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Today I am not the one I was yesterday:
Archaeology, identity, and change

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INTERARCHAEOLOGIA, 4

TODAY I AM NOT THE ONE I WAS YESTERDAY: ARCHAEOLOGY, IDENTITY, AND CHANGE

Papers from the Fourth Theoretical Seminar of the Baltic Archaeologists (BASE), Archaeology and Identity, held at the University of Helsinki, Finland, October 8th–10th, 2009, and the Fifth Theoretical Seminar, Archaeology Today: Things to be Changed, held at the University of Tartu, October 27th–29th, 2011

Edited by Arvi Haak, Valter Lang & Mika Lavento

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SECURING THE TIMELINE OF OUR PAST: CONCERNS AND PERSPECTIVES OF RADIOCARBON DATING IN THE EAST BALTIC

Giedrė Motuzaitė-Matuzevičiūtė

One of the first things archaeologists try to define when dealing with an artefact or site is its age. Radiocarbon dating of organic material is the most common method used in modern archaeology to determine the age of an object. However, the selection of which organic material should be used for dating an object is not always very straightforward, since the received dates from radiocarbon dating can be skewed significantly by sample contamination, reservoir effects, old wood effects, and other factors. Large uncertainties in the reported radiocarbon age, and/or wide gaps between multiple dates from the same site, are indicators of problems in sample selection for dating. The present chronology of east Baltic prehistory is mainly built on such problematic dates. The aim of this paper is to draw attention to such potential problems, and discuss the challenges involved in the determination of a more precise chronology for our past.

Key words: ^{14}C, AMS dating, reservoir effect, old wood effect.

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Introduction

A secure chronological understanding of an archaeological site or object is usually one of the primary aims of every archaeologist. The understanding of a precise chronology influences how we make our later interpretations of the sites and objects we study, and then draw conclusions about their importance, meaning, origins, and affiliations. Therefore, an accurate determination of an archaeological object's age is of crucial importance. Radiocarbon dating techniques have advanced significantly since Willard Libby first announced his discovery of the method. The precision of radiocarbon dating has improved, while simultaneously the sample size required to establish a date has decreased. Today it is up to every archaeologist to take advantage of ^{14}C dating and to apply the technique to materials from their sites. However, like in any science, no matter how advanced the technology, mistakes are inevitable if the wrong combination of samples has been selected. In this paper I am not going to go into the details on how the ^{14}C dating methods work, but rather draw attention to some common mistakes archaeologists make while selecting samples for radiocarbon dating. I will present some general observations on radiocarbon dates from the archaeological literature of the east Baltic which have blurred various chronologies, and discuss how to make such chronologies more accurate and reliable. I will aim to outline very briefly which materials we should avoid and which materials are best suited for radiocarbon dating.

Concerns for the present east Baltic chronology

While examining the radiocarbon dates that have shaped the present chronology of the east Baltic prehistory, large gaps in the chronology of the published dates have been revealed; for example, in many cases dated materials from the upper layers of a site have generated older dates than materials from the layers below (e.g. Timofeev *et al.* 1997; 2004; Stančikaitė *et al.* 2009). Sometime chosen samples from a single occupation site have generated ages over a thousand years apart in span, with standard deviation values of over ±200 years (e.g. Rimantienė & Ostrauskas 1998; Timofeev *et al.* 2004). The types of dated material also vary widely. So far I have been able to find the following dated material in the literature: sapropel, peat, wood (species usually unidentified), oak wood, charcoal, pottery sherds, organic material on pottery walls, terrestrial animal bone, marine animal bones, fish bones, human bones, mollusc shells, organic layers in stratigraphy, organic matter gathered from the barrows, silty gyttja, and gyttja with charcoal. Very often the dated material is not indicated in the publication, and in most cases only one date per archaeological context has been obtained and reported. It is not surprising that the chronology derived from such dates from one or multiple sites often simply does not make any sense. These are the main reasons why:

Firstly, most of the dates that formed the east Baltic chronology have been obtained using conventional ^{14}C dating methods. Laboratories using older ^{14}C dating methods require much more material for dating than do Accelerator Mass Spectrometry (hereafter referred as AMS) laboratories, and in addition the most common procedure often used when dating in conventional laboratories is the averaging of many individual dates obtained from molluscs, charcoal, or bone fractions into one average date, resulting in a higher range of possible error. Very often archaeologists choose conventional laboratories such as Kiev Radiocarbon Laboratory and Radiocarbon Laboratory in Saint Petersburg, which offer low-priced radiocarbon dating services that apply such methods.

Secondly, some dates from the east Baltic are obtained from dating pottery and mollusc shells from kitchen midden sites, organic residue on pottery (potentially consisting of marine/fresh water organisms), animals whose diet mainly consists of eating marine or fresh water organisms (such as fish or molluscs), or those organisms themselves. A series of problems connected with the radiocarbon dating of pottery which results in incorrectly older dates has been outlined by Bonsall *et al.* (2002). In the latter paper, the authors note that dated pottery will result in an older ^{14}C date if:

1) The clay of the pot contains carbon of geological age;

2) Dated potsherds contain a crushed mollusc shell temper, which will result in an older reservoir age in the case of marine molluscs or a 'hard water effect' for terrestrial snail species;

3) Peat or 'old wood' was used as a fuel to fire pots or to cook food, which was then absorbed into the vessel;

4) Dated organic residue on pottery walls is that of terrestrial/marine fish, shellfish, or molluscs.

Difficulties arise in dating these organisms because molluscs, living in a calcareous environment, incorporate through photosynthesis a substantial amount of dissolved geological-age carbon from the ground or river water, especially where flow takes place through areas of chalky or limestone bedrock (Aitken 2001). Absorbed C ions are synthesized into $CaCO_3$ during mollusc growth, causing a so-called 'hard water effect', making the apparent age of the dated material much older than reality. An experimental study has shown that, when dating marine shells, 405±40 years must be subtracted from the radiocarbon age to remove the bias resulting from the reservoir effect (Harkness 1983). However, this effect varies throughout various landscapes, where some generate a much more prominent hard-water effect on animals than others do (Reimer 2012). Some regions of the east Baltic, such as southern Lithuania, are rather calcareous in nature and contain chalk and limestone outcrops in their geology. Therefore, research into developing a calibration process for mollusc and fish radiocarbon dates needs to be conducted by dating living molluscs and correlating their 'hard water' error with their archaeological age. Therefore, all radiocarbon dates from molluscs and pottery with a mollusc shell-based temper will remain older than actual. Recently, however, the Kiev Radiocarbon Laboratory and Radiocarbon Laboratory in Saint Petersburg have developed a new methodology for eliminating any mollusc components from a pottery temper prior to dating its organic content, which allows for correlation of the reservoir effect on dated material (Zaitseva *et al.* 2009).

As mentioned above, geological carbon will also affect the fish species that live in the calcareous environment and therefore humans who eat the fish. The dating bias resulting from the hard water effect probably can be inferred from the fact that some of the earliest dates from the Mesolithic period of eastern Baltic are ones obtained from the dating of humans, such as those from the site at Spigino horn (Butrimas 1989; Rimantienė 1996) who probably were relying heavily on fresh fish resources. As recent research has demonstrated the dating of humans from the Upper Palaeolithic – Chalcolithic periods in Ukraine are strongly distorted in radiocarbon age by the reservoir effect, resulting in a much older apparent age (Lillie *et al.* 2009). Stable isotope analysis of carbon and nitrogen ratios have shown that those humans were highly reliant on fresh-water fish as a food source (Lillie 1996; 1998; 2001; Lillie & Richards 2000; Lillie & Jacobs 2006; Lillie *et al.* 2003; 2009). The dates of a fish bone pendant in a human grave were 400 years older than dates from the human remains, and 700 years older than a deer pendant in the same grave. Those dates permitted the correlation of the offset for the reservoir effect in human collagen. The carbon and nitrogen stable isotope values from Neolithic–Bronze Age humans in Lithuania and Latvia indicate a high consumption of fish (Antanaitis & Ogrinc 2000; Antanaitis-Jacobs *et al.* 2009; Eriksson *et al.* 2003); however, whatever potential reservoir effect this might impose on the radiocarbon ages from these human remains has not yet been estimated. Similar situations could be found in all the radiocarbon dates obtained from dating the fish-consuming humans across the Baltics of the Mesolithic–Neolithic (e.g. Lõugas *et al.* 2007, Kriiska *et al.* 2007, Rosentau *et al.* 2011).

Thirdly, hardly any dates from the east Baltic region come from dating charred seeds, the age of which reflect a single growing season and therefore provide the most accurate material for dating.

Fourthly, dates received from wood charcoal are not accompanied by wood species identification, allowing the possibility of an 'old wood effect' that can influence the resulting date. The 'old wood effect' is inevitable if the material dated is a long-lived tree species and the original location of dated portion within the cross section of the tree trunk is unknown. The central rings of a long-lived tree can differ by thousands of years from the outer ones. One of the commonly used species for radiocarbon dating is the oak, which the reader should note is a long-lived tree species.

Finally, dating gyttja, sapropel, or peat is a bad idea, especially if there is other material available from the archaeological site for dating. Material of unknown geological processes can result in older or younger dates than the actual age of the dated horizon, especially if the site from where the ^{14}C samples are taken is situated within a fluctuating water level zone. Changes in the water table can bring older peat material from bottom layers of a site to the top and vice versa, resulting in mixing of the stratigraphy. Also soil leaching and eluviation processes often move organic-rich top soil to lower horizons (O'Connor & Evans 2005).

Summing up on things to know while selecting samples for ^{14}C dating

It is not too late to revise the east Baltic chronology as long as all archaeologists strive to understand the importance of choosing the right material for dating. Dates that have been received from dubious material have to be discarded as invalid. Here is a brief protocol that one must keep in mind while selecting dates for ^{14}C dating:

1) Ideally – at a minimum 3 samples per layer/archaeological context have to be chosen for dating, in order to provide a trustworthy understanding of the object age;

2) Perennial plant seeds are the best material to date as they will give the best age estimate for the object;

3) Wood charcoal can also be dated as long as the wood species are first identified. For the long-lived species, material from the outer rings should be selected. If the species is not known, choose twigs or small branches for dating;

4) Terrestrial herbivores such as deer/cattle or cattle are preferred for dating. When dating omnivores, such as human bones, a stable isotope analysis should be made first to evaluate the contribution of fish in the diet. Also, the reservoir effect in humans can be corrected by dating terrestrial animal bones from the same context (for example, deer pendants);

5) Alkalinity is the driving force behind the magnitude of the freshwater reservoir offset (Reimer 2012). Therefore, every archaeologist should test the bedrock of an area and consequent alkalinity of the river or lake water to find out whether or not there is the potential for a reservoir effect on samples from the area.

Avoid dating

The following materials should be avoided for selection in dating:

1) Material such as long-lived tree species, especially samples from the internal rings;

2) Fish and molluscs or other fresh or saline water animals should not be dated unless also correlating for the reservoir effect in humans;

3) Dating animals that eat fresh water or marine organisms, such as humans, pigs, dogs, should be avoided. If human or other omnivore bone has been chosen for dating, ^{14}C dating results should be compared to the $\delta^{13}C$ values of the sample to infer fish consumption (especially if marine fish was consumed). However, $\delta^{13}C$ values are only relevant if dated material is bone collagen. $\delta^{13}C$ values will have very different implications if they are derived from dating hydroxylapatite in cremated bones;

4) Dating organic residue on pottery can also be tricky as it may contain fish/mollusc remains;

5) Humus/gyttja geological samples with unknown formation processes must be avoided and the macro-remains from pollen core sample have to be selected for dating;

6) The last thing to remember when sending samples to radiocarbon laboratories is to find out whether those samples have been pre-treated chemically after their discovery or not. The pre-treatment usually involves soaking samples in chemicals or using bone glue to keep broken artefacts together. Any chemical contacts should be noted on the sample submission form. The samples sent for dating should be stored in aluminium foil or glass tubes, avoiding plastic containers.

Conclusion

To sum up, there are some simple rules to obtain a reliable radiocarbon dating:

Material for dating has to be chosen carefully.

Dating materials the nature of what is not precisely known, should be avoided: 'dark organic earth', ash, soil, peat, long-lived trees or food residues on pottery are not suitable for dating.

Best materials to AMS date are twigs, grain, terrestrial herbivore bone, or outermost tree ring.

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