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DISCREPANCIES BETWEEN CONVENTIONAL AND AMS-DATES FROM COMPLEXES WITH ASBESTOS AND POROUS WARE – A PROBABLE RESULT OF 'RESERVOIR EFFECT'?

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INTRODUCTION

To begin with, we suggest our reader to treat the ideas presented in this paper as preliminary considerations. Although there is not enough data to fully support the hypothesis formulated here there are, at the same time, enough facts that allow us to make such a statement. Our goal is to draw attention to existing problems and provide an explanation, which, according to us, is the most plausible at the moment.

This paper discusses the differences observed between radiocarbon age determinations of archaeological materials made from different datable substances. The detection of such discrepancy is the result of the progressive increase in the amount of radiocarbon dates. The more dates originating from more or less secure contexts we obtain, the bigger are the possibilities to build up a very detailed chronology of the archaeological sources. Differences in 100–300 years do not play significant role when only a few dates are available for a given cultural group; but when the set of dates is substantial, they become increasingly more important. We chose the sites with Asbestos and Porous Ware as the main focus of our investigation. Although the number of dates originating from Finnish sites is several times bigger than the number of dates obtained from Russian territory, the overall amount of radiocarbon dates available allows us to bring the discussion on chronology to a different level and consider the relatively small time intervals, discussed in the following, significant.

Initially, after the invention of radiocarbon analysis, wood charcoal became the main material for dating in Fennoscandia. Yet, pieces of burned wood, however good for determining their own radiocarbon age, are quite difficult to connect to any specific artifacts. In most cases their relation to any set of artifacts is not obvious and should not be taken for granted. Also the 'old wood effect', resulting in older ages of many wooden samples (Bowman 1995: 51; Vagner 2006: 178–9), and the quite high probability of contamination by younger organics, caused by the location of archaeological cultural layers in the topsoil, lessen the value of charcoal samples as a source for dating.

Introduction of the AMS-technique made it possible for us to date certain artifacts. In the case of Fennoscandia, the most frequently AMS-dated artifact group is ceramics, i.e. food crust attached to the walls of vessels. Dating samples of crust on pottery with the aid of mass-spectrometer has evident advantages over dating wood charcoal samples obtained from cultural layer. First, a straight connection between the date and the concrete ceramic specimen is established without any doubt. Second, the probability of sample contamination by younger organics is much lower.

Nevertheless, the picture is still not as clear as we would prefer it to be. The first AMS-datings of crust obtained from Late Neolithic ceramics from Finland demonstrated older ages compared to charcoal samples gathered during excavations of the same settlements and dwellings, from which the dated ceramics originated (Karjalainen 2002; Pesonen 2004). Consequently, general pessimism concerning charcoal samples followed these first results, including the dates from the walls of burnt-down dwellings. Nevertheless, the increasing amount of AMS-dates of food crust has showed a stable deviation between

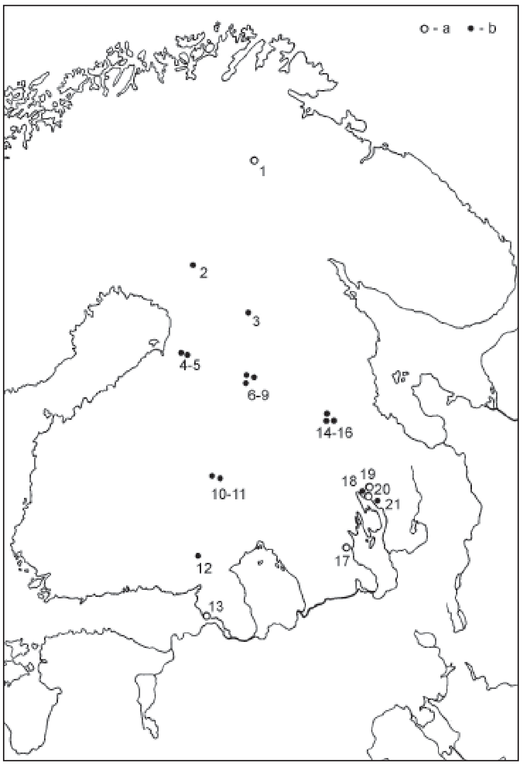


Fig. 1 Distribution of radiocarbon dated sites with Asbestos and Porous Ware of Voynavolok, Orovnavolok, Kierikki, Pöljä and Jysmä types. Key: a) sites with Voynavolok type ceramics with radiocarbon dates from crust on ceramics and charcoal from housepits; b) sites with ceramics of Orovnavolok, Kierikki, Pöljä and Jysmä types with radiocarbon dates from crust on ceramics and charcoal from housepits. Sites: 1. Inari Vuopaja, 2. Rovaniemi Kärräniemi, 3. Posio Kuorikkikangas E, 4. Yli-Ii Korvala, 5. Yli-Ii Kuuselankangas, 6. Suomussalmi Joenniemi, 7. Suomussalmi Kalmosärkä, 8. Suomussalmi Joenniemi, 9. Suomussalmi Kukkosaari, 10. Outokumpu Sätös, 11. Outokumpu Laavussuo, 12. Lappeenranta Ahvensaari, 13. Okhta, 14. Tunguda III, 15. Tunguda XIV, 16. Tunguda XVII, 17. Fofanovo XIII, 18. Voynavolok XXIV, 19. Voynavolok XXVII, 20. Chernaya Guba IX, 21. Orovnavolok XVI.

their radiocarbon age and the age determined for wooden remnants. In our opinion, this can hardly be explained only by accidental factors.

DATES FROM COMPLEXES WITH ASBESTOS AND POROUS WARE

In the case of sites with Asbestos and Porous Ware, we have a specific category of charcoal samples that can be generally considered reliable – charcoal from housepits, especially from burned-down constructions of housepits. At least, these samples can be connected to a certain object – the dwelling. They are usually taken from a considerable depth, which greatly reduces the probability of contamination. Progressive increase, both in the number of AMS-datings of Asbestos and Porous Ware (from Finland and Karelia) and charcoal datings from excavated housepits, gives us an opportunity to compare the whole series of available radiocarbon datings.

While working on this paper, we gathered all the available radiocarbon dates from complexes with different varieties of Asbestos and Porous Ware. We have included datings from sites where both crust on pottery and charcoal from housepits has been dated, but, in addition, also radiocarbon dates from settlements where only either datings made of crust samples or of charcoal from dwellings exist. Our study includes ceramic varieties of Voynavolok type, mostly present on the Russian side of the present border, Orovnavolok type of Karelia (Zhulnikov 1999; 2005), and, closely resembling it, the Finnish types of Pöljä, Kierikki and Jysmä (Meinander 1954; Edgren 1964; Siiräinen 1967; Carpelan 1979; Lavento & Hornytzkyj 1996). In total, we have used 44 dates from 21 sites; 20 dates were made of food crust samples, 23 of charcoal samples and one of a tar sample (Tables 1–3). The majority of datings were taken from published sources (Schulz 2000; Karjalainen 2002; Pesonen 2004; 2006; Zhulnikov 2005; Sorokin et al. 2009), except for two AMS-dates of crust on ceramics from Karelian sites Voynavolok XXVII and Fofanovo XIII (Table 1), which are published here for the first time. Distribution of dated sites is presented in Figure 1. The dates are given in the form they have been published in the corresponding articles. Calibration of dates that were not calibrated in the original publications was performed using the OxCal-program, version 3.10 (Bronk Ramsey 2005).

Table 1. Radiocarbon dates from sites with Voynavolok type pottery.

Site	Code	Date	Material and context	cal BC (2σ)	Reference
Voynavolok XXVII	TA-1726	4280±80	charcoal: housepit wall	3150–2550	Zhulnikov 2005: 23
Voynavolok XXVII	TA-1748	4410±50	charcoal: housepit wall	3330–2900	Zhulnikov 2005: 23
Chernaya Guba IX	TA-2140	4340±80	charcoal: housepit wall	3350–2700	Zhulnikov 2005: 23
Voynavolok XXVII	Hela-2428	4693±35	crust on pottery	3630–3370	–
Fofanovo XIII	Hela-2812	4454±42	crust on pottery	3340–3005	–
Inari Vuopaja	Ua-4364	4805±85	crust on pottery	3660–3520 (1σ)	Carpelan 2004
Okhta	SPb_39	4390±100	crust on pottery	3364–2971	Sorokin et al. 2009

The dates were combined in several graphs (Figs. 2–4). These graphs clearly show that there is a stable tendency to crust samples from pottery to be somewhat older than charcoal samples from dwellings. Even if the ranges of calibrated datings do overlap in many cases, the extremes of the crust samples are always older than the extremes of the charcoal samples. We assume that such stable discrepancies cannot be explained only by the presence of younger organics in the charcoal samples from housepit walls – especially, if we take into account that the samples were taken from a considerable depth. Probably, here we might be dealing with some sort of natural law, which results in older radiocarbon ages of samples of charred crust on ceramic vessels. Yet another likelihood is that this law has to do with the composition of food that was cooked in these vessels.

DISCUSSION AND SUMMARY

We may assume that the differences in dates result from the characteristics of particular samples. In the case of charred crust we are most likely dealing with food residues. Accordingly, with regard to animal-based food, the residues on the walls of ceramic vessels should correlate with the animal and fish bones found on sites. Even though the collections of excavated bones are quite fragmentary due to several reasons (animal parts selectively taken to settlements during Stone Age, preservation, etc.), probably, they still reflect the eating habits or opportunities offered by the environment of the time.

The available results of osteological analyses of faunal assemblages from Finland dated to the Late Neolithic–beginning of Early Metal Period (c 4000–2000 cal. BC) indicate a very high propor-

Table 2. Radiocarbon dated charcoal samples from pithouse structures at sites with Orovnavolok, Kierikki or Pöljä type pottery.

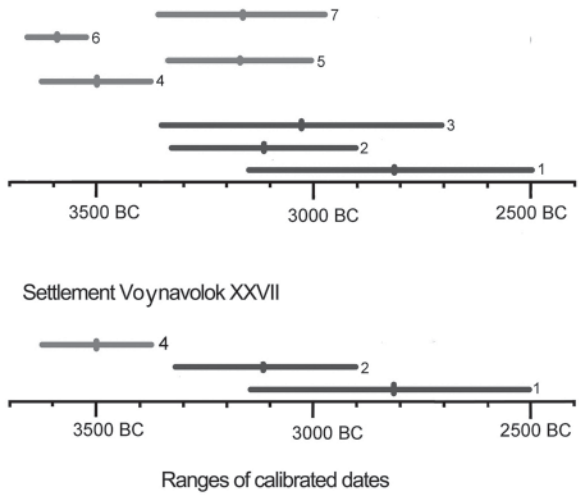
Site	Code	Date	Material	cal BC (2σ)	Reference
Voynavolok XXIV	TA-844	4200±80	charcoal	3050–2450	Zhulnikov 2005: 23
Voynavolok XXIV	TA-820	4250±70	charcoal	3030–2620	Zhulnikov 2005: 23
Tunguda III	TA-2270	4350±100	charcoal	3400–2650	Zhulnikov 2005: 23
Tunguda III	TA-2200	4220±60	charcoal	2930–2610	Zhulnikov 2005: 23
Tunguda XIV	TA-2018	4210±60	charcoal	2920–2580	Zhulnikov 2005: 23
Tunguda XIV	TA-2019	4340±80	charcoal	3350–2700	Zhulnikov 2005: 23
Tunguda XVII	TA-2289	4370±60	charcoal	3330–2880	Zhulnikov 2005: 23
Tunguda XVII	TA-2290	3920±60	charcoal	2570–2200	Zhulnikov 2005: 23
Orovnavolok XVI	TA-828	4200±20	charcoal	2890–2690	Zhulnikov 2005: 23
Kuorikkikangas	Su-2679	3940±70	charcoal	2620–2200	Pesonen 2006: 201
Kuorikkikangas	Su-2680	4140±90	charcoal	2900–2480	Pesonen 2006: 201
Yli-Ii Korvala	Hel-3918	4460±100	charcoal	3400–2850	Schulz 2000
Yli-Ii Korvala	Hel-3917	4340±100	charcoal	3350–2650	Schulz 2000
Outokumpu Sätös	Hel-4307	4180±90	charcoal	3000–2490	Karjalainen 2002: fig. 2
Outokumpu Sätös	Hel-4309	4300±90	charcoal	3350–2600	Karjalainen 2002: fig. 2
Outokumpu Sätös	Hel-4308	4380±90	charcoal	3350–2870	Karjalainen 2002: fig. 2
Outokumpu Laavussuo	Hela-153	4010±60	tar	2750–2300	Karjalainen 2002: fig. 2
Outokumpu Laavussuo	Hel-3974	4070±110	charcoal	2900–2300	Karjalainen 2002: fig. 2
Outokumpu Laavussuo	Hel-3975	4420±100	charcoal	3370–2880	Karjalainen 2002: fig. 2
Outokumpu Laavussuo	Hel-3976	4090±100	charcoal	2950–2300	Karjalainen 2002: fig. 2
Outokumpu Laavussuo	Hel-3977	4170±100	charcoal	3050–2450	Karjalainen 2002: fig. 2

Table 3. Radiocarbon dated samples of crust on ceramic sherds from sites with Kierikki, Pöljä or Jysmä type pottery.

Site	Code	Date	Material	cal BC (2σ)	Reference
Suomussalmi Joenniemi	Hela-100	4285±80	crust	2920–2880	Pesonen 2004: 97
Suomussalmi Joenniemi	Hela-102	4555±80	crust	3490–3100	Pesonen 2004: 97
Yli-Ii Korvala	Hela-136	4475±60	crust	3340–3030	Pesonen 2004: 97
Suomussalmi Kalmosärkä	Hela-138	4485±100	crust	3360–2930	Pesonen 2004: 97
Suomussalmi Kalmosärkä	Hela-139	4370±90	crust	3100–2890	Pesonen 2004: 97
Suomussalmi Joenniemi	Hela-143	4170±85	crust	2880–2580	Pesonen 2004: 97
Suomussalmi Kukkosaari	Hela-145	4390±100	crust	3310–2900	Pesonen 2004: 97
Rovaniemi Käräniemi	Hela-147	4450±105	crust	3350–2920	Pesonen 2004: 97
Lappeenranta Ahvensaari	Hela-360	4450±60	crust	3330–2940	Pesonen 2004: 97
Posio Kuorikkikangas E	Su-2682	4290±80	crust	3150–2600	Pesonen 2006
Outokumpu Sätös	Hela-345	4415±75	crust	3310–2920	Pesonen 2004: 97
Outokumpu Sätös	Hela-346	4390±70	crust	3100–2910	Pesonen 2004: 97
Outokumpu Sätös	Hela-347	4540±75	crust	3370–3100	Pesonen 2004: 97
Outokumpu Sätös	Hela-348	4290±60	crust	2920–2880	Pesonen 2004: 97
Outokumpu Sätös	Hela-349	4425±55	crust	3260–2920	Pesonen 2004: 97
Yli-Ii Kuuselankangas	Hela-52	4420±90	crust	3330–2920	Pesonen 2004: 97

tion of water resources (i.e. seal bones in coastal areas and fish bones in inland areas), reaching about 80% of the total assemblage (Savvateev & Vereshchagin 1978; Savvateev 1991; Kotivuori 1993; Hálen 1994: 164; Pesonen 1996: 112; Ukkonen 1996: 78; Koivunen 1997: 50; Karjalainen 1999: 186; Katiskoski 2002: 194; Leskinen 2002: 168; Pesonen 2006: 204; Mökkönen 2011: 37). Osteological analyses of faunal remains from Karelian sites of the Neolithic–Early Metal Period has so far been performed only once in the 1970s. Except for the settlements on the White Sea coast, which are characterized by the prevalence of seal bones, the rest of the analyzed assemblages contained very few bones of aquatic organisms, i.e. fishes (Savvateev & Vereshchagin 1978). Nevertheless, the assemblages analyzed in this study were obtained with the aid of nowadays rather outdated methods (yet fully acceptable at that time): excavating with shovels and without sieving the soil. Therefore, it is very likely that tiny fish bones were simply missed and thrown away.

Very interesting results were also obtained during recent (2010–11) excavations of the Fofanovo XIII site on the western coast of Lake Onega, in the outfall of River Shuya (Fig. 1). It is a workshop site for producing the so-called 'Russian-Karelian' stone axes and adzes (Tarasov 2003; Tarasov et al. 2010). The high amount of finds allows us to speak about some sort of 'mass-production': over 300 000 finds (mostly production debitage) were discovered in an area of just 30 square me-



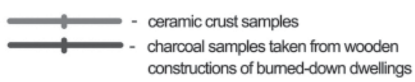


Fig. 2 Ranges of calibrated dates from sites with ceramics of Voynavolok type. For original data, see Table 1.

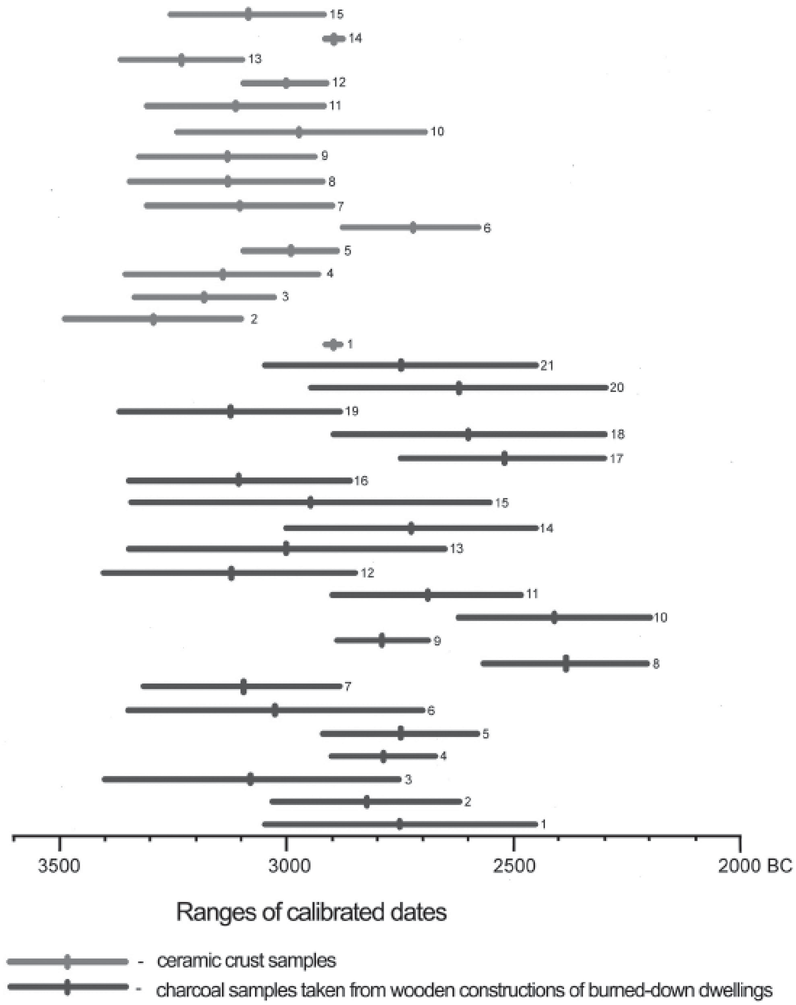


Fig. 3 Ranges of calibrated dates from sites with ceramics of Orovnavolok, Kierikki, Pöljä or Jysmä types. For original data, see Tables 2 & 3.

ters excavated on the site. The materials are still being analyzed and total statistics have not been prepared. Ceramics found in Fofanovo XIII can be attributed to the Voynavolok type. Besides other materials, the site provided also a very rich assemblage of bones, which, unlike all other sites in Finland and Karelia, are not calcinated, i.e. not burned. The site provides a unique opportunity to estimate the contents of full faunal assemblage, at least within the excavated area. Although osteological analysis has not been preformed yet, it is already possible to state that fish bones absolutely outnumber bones of all other animals.

Consequently, if marine mammals and fishes really constituted the biggest part of diet, then the use of ceramic vessels predominantly for cooking fishes and seals is very probable. Water organisms are a subject to the so-called 'reservoir effect', which results in older radiocarbon age compared to their real age (Vagner 2006: 166–8).

This phenomenon is described and explained more extensively in marine context (e.g. Dumond & Griffin 2002; Björck et al. 2003; Dutta 2008; Russell 2011). However, analogous effect has been reported to take place in freshwater situations (e.g. Vagner 2006: 167) and is observable in present-day freshwater fishes and mollusks (Fischer & Heinemeier 2003 with references). 'Reservoir' or 'hardwater effect' of freshwater fishes and mollusks serves as an example, which can be used to explain the differences between AMS-dates of charred crust on pottery and the age of their 'ar-

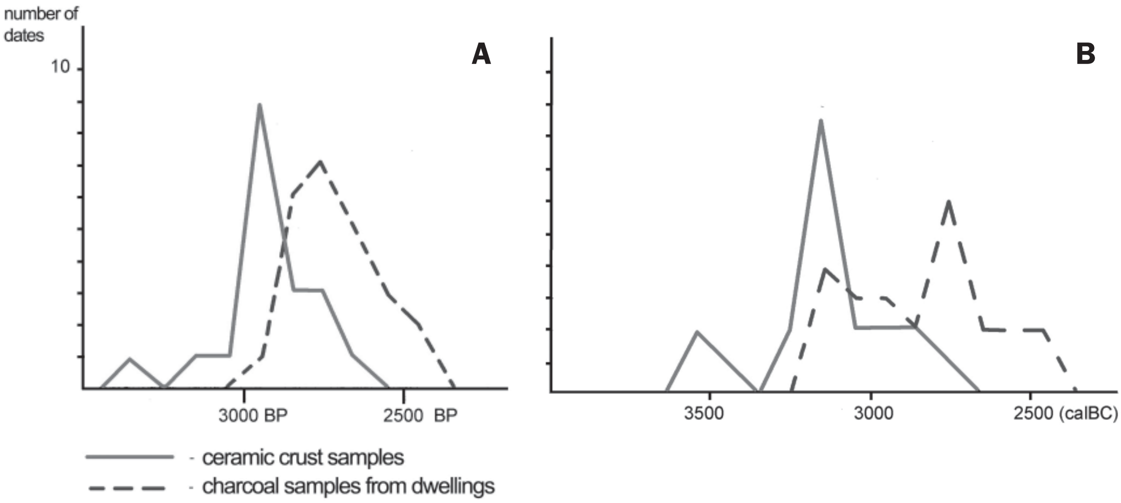


Fig. 4 Quantitative distribution of average values of non-calibrated (A) and calibrated (B) radiocarbon dates made of food crust samples and charcoal from dwellings from sites with Asbestos and Porous Ware of Voynavolok, Orovnavolok, Kierikki, Pöljä or Jysmä types.

chaeological context' in northern Europe (Fischer & Heinemeier 2003) as well as in regions situated to the north-west from the Caspian Sea (Van der Plikht et al. 2007), and has also been referred to in the context of 'too old' Comb Ware burials in the Eastern Baltic (Kriiska et al. 2007).

Since the crust on the walls of ceramic vessels may in most cases have been formed as a result of cooking water animals and fishes, we find it reasonable to assume that the obvious discrepancies in radiocarbon datings presented here might have something to do with the 'reservoir effect'. Domination of water or terrestrial organisms in cooked food can also be detected by the ratio of ^{13}C- and ^{15}N-isotopes. Especially the latter can provide good indication of fishes (Van der Plikht et al. 2007: 42), but data concerning these isotopes in material used for the analysis is published very seldom. Therefore, we cannot refer to isotope data for supporting our hypothesis. We can only mention that the values of $\delta^{13}C$ of the two dates recently obtained for the sites with Voynavolok type ceramics, published here for the first time, are close to the values characteristic for river fishes (-26.6‰ for the date from Voynavolok XVII, -27.5‰ for the date from Fofanovo XIII) (Fischer & Heinemeier 2003: Fig. 6; Van der Plikht et al. 2007: 42).

Since underestimation of the 'reservoir effect' might result in distorted views on the chronology of different types of ceramics and antiquities of the Late Neolithic–Early Metal Period in northern Europe, we propose a comprehensive investigation of this phenomenon. The analysis of chemical composition of crust on ceramic vessels might provide us with data about the actual composition of the cooked meals. Similarly, we might get information from series of new radiocarbon datings made of different materials, including both fish and animal bones, obtained from sites that functioned during relatively short time, for about 50–100 years (Fofanovo XIII as a possible example). Hence, we believe that the analysis of chemical composition of crust on ceramic vessels might be beneficial for obtaining solid grounds for the hypothesis presented here.

In any case, 44 radiocarbon dates collected from 21 sites clearly demonstrate the dissonance between the AMS-dates from charred crust found on the walls of ceramic vessels and the conventional ^{14}C-dates from charcoal found on Late Neolithic and Early Metal Period dwelling sites with Asbestos and Porous Ware in Finland and Russian Karelia. As a result, dates from charred crust are systematically older than the ones from charcoal and one of the explanations probably lies in the 'reservoir effect'.

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