuments of the Copper Age of the Southern steppe area of Ukraine which belonged to the Novodanilivka and the Post-Mariupol types (Archaeology of Ukrainian SSR, 1985). Unfortunately, there are practically no radiocarbon data for dating these monuments. Their connection with the B stage was assessed by synchronizing these monuments with those of Tripolie or SSC by availability of cultural relations, imported ceramics, etc.

Nen-C stage, Late-Tripolie - Lower-Mykhailivska (3500-2800 years BC). It is the final stage in development of monuments of the Neo-Eneolithic period in Ukraine which is characterized by further evolution of the Tripolie and Sredny Stog cultures of the Copper Age as well as Neolithic cultures of DDR and PCC.

The composition of the Tripolie culture evolved by that time in the direction of expansion of cattle-breeding (Usatovo, Maiaki). This culture degraded considerably, in particular, in ceramic production, house-building, etc. (Sofievka, Gorodok, Evminka). Late SSC monuments can be found at the Nen-C stage. This is determined from new radiocarbon dates of samples from the Petrovska Balka settlement in the Crimea. To some extent a new find (the figurine of Tripolie C2 stage from the Derievka settlement) points to this fact.

Monuments of the Lower-Mykhailivka type of the Lower-Mykhailivka-Kemi-Oba culture (LMKO) play an important role at the C stage of the Neo-Eneolithic period in the South of Ukraine. They are known from materials of the lower layer of Mykhailivka settlement near the Dnieper and numerous interments (Archaeology of Ukrainian SSR, 1985). This was a cattle-breading steppe culture with a peculiar composition of artifacts. Ceramics was predominantly plain-bottomed, dark, often glossed and poorly decorated. They are considered to be creators of anthropomorphic stone sculptures. They buried the dead in supine position or with bent knees.

S.P.Kruts (Kruts, 1972) gave much attention to specific anthropologic features of the LMKO culture carriers who differ by a long scull, a narrow, high face, high orbital index, etc. (Table 2). On the whole they belong to the group of Eastern Mediterranean peoples.

From the standpoint of the researchers, the LMKO culture played an important role in the history of the Northern Black Sea Littoral, particulary in the transformation of the Usatovo type culture composition as well as in the appearance and development of the so-called monuments of Zhyvotilovka type.

Fairly complicated processes of transformation of Late-Neo-Eneolithic cultures into the Bronze Age cultures proceeded towards the end of the C stage of the Neo-Eneolithic period. This chiefly concerns LMKO culture which at the Kemi-Oba stage was related to the Bronze Age by experts. On the basis of the Sredny Stog II culture near the Dnieper and Don Rivers and the Khvalynsk culture near the Volga River, Pit Cultures of steppe cattle-breeders appeared at the same time. Many researchers consider this culture to belong to the beginning of the Bronze Age. Numerous Pit tribes settled in the steppe zone of Eastern Europe, and assimilated or forced out all former inhabitants, including Tripolie, Kemi-Oba, Post-Mariupol tribes and others. A part of the Kemi-Oba forced out by Pit tribes migrated, possibly, to the Crimea.

Thus, in the end of the 3rd millennium BC the Neo-Eneolithic period gave way to Bronze Age in the steppe zone of Ukraine.

To make the picture of the historic evolution of the population of Ukraine at the end of the Neo-Eneolithic culture — beginning of the Bronze Age complete, we shall dwell on the development of ethnic-cultural processes in the Northern forest-steppe and Polessie areas of the country. These areas, as in the Volyn', Pripiat and Dnieper River basins at earlier stages, were inhabited by DDR tribes, and to the North-East of Ukraine — by PCC carriers.

The expansion of inhabitation area of the carriers of the new Eneolithic cultures — Funnel Beaker Culture (FBC) and Globular Ware Culture (GWC) was an important event in the history of the DDR population of that time, which one after another penetrated here from the West (Archaeology of Ukrainian SSR, 1985). These were cattle-breeding agricultural cultures. Many facts of the cultural contacts between FBC carriers and the Tripolie people of the C2 stage were determined by Yu.N.Zakharuk (Zakharuk, 1959), T.S.Movsha (Movsha, 1985), M.A.Peleshishin (Peleshishin, 1998) and E.V.Tsvek, (Tsvek, 1985). FBC is radiocarbon dated back to 3800-3300 years BC (Shchiber, 1994). GWC is dated to the middle-second half of the 4th millennium BC.

These newcomers migrated for several generations and then apparently were assimilated by the local Neolithic surroundings. According to the conclusions of anthropologist T.S.Konduktorova (Konduktorova, 1978) GWC carriers had pronounced Europeoid features and moderately developed relief.

In the beginning of the 3rd millennium BC owing to the spreading of Corded Ware cultures in this area, the Neolithic period was substituted by the Bronze Age.

Nevertheless, there is every reason to think that population of later DDR and PCC cultures did not disappear completely from the North of Ukraine. People of the DDR culture together with the CWC tribes took part in the formation of the Tshinetska culture (Gardovsky, 1958; Sveshnikov, 1974) of the Middle Bronze Age, while PCC people transformed into the Marianovka and then Bondarikha cultures of the Middle and Late Bronze Age. However these questions are beyond the scope of the present work.

Conclusion.

Summarizing the conducted study of chronology and division of Post–Mesolithic cultures of Ukraine into periods we come to the conclusion that, firstly, "the Neolithic revolution", i.e. transfer of the population from the Mesolithic to the Neolithic period took place in the middle of the 7th millennium BC. Secondly, beginning from that time up to 5500 years BC, i.e. for about a thousand years cultures of the Neolithic (Early Neolithic) period which had been substituted by the Neo-Eneolithic period developed here, i.e. period of simultaneous living of the Neolithic and Eneolithic cultures at the adjacent areas. The Neo-Eneolithic period in turn was divided into three stages: Early-Tripolie - Late-Mariupol (A), Middle-Tripolie — Sredny Stog II (B) and Late-Tripolie - Lower-Mykhailivka (C). The Neo-Eneolithic period in Ukraine was substituted in the beginning of the Bronze Age by an expansion of Pit-grave culture in the South and Corded Ware cultures in the North.

In closing it is necessary to say that the Mariupol type cemeteries, from which we began our investigation, existed for very long time in the Neolithic and into the first stage of the Neo-Eneolithic periods, i.e. over 2000 years (6500-4000 years BC). Some of these cemeteries probably appeared in Late the Mesolithic period.

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The chronology of the burual-mounds belonging to the Kosh-Pei group in Tuva

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Abstract

The Chronology of the Burial-Mounds to Kosh-Pei group in Tuva. We discuss the problems of the chronology of the barrows of the Kosh-Pei complexes excavated during the 1989 and 1991 years in Tuva Republic (Russia). For these aims we used both archaeological and radiocarbon data. Most of the gold and bronze artefacts from these barrows allow us to suggest that they belonged to the nobility with a high social-cultural level. The character features of ornament, iron weapons, beads, bronze mirrors and cauldron testify that these complexes existed in the Scythian time. The single ^{14}C date produced from the remains of the wood construction of one of the barrows from the Kosh-Pei-1 group is not contradict this suggestion.

Key words: Tuva, Sayan-Altai, Scythian time, cultures, chronology.

Introduction

During 1989 and 1991 the Tuvinian expedition of the Institute for the History of Material Culture excavated three burial mounds belonging to the complex Kosh-Pei 1 and 2 in the central part of the Uyuk Depression, near the village of Arzhan (Semenov, 1994).

One has no doubts as about great importance of the Uyuk Depression sites as a sacral center of Sayan-Altai Scythians which might be compared to the Pontic Herross as mentioned by Herodotus. There, along with huge "royal" burials of Arzhan type hundreds of Scythian noble warriors graves belonging to different time are situated. Because of this many robbers were repeatedly attracted to this area and, for this reason, almost all burial mounds in the Uyuk Depression were partly or totally robbed. The robbery and desecration of large burial mounds had began already during Hsiung-nu expansion which is evidenced by the excavations at the nearby village of Malinovka on the left bank of the Uyuk River where the secondary Hsiung-nu graves were found inside Scythian timber graves. The burials of the Kosh-Pei group had the same fate. But once the deep pits here had been flooded by subsoil waters and this prevented their second robbery, that is why some grave goods have been left for archaeologists. The ground water which flooded the deep pots, prevented the new robberies but damaged the bronze and iron pieces. In spite of that about 350 objects of different types were found at Kosh-Pei 1 and 2, thus enabling one to define the place of these unique monuments in the sphere of Scythian cultures of the Sayan-Altai Upland and Eastern Kazakhstan.

Results and discussion

Burial mound No, 2.2 m tall and 40 by 30 m in cross-section, is situated at the Turan-Arzhan-Chadyn cross-roads. The sandy-loamy construction covered a rectangular burial pit, 6.2 by 6.2 m in size and 4.2 m deep from the level of the palaeosoil. The pit was covered by the wooden logs. The timber burial chamber was made up by split logs, its walls consisting of three levels of trunks, 4.1 by 3.6 m in size.

The second burial mound had no accomplished superficial constructions. The pit 7.1 m long, 6.1 m wide and 4.2 m deep. It was surrounded by the thick deposit of dug-out soil. The wooden cover of the pit was supported by a ledge 2 m beneath the edge. The timber burial chamber 3 by 3 m in size had the walls in three-levels, upon which two additional levels from split trunks were ajoined.

Burial complex Kosh-Pei 2 (a series of 18 mounds) is situated to the North-West from Kosh-Pei 1 (Fig. 1). A single intensely ploughed mound

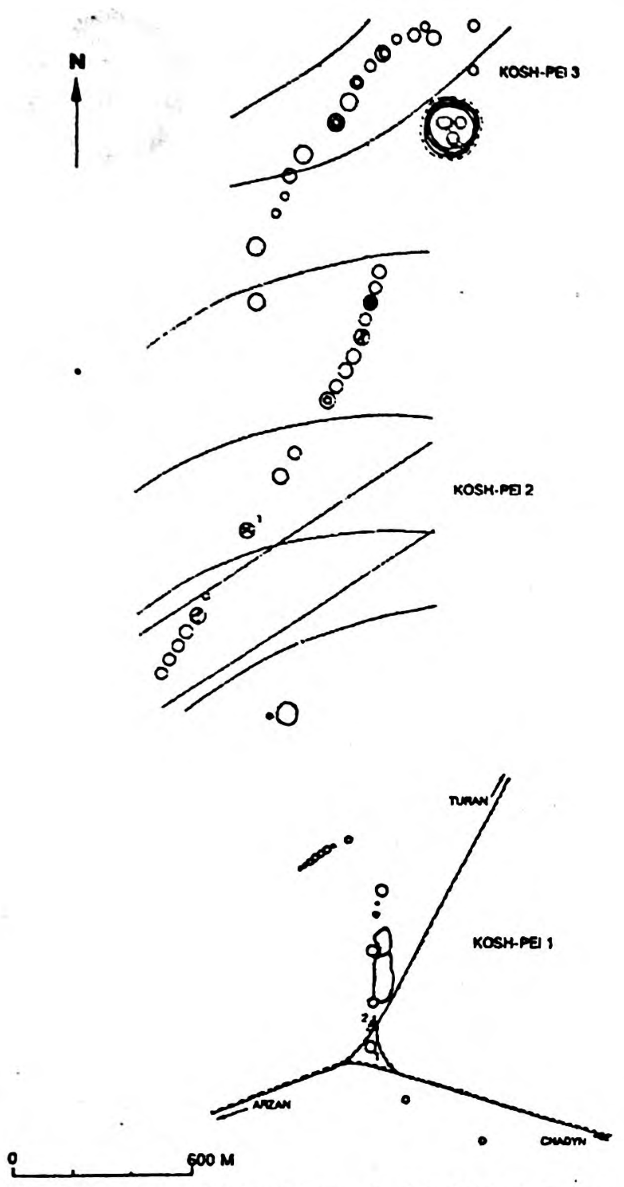

Fig. 1. Positions of the burial-mounds of the Kosh-Pei group in Tuva.

was excavated there. Prior to the excavation it was 1.5 m tall and 28–30 m in diameter. The pit's depth was 3.5 m deep from the level of the palaeosoil. The timber burial chamber 2 by 3 m in size had the walls in three-levels. The floor and the cover consist of parallel lain wooden logs. Despite minor distinctions all three burial sites may be analysed jointly.

The burial mound at Kosh-Pei 2 with its floor being above the ground water level was robbed much more intensely. There due to two dozens of small gold ornaments, mostly from burial garments as well as pieces of iron have survived.

The occurrence of iron in each of the three burials of the Kosh-Pei group is remarkable as it had been thought that this metal appeared in Tuva not earlier than in the 5th centery BC, while in the Saka cultures in the lower reaches of the Syr-Darya and Amu-Darya (Oxus) Rivers iron items appeared already in the 7g6th century BC or even earlier. Thus, the burial complex of Sakar-chaga dated from the 8–7th century BC contains iron objects often incrusted with golden foil (Yablonsky 1992). It is very important for establishing the age of the Kosh-Pei cemetery, as the iron pieces covered with gold foil were also found there. One notes there two double-spiral buckles and one buckle showing scratching beast of prey, as well as an iron dagger (Fig. 2–3,5,25). The occurrence of the tradition to decorate iron pieces with gold in the most ancient complexes of Scythian culture is of great importance.

The grave goods from the Kosh-Pei barrows cover a wide chronological period as one has no reliable indicator for of age. Similar tiny gold beads and hemispherical plaques with a loop inside were reported from the Chylikta burial mound (Fig. 2–1,2). These specific jewlery items show a high professional level of Scythian gold smiths and most evidently they came from the same center of craft. It is remarkable that the beads are 0,1 by 0.05 cm in size, while the plaques with small circular loops are less than 0.5 cm in diameter. The Chylikta burial mound (and the mound No 5 where similar ornaments were fiund) are dated to the 7–6th centurties BC (Akyshev, 1983). These items make possible to define the *terminus post quem* for the burial mounds of the Kosh-Pei 1 cemetery.

A series of other finds, the so-called double-spiral belt buckles found in the burial mound 1 (Fig. 2–4, 5) might be also attached to a certain period of time. Items of the same kind are widespread from Inner Mongolia to the Ordos and the Upper Ob River. Most probably they came from China where they are known from "Springs and Autumns" to "Warrying Kingdoms" periods. Generally these plaques originating from the area ranging from Transbaikalia to the Upper Ob' date from the 5–3th centuries BC, but there are earlier finds in Tuva which could belong to the 7–6th centuries BC (Semenov, 1997). In the catalogue by Shu Takahama and Tei Hatakeyama, the plaques with attached small horizontal tube, through which thin strap was tread are dated from the 6–4 cent. BC (Takahama & Hatakeyama, 1997, Fig. 169-1, 169-2; List of Exhibits IX, 169) and are alike to Kosh-Pei items. One of the iron plaques with gold foil from Kosh-Pei (Fig. 2–4) makes it possible to date the beast of pray image also made from iron and covered with gold foil (Fig. 2, 3). Probably it was part of the same belt set.

Some specific gold ornaments, such as the finial of a headdress showing an ibex on a cone have analogues

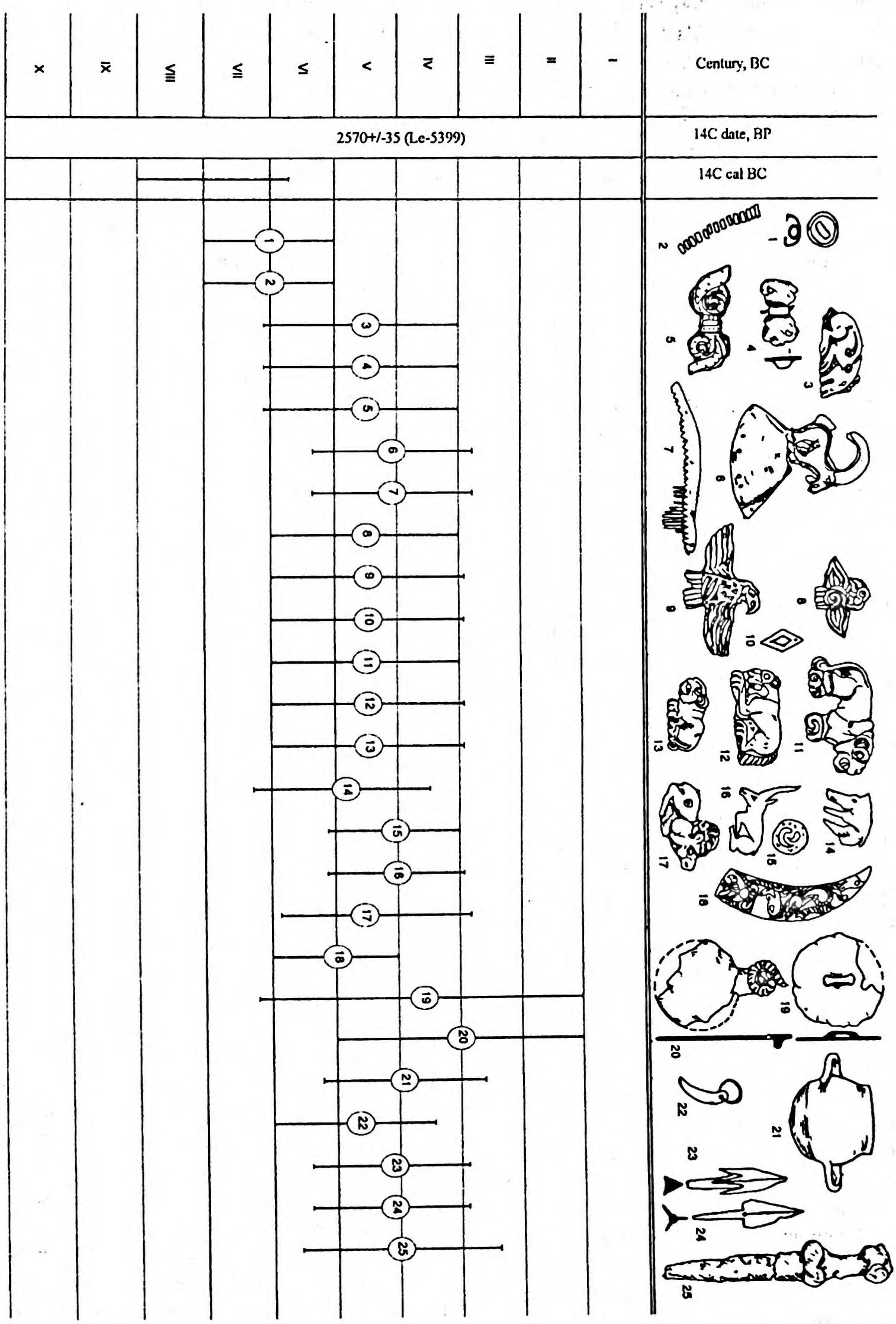

Fig. 2. Chronology of the burial-mounds of the Kosh-Pei group.

in the burial mound No 2 on the River Teplaya in the Us Depression (Bokovenko, 1994), and there are imitations of this animal in the Ak-Alakha 1, the burial No 1 in the Altai (Polos'mak, 1994). The barrow on the River Teplaya is dated by N.Bokovenko to 500–300 years BC. The ^{14}C date for this burial is 2490±60, Le 5132 (Sementsov et al, 1997), or the 5th century BC. This date is supported by the grave goods from this burial which include the pottery indicating a turning point, that had taken place in the 5th century BC. To the same period, i.e. the 5th century BC N.Polos'mak dates the burial No1 in the Ak-Alakha, considering the presence of iron as the main proof, as she believes that iron was unknown in the Sayan-Altai before that time (or at least it was not widely used) (Polos'mak, 1994). But in Tuva iron objects were found in several Aldy-Bel sites, which were in existence well in advance of the 5th century BC (e.g., the burial complex of Sypuchiy Yar, Semenov,1997). At any case the Kosh-Pei gold ornament with a goat is not younger than the 5th century BC. Taking into account that the age of the total Kosh-Pei complex to be older than, that of the burial complex on the Teplaya River, which is the nearest one, we can date the appearance of such ornaments in Tuva to the 6th century BC and they survived in this area till the 3rd–2nd centuries BC, as they are attested among the finds in the Suglug-Khem 1 and 2 burial complexes.

Obviously the head dress was decorated with gold sewn-on plaques in the shape of eagles. There are more than 20 of them in the Kosh-Pei barrows. They include five groups: three types of griffins with ears (Fig. 2–8), one type of an eagle with smooth body and one with feather-like ornamented chest (Fig. 2–9) (Kilunovskaya, 1994). There are no direct analogies to them in Tuva. The nearest ones in space and time are "eagles" from the burial mound 126 in the burial complex Turan 4, the date of which is the 5th –4th centuries BC. To the same time belong the eagle figurines from the Teplaya River. Similar objects in the Doge-Baary complex, burial 20 are dated by the author of the excavations to the 6th–4th centuries BC (Chugunov, 1994) which is supported by ^{14}C date: 2510±25 (Le-5196). This burial mound is very important for the comparative dating of the Kosh-Pei complex as it contains the iron gold-covered objects and the arrow-heads and earrings similar to the Kosh-Pei. The early age of the burial (even considering pottery among the grave goods) is indicated by the occurrence of bimetallic battle-axe having the analogues in the key site of the Sakar- Chaga 6, burial 23 (Yablonsky, 1992).

12 foil ornaments showing walking and scratching beasts of prey were found in the Kosh-Pei burials; they have analogues in the burial 9 from the Kuylug-Khem 1 complex, the burial No 3 from the Urbun complex and the burials No 5 and No 48 from the Kok-el complex. According to M. Kilunovskaya they are more primitive and resemble the plaques from the burial mound No 31 in the Tagisken complex (Kilunovskaya, 1994) which are dated by M. Artamonov to the 5-4th centuries BC (Artamonov 1973, Fig. 20–22). The burial complex Tagisken following the recent research is dated to an early period and the main part of the burials belongs to at least the 6th century BC. The burial complex of Ust-Bukon in Eastern Kazakhstan includes the similar gold lions dated to the 6–4th centuries BC (Itina, 1992; Bokovenko & Zadneprovskiy, 1992). The complex with gold lions from the Kuylug-Khem, the burial No 9 may be reliably dated to the 6–5th century BC having the cone-like gold earring with a pendant. Similar ornaments occur also in Tuva, Altai, Kazakhstan and the Lower Volga and belong to the 7–5th centuries BC (Semenov, 1999).

Gold ornaments in the form of a wild boar, capricorn and ibex (Fig. 2–14, 16, 17), as well as geometric sewn-on plaques (Fig. 2–10,15) from the burial mound No 1 from the Kosh-Pei 2 similar to the finds from the Chilikta, the Tagisken and later sites at the Doge-Baary may be dated to the 6–5th centuriers BC.

Carved boar fang from the burial No 2 from the complex Kosh-Pei 1 (Fig. 2–18) by the analogy with other finds from various regions of the Scythian area, dates from the end of the 6th — first half of the 5th centuries BC (Chezhina, 1991).

Bronze mirrors both in shape of a disk with a loop in the center (Fig. 2–19) and medal-like ones with open-work protruding handle or with a loop on the reverse side date not earlier than the 5th century BC. The first type of the mirrors existed throughout the whole Scythian epoch, while the second one is unknown before the middle of the 1st millennium BC. The same may be said about the bronze cauldrons with lateral paired loop handles (Fig. 2–21). In Tuva and the Minusinsk Valley they appear in the 5th century BC, but B.Litvinskiy admits an earlier date for such cauldrons from the burial complex Khargysh 1 in the Pamir Mountains: the end-middle of the 6th century BC (Litvinskiy, 1972).

As for the arrowheads (Fig. 2– 24), these types are known to exist starting from the 7th century throughout the whole Scythian period. By analogies to the Uigarak finds they may belong to the 6th century BC. The dagger with traces of a gold covering is similar to their items from the Issyk burial mound, dated to the 5–4th centuries BC. Iron was already in use in Tuva at this time.

Conclusion

The chronological table for the most representative finds from the Kosh-Pei indicates the 5th century BC as the most probable time of their emergence. Only the ornaments of the Chilikta type do not extent beyond the limits of the 6th century BC, consequently we may assume that the Kosh-Pei barrows belong to the turn of the 6th and the 5th centuries BC which do not contradict the result of cross-checked ^{14}C dates.

The ^{14}C dates for the burial mound No 2 from the Kosh-Pei 1 (2570±35) (Le 5399) indicate the second half of the 6th century BC. Calibrated dates suggest an even older age. The date which is older than the archaeological estimate might be explained by the technology of the timber grave burial No 2. It was built from wooden logs and the outer tree-rings of the older logs being cut off. Otherwise one should consider that the entire chronology of the Scythian cultures in Tuva and the Sayan-Altai to be shifted backwards in time, taking into account the most ancient dates of the Arzhan burial mound.

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14

The Upper Paleolithic site of Yudinovo and its place in the Paleolithic of the Central Russian plain

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Abstract

This paper is focused on the determination of the chronological position of the Upper Palaeolithic site Yudinivo using the archaeological, geological data and the radiocarbon dating. The set of radiocarbon dates for the different Upper Palaeolithic sites in the Desna river basin was compared. The radiocarbon dates obtained are testified that the Yudinovo site existed during the Magdalenian time what corresponds to the archaeological and geological data. The Yudinovo and the Timonovka sites are related to one group of the Upper Palaeolithic sites located in the region investigated.

Key words: the Upper Palaeolithic, radiocarbon dating, the Desna river basin, the Magdalenian time.

Introduction

The Upper Paleolithic habitation site of Yudinovo is of key importance for the study of the Upper Paleolithic in Eastern Europe. The site is located at the Yudinovo village (the Bryansk province) at the right bank of the Sudost river, the right tributary of the Desna river 450-km south-westwards from Moscow. Polikarpovich (1968) discovered the site in 1934. His exploration revealed the remains of two presumable domestic structures made of mammoth bones. The excavations were renewed in the 1960s by Bud'ko (1970) and later continued by the authors (Abramova, 1995; Abramova, Grigorieva & Christensen, 1997; Abramova & Grigorieva, 1997). The fieldwork of 1981 to 1984 produced two new dwellings structures of mammoth bones, which are conserved under the special construction, belonging to the local branch of the Bryansk Regional Museum.

The main aim of these new investigations is to illuminate the place of the site in the Upper Paleolithic of the Desna river Basin and, in a more general way, in the context of the Paleolithic of the Russian Plain. Multidisciplinary studies, including geological and archaeological exploration and radiocarbon dating are oriented toward this goal.

Yudinovo: site setting & archaeological record

Yudinovo is the only Upper Paleolithic site at the Desna river basin, which is located at the first riverside terrace (7 to 10 m's high).

Hollows disturb this terrace over 100 m long. The habitation horizon of the site is embedded in loess-like sediments on the depth of 2.0 to 2.5 m (Velichko, 1961).

The site produced a rich faunal record. Mammoth and Arctic fox dominated the fauna, bones of reindeer, red deer, bear, wolf, bison, marmot, beaver, lemming, etc. are also identified. Human remains include a fragments of the right humerus discovered by Polikarpovich in the trench no. 17 and teeth (a milk tooth discovered at the square D-54-1 in 1987 and a second molar discovered at the square A-52 in 1990).

Excavations yielded rich and diversified collection of lithic and bone artifacts. Chalk flint, procured

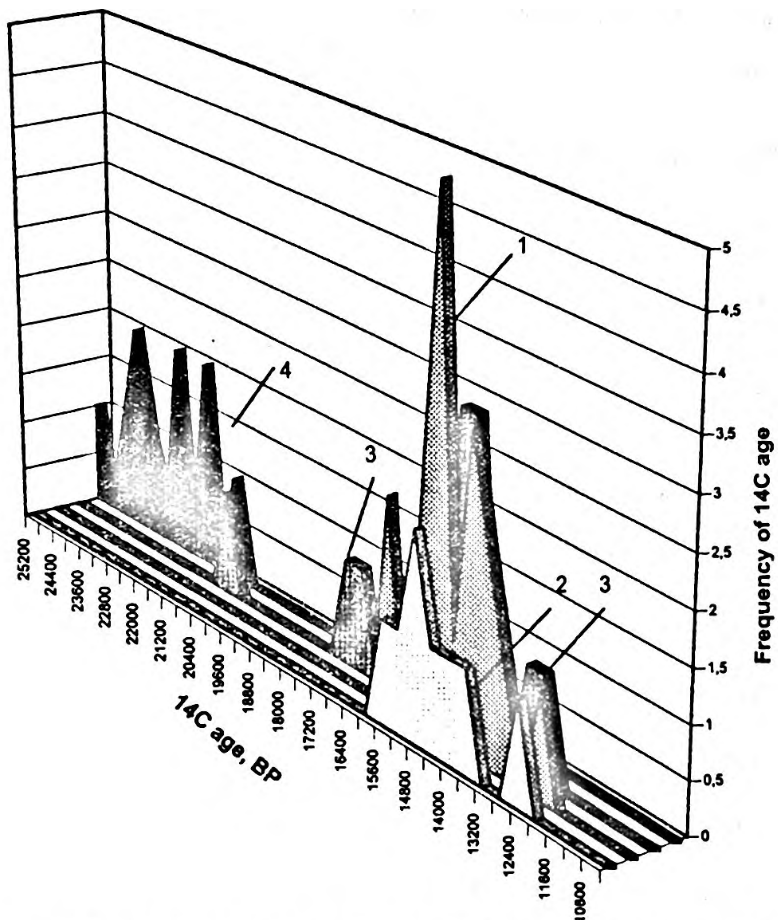

Fig. 1. The Histograms of the distribution of the ^{14}C dates for the Upper Palaeolithic sites of the Desna River basin. 1-Yudinovo, 2-Suponevo &Timonovka, 3- Eliseevichi, 4- Khotylevo.

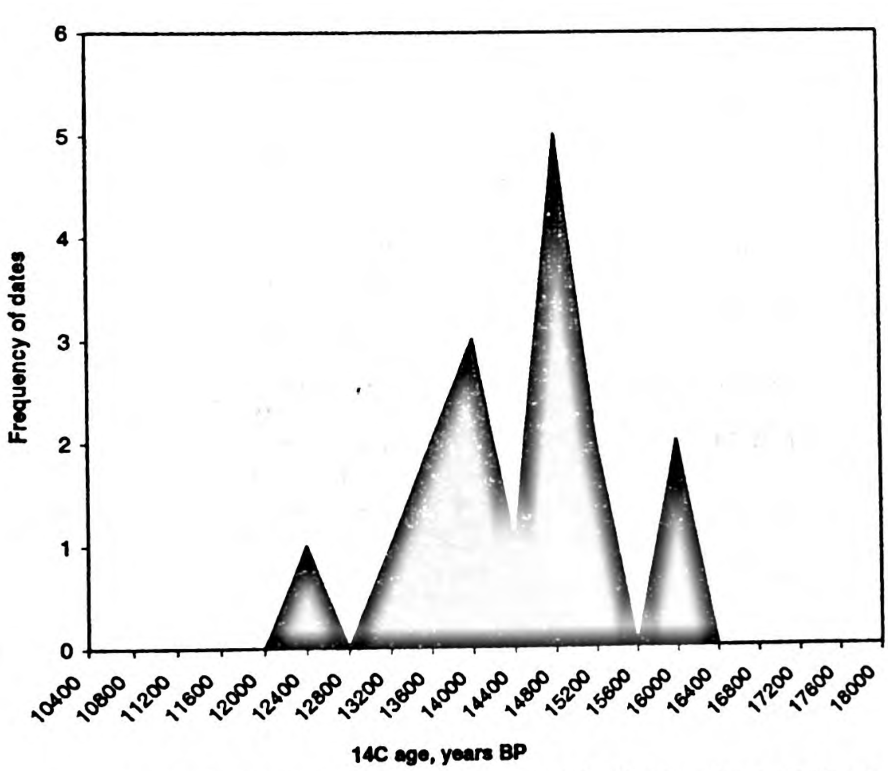

Fig. 2. The histogram of the distribution of the ^{14}C dates for the Yudinovo.

Table.

Radiocarbon dates of the Upper Palaeolithic sites for the Desna River basin.

No	Lab. index	^{14}C age, BP*	Site, N.Latitude/-E.Longitude	Material for dating
1	GrN-21899	24220±110	Khotylevo-2,- 53°12'/34°19'	Bone
2	IGAN-73	24960±400	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
3	GrN-22216	23870±160	Khotylevo-2,- 53°12'/34°19'	Bone
4	Lu-359	23660±270	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
5	GIN-8497a	23300±300	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
6	GIN-8406	22700±200	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
7	GIN-8496	22660±120	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
8	GIN-8495	21720±170	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
9	GIN-8486	21680±150	Khotylevo-2,- 53°12'/34°19'	Burned bone
10	GIN-8497	21170±260	Khotylevo-2,- 53°12'/34°19'	Mammoth tooth
11	Le-450	20570±430	Eliseevichi-1,- 53°13'/33°44'	Charcoal
12	Lu-360	17340±170	Eliseevichi-1,- 53°13'/33°44'	Mammoth tooth
13	GIN-4138	16850±120	Eliseevichi-1,- 53°13'/33°44'	Mammoth tooth
14	IGAN-556	15620±200	Eliseevichi-2,- 53°13'/33°44'	Mammoth tooth
15	QC-889	15600±1350	Eliseevichi-1,- 53°13'/33°44'	Burned bone
16	GIN-4136	14590±140	Eliseevichi-1,- 53°13'/33°44'	Mammoth tooth
17	GIN-4186	14590±140	Eliseevichi-1,- 53°13'/33°44'	Mammoth tooth
18	Lu-126	14470±100	Eliseevichi-1,- 53°13'/33°44'	Mammoth tooth
19	GIN-5475	14240±120	Eliseevichi-1,- 53°13'/33°44'	Burned bone
20	GIN-4139	14100±400	Eliseevichi-1,- 53°13'/33°44'	Tooth
21	GIN-4135	14080±70	Eliseevichi-1,- 53°13'/33°44'	Burned bone
23	GIN-4137	12630±360	Eliseevichi-1,- 53°13'/33°44'	Mammoth tooth
24	Le-3301	15790±320	Yudinovo,- 52°40'/33°14'	Bone
25	Lu-127	15660±180	Yudinovo,- 52°40'/33°14'	Mammoth bone
26	Le-3302	14980±110	Yudinovo,- 52°40'/33°14'	Mammoth tooth

Table (continued)

No	Lab. index	^{14}C age, BP*	Site, N.Latitude/- E.Longitude	Material for dating
27	Le-3835	14870±150	Yudinovo,- 52°40'/33°14'	Mammoth tooth
28	GIN-5588	14500200	Yudinovo,- 52°40'/33°14'	Burned bone
29	Le- 5519	13200±200	Yudinovo,- 52°40'/33°14'	Burned bone
30	Le-5518	1285±0200	Yudinovo,- 52°40'/33°14'	Burned bone
31	GIN-4801	14470±160	Yudinovo,- 52°40'/33°14'	Bone
32	GIN-5661	14610±60	Yudinovo,- 52°40'/33°14'	Burned bone
33	GIN-4802	14650±105	Yudinovo,- 52°40'/33°14'	Bone
34	ISGS-2084	14300±110	Yudinovo,- 52°40'/33°14'	Burned bone
35	ISGS-2085	13980±110	Yudinovo,- 52°40'/33°14'	Mammoth bone
36	Lu-103	13830±850	Yudinovo,- 52°40'/33°14'	Burned bone
37	Lu-153	13650±200	Yudinovo,- 52°40'/33°14'	Burned bone
38	Le-3303	13380±160	Yudinovo,- 52°40'/33°14'	Bone
39	OxA-695	13300±200	Yudinovo,- 52°40'/33°14'	Burned bone, organic fraction
40	Le-3401	12980±320	Yudinovo,- 52°40'/33°14'	Burned bone
41	OxA-696	12300±200	Yudinovo,- 52°40'/33°14'	Burned bone, inorganic fraction
42	GIN-2003	15300±700	Timonovka-1,- 53°11'/34°22'	Burned bone
43	Lu-358	15110±530	Timonovka-1,- 53°11'/34°22'	Mammoth bone
44	GIN-8413	14750±120	Timonovka-1,- 53°11'/34°22'	Mammoth tooth
45	GIN-8414	14530±120	Timonovka-1,- 53°11'/34°22'	Mammoth tooth
46	IGAN-86	12200±300	Timonovka-1,- 53°11'/34°22'	Mammoth bone
47	GIN-3719	14260±120	Suponevo,- 53°11'/34°23'	Mammoth tooth
48	GIN-7729?	13920±140	Suponevo,- 53°11'/34°23'	Mammoth bone
49	GIN-3381	13500±100	Suponevo,- 53°11'/34°23'	Mammoth tooth
50	GIN-5778	13950±70	Sevsk mammoth place,52°09'/34°27'	Bone
51	GIN-6209	13680±60	Sevsk mammoth place,52°09'/34°27'	Mammoth tusk

* The radiocarbon dates produced by the Institute of the History of Material Culture ^{14}C Lab (Le-) and Geological Institute (GIN-) have been checked according to the archive of the laboratory journal and can be differed from those presented in publication (Svezhentsev &al, 1996).

from elsewhere, was used as a main raw material. It seems that sources of raw material were located nearby the site because even initial phases of flint nodules utilization are not represented. Endscrapers and burins are the main tool classes. There are also retouched blades, points and splintered pieces. The lithic assemblage is similar to other Upper Paleolithic sites of the Desna river basin (Timonovka, Chulatovo, and Bugorok).

The site yielded a remarkable series of ivory objects. Hunting weapons, different implements, personal adornments and art objects, ranging from large points to miniature perforated beads, are worthwhile to mention.

Ornament with geometrical design is widespread. Bone inventory is similar to other Upper Paleolithic assemblages of Eastern Europe in spite of cultural differentiation.

There are a series of the Upper Paleolithic sites (Khotylevo, Eliseevichi, Timonovka, Suponevo, and Yudinovo) and the Sevsk mammoth deathsite located at the Desna river basin nearby Bryansk . According to the geological data, the intensive human occupation of the area took place in cold phases of the Late Pleistocene. Three occupation episodes could be distinguished:

1. The final phase of the Bryansk Interstadial (25 to 22 ka).

2. The succeeding cold phase (from 20 to 16 ka).

3. The final phase of the Late Pleistocene (15 to 13 ka).

Two patterns of site location could be discerned during the Late Pleistocene at the Desna river. The first group of localities sits at high riverside terraces or watersheds near the Cretaceous deposits rich in flint. The second group is associated with the first terrace of small tributaries of the Dnieper River. Sites occupied places protected from the floods, while the swampy floodplains nearby are considered as possible deathsites for animal herds (Velichko, Gribchenko, and Kurenkova 1997). These are located far from the raw material sources, meanwhile the disposition seems to be favourable for hunting activity. Yudinovo apparently belongs to this group.

Yudinovo could be assigned to the Late Upper Pleistocene. It falls within the same time span as the Timonovka cluster of sites, while the latter could be slightly older.

Discussion

From the late 1970s on the radiocarbon dating has been intensively used in the study of the Upper Paleolithic sites of the Desna river valley.

A series of radiocarbon dates are presented in Table 1. Fig.1 demonstrates the age of the sites. The ^{14}C dates for Khotylevo, lying between 24 and 22 ka, are the oldest in the group. The site is assigned to the Gravettian. Eliseevichi is younger, the dates for this site lye mostly between 16 and 14 ka, while other dates are scattered from 21 to 12.6 ka. This is a gap in the distribution of the dates between 20 and 18.2 ka, which could be either a result of depopulation due to hard environmental conditions or a result of insufficient research. Yudinovo, Timonovka, and Suponevo fall within the same time span (15 to 14 ka). Two available dates referred the Sevsk mammoth deathsite to the age ca. 13.5 ka, thus this locality is hardly to connect with other occupations of the area. The dates from Yudinovo are shown at Fig. 2. These are clustered between 15.6 and 13.2 ka.

Conclusion

Thus the radiocarbon dates as well as geological and archaeological evidences have confirmed the Magdalenian age of Yudinovo (15 to 10 ka) Polikarpovich (1968), a first investigator of the site, regarded Yudinovo as belonging to the Lower Magdalenian. Later Bud'ko (1970) assigned Yudinovo and Timonovka to the so called Pre-Magdalenian. Our data allows to argue that Yudinovo could be considered as Magdalenian site from the chronological viewpoint.

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