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NEW ^{14}C DATES OF NEOLITHIC AND EARLY METAL PERIOD CERAMICS IN LITHUANIA

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ABSTRACT. Twenty-three samples of charred food remains, charcoal, burned animals, and human bones from 14 Lithuanian prehistoric sites were dated by radiocarbon as part of a dating project oriented towards renewing the prehistoric ceramics chronology. The new dates modified the dating of ceramic styles by hundreds to a thousand years. Three Textile Ware sherds were dated to 4230–2920 cal BC—the oldest known dates of Textile Ware pottery in the East Baltic. The organic-tempered pointed-bottomed Narva and Combed-like Wares were dated to 3970–3370 cal BC, while Bay Coast Ware (*Haffküstenkultur*, *Rzucewo*), including vessels decorated with cord impressions, were dated to 3940–3540 cal BC, i.e. to a period well preceding the Corded Ware/Battle Axe horizon in Europe. Three dates of Globular Amphorae Ware placed the phenomenon directly beyond the Bay Coast chronology, i.e. in 3450–2920 cal BC. Chamotte-tempered Corded Ware from SE Lithuania was dated to 2840–2570 cal BC. The first absolute dating of coarse ware of the Žalioji type pointed to a period of 760–515 cal BC instead of the previously assumed 2nd millennium cal BC. Cremated human bones from urns found at Paveisininkai, Kernavė, and Naudvaris cemeteries were dated to 790–380 cal BC. Accelerator mass spectrometry (AMS) dates obtained from charred food remains should be treated with a certain caution due to a possible freshwater reservoir effect that has not yet been examined in Lithuania.

INTRODUCTION

Recent accelerator mass spectrometry (AMS) datings have essentially changed the archaeological chronology for the Holocene period almost throughout the world. One essential and specific type of dated material has been ceramic sherds with charred crust adhered to their surfaces. Ceramics have proven to be very practical material for laboratory dating because there is always a preliminary pottery chronology, which provides a good starting point for hypotheses and revising of the chronology by the AMS method. Ceramics have usually been well documented, and samples for AMS dating should represent already-known types and styles. Together, these groups normally form chronological series, and in addition they have parallels in other countries where chronologies are available for comparison.

In Lithuania, over 130 dates have been obtained for Stone Age and Early Metal period sites up to 2010. However, most of those dates do not have straightforward associations with prehistoric pottery, and only a handful of AMS dates (Piezonka 2008) came from food residues on pottery. The great potential of the radiocarbon AMS method for revising chronological schemes has already been demonstrated by several studies in the East Baltic (Timofeev et al. 1995, 2004; Kriiska et al. 2005, 2007). In Lithuania, a special dating project was developed and implemented in 2010 by the authors of the current publication. The aim of the project was to revise the traditional typological periodization and chronology of prehistoric pottery.

METHODS

The samples were collected at the storage facility of the National Museum of Lithuania. For sample selection, preferences were set for typical vessels of various styles and for the upper parts of the vessels. The museum's inventories were studied and also visual inspection was implemented with and

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without the solvents C_2H_5OH and C_3H_6O, to avoid samples contaminated with intrusive carbon that had become trapped in the ceramic matrix during the conservation or restoration processes. Twenty-two samples of charred food remains and burned animal and human bones were ^{14}C AMS dated at the Dating Laboratory, University of Helsinki. A single charcoal sample was also dated by ^{14}C using a conventional beta-counting technique at the Radioisotope Research Laboratory, Nature Research Centre, Vilnius.

The cremated bone samples were pretreated according to the accepted methods (Lanting et al. 2001). The bone material was first washed with distilled water, dried at 100 °C, and crushed. Then, possible organic contamination was removed by keeping the samples in 1.5% sodium hypochlorite (NaClO) solution (48 hr). After neutralization to pH = 7, the samples were treated with 1M solution of acetic acid ($C_2H_4O_2$) (24 hr), and then again neutralized and dried. Eventually, the sample carbon of the inorganic carbonate of the bone was extracted as CO_2 with a saturated solution of phosphoric acid (H_3PO_4).

The charred crust samples were pretreated with the acid-alkali-acid (AAA) method. The samples were first acid-washed with 2% hydrochloric acid (HCl) at 90 °C until the color of the solution did not change. This was followed by a sodium hydroxide (NaOH) wash (80 °C) until all the soluble organic fractions were removed. The samples were then acid-washed again (1% HCl for 2 hr at 90 °C) to ensure removal of atmospheric CO_2 possibly chemically adsorbed by NaOH, and neutralized. Eventually, the samples were packed inside evacuated glass ampoules together with CuO grains and subsequently combusted (10 hr at 520 °C) to extract CO_2.

For both types of samples, the formed CO_2 was purified, subjected to isotope ratio mass spectrometry (IRMS; Finnigan MAT Delta E) for $\delta^{13}C$ measurements and eventually reduced to carbon, which was then pressed into an AMS cathode. The ^{14}C concentration was measured by AMS at the Uppsala Tandem Laboratory. All ^{14}C dates were calibrated by OxCal 4.1 software (Bronk Ramsey et al. 2010) and the calibration curve IntCal09 (Reimer et al. 2009).

SITE AND SAMPLE DESCRIPTIONS

The dated sites are located throughout Lithuania, which means that both coastal and inland sites are represented (Figure 1). This is essential when researching the dating methodology and the influence of the water reservoir effect on the results. Further, the difference between inland and coastal areas is essential when trying to understand the influences and development of large cultural zones. These points of view will be discussed later in the article.

Kernavė cemetery (54°53′6.13″N, 24°50′2.67″E) is situated on the right bank of the Neris River. It was excavated in 1989–1990 and an area of 656 m^2 was uncovered and 18 cremated graves were explored. Burned bones had been placed inside stone boxes, in simple pits or in ceramic urns within pits. Grave goods were preserved only at 3 graves. The materials found included an iron ring, a bronze pin with a spiral ring, 2 small bronze chain links, and a spiral temple ornament. Mesolithic, Early Bronze Age, Roman period, and Medieval artifacts were also found at the cemetery area. No ^{14}C dates were previously obtained. The cemetery was attributed to the so-called Brushed Pottery culture and dated by typological background to the 3rd or 2nd centuries BC (Luchtanas 1992a). In 2010, a sample of 4.4 g of cremated human bones was taken from the inner material of an urn from grave No. 5. The fragments of burned bones belonged to a child up to 7 yr old (Jankauskas 1992).

Naudvaris cemetery (55°3′9.84″N, 22°28′17.35″E) is situated on a sandy dune ~800 m from the northern bank of the Nemunas River. An area of ~600 m^2 was uncovered in 2001–2005 and 2009.

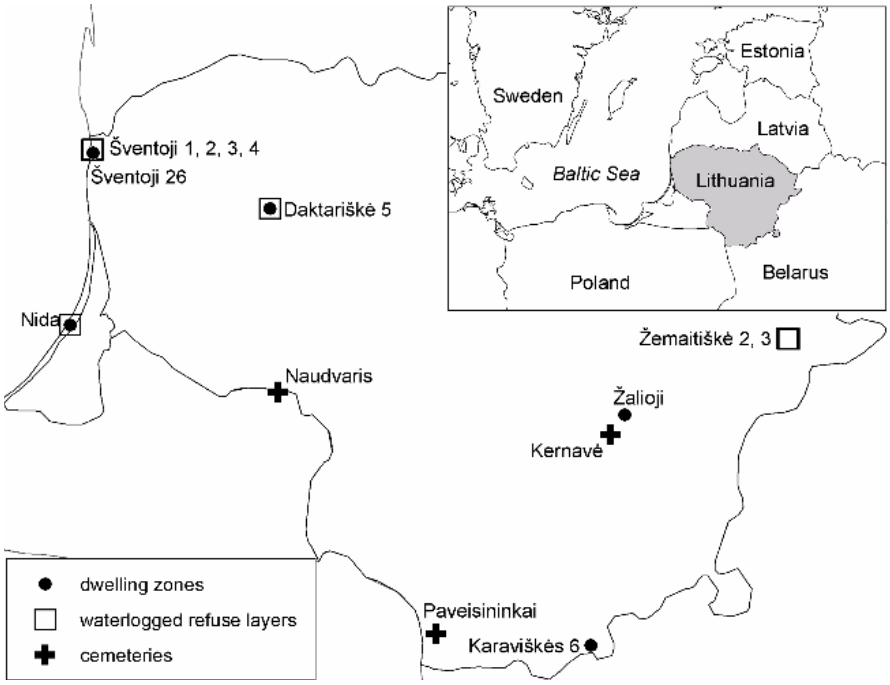

Figure 1 Stone Age and Bronze Age sites dated within the project

Twelve graves including 11 cremations and a single inhumation were investigated. Burned bones were placed into pits without urns or they were found inside the urns. The burned bones from an urn in grave No. 2 were dated to 970–830 cal BC (Ki-10641: 2750 ± 60 BP; Šiaulinskas 2006). In 2010, a sample of 9.4 g of cremated human bones was taken from the inner contents of the urn found at grave No. 1.

Paveisininkai cemetery (54°4′30.73″N, 23°36′26.72″E) is situated on a large hill at the bank of Veisiejis Lake, close to the Lithuania-Poland border. The hill was fortified during subsequent periods when the cemetery had been abandoned there. The cemetery and the hillfort were investigated in 1962. An area of 240 m^2 was uncovered on the top platform of the hill and on a rampart. Altogether, 27 cremations were found in the cemetery. Urns or cremated bones without an urn were placed into simple pits. Otherwise, special stone constructions were arranged for burials. The cemetery was dated by typological background to the 1st millennium BC (Kulikauskas 1982). In 2010, a sample of 5.2 g of cremated human bones was taken from the inner material of an urn found in grave No. 1.

Karaviškės 6 site (54°1′34.71″N, 24°40′50.08″E) is situated in SE Lithuania, on the southern bank of the former lake. The Karaviškės 6 site was investigated in 1997–2001 and 2003–2005. So far, an area of 1245 m^2 has been uncovered. The scattered remains of a Corded Ware settlement were detected at the western part of the site, across a coastal area 50 m long and 15 m wide. The minimum number of Corded Ware pots was 37. Clay mass was tempered with chamotte and sand. Another characteristic feature of Corded Ware was 1 or 2 wavy or ornamented collars moulded below the rim. Only 4 vessels were ornamented by cord impressions. Some pressure-flaked flint knives, heart-shaped arrowheads, and fragments of ground flint axes made from local and imported Krzemionki flint were also found there (Piličiauskas 2006). Two fireplaces without ceramics were dated to the

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Middle Neolithic, i.e. 3790–3650 cal BC (Ki-9452: 4940 ± 70) and 3690–3520 cal BC (Ki-9453: 4820 ± 70). Attempts to find macroscopic food residues on corded sherds gave no results. The only way to establish the chronology for the group was to date an organogenic material found together with the ceramics in pits or other closed contexts. In 2010, a sample of 1.7 g of burned animal bones was taken from a small, shallow pit that contained sherds classified as chamotte-tempered Corded Ware.

Šventoji 1 site (56°1′1.92″N, 21°5′21.85″E), together with the other 42 prehistoric sites known from the same region, is situated in NW Lithuania in the coastal zone (Piličiauskas et al. 2011). Waterlogged refuse layers (gyttja) accumulated at littorals of a lagoonal lake were excavated at the Šventoji 1–4 sites. The Šventoji 1 site was investigated in 1967–69, 1974–1978, and 2006. An area of 6750 m^2 was uncovered and 6 ^{14}C dates were obtained (Rimantienė 2005). The site dates to 3520–2350 cal BC. Most of Šventoji 1 ceramics inspected at the Lithuanian National Museum revealed traces of various lacquers, glues, and other restoration materials. A large part of the Globular Amphorae vessel, with very impressive and elaborate ornamentation, was found during an extensive survey by test-pitting in 2006 (Brazaitis 2007). Unfortunately, the largest fragments have been saturated with polymers. Therefore, another sample was chosen for AMS dating. It was a single small sherd with mineral-tempered clay mass that was found ~30 m north of the site of the aforementioned pot.

Šventoji 2 site (56°0′53.75″N, 21°5′10.22″E) was investigated in 1967–1969. An area of 592 m^2 was uncovered (Rimantienė 2005; Juodagalvis 2006; Brazaitis 2008). Šventoji 2 and 4 sites are situated side-by-side and were dated together to 4040/3700–2580 cal BC by 19 ^{14}C dates obtained from wooden artifacts and animal bones. In 2010, a single sherd with coarse stone temper and cord impressions was chosen for direct AMS dating. It was classified as the Globular Amphorae style.

Šventoji 3 site (56°0′57.18″N, 21°5′13.20″E) was investigated in 1971–1972, 2004–2005, and 2007. An area of 888 m^2 was uncovered and the site was dated to 3310–2580 cal BC (Rimantienė 2005; Juodagalvis 2006; Brazaitis 2008). In 2010, 3 samples of charred crust were taken for AMS dating from the upper parts of porous ceramics tempered with crushed shells. The ceramics represent the Narva style, which has particular parallels with Late Sārnate Ware from SW Latvia (Bērziņš 2008).

Šventoji 4 site (56°0′53.23″N, 21°5′5.87″E) was investigated in 1972, 1986–1995, 1997–1998, and 2002–2006. An area of 1510 m^2 was uncovered during archaeological excavations and an additional area of 999 m^2 was investigated by test-pitting (Rimantienė 2005; Juodagalvis 2006; Brazaitis 2007). Visual examination of the ceramics from 2003 revealed no traces of polymers. One sample of charred crust was taken for AMS dating from a ceramic fragment with porous clay mass. The sherd was classified as Narva Ware.

Šventoji 26 site (56°0′8.08″N, 21°5′27.29″E) is situated on the eastern bank of the former lagoonal lake, further south from the sites Šventoji 1–4. A dwelling area was situated on a sandy plain formed during the maximal transgression of the Littorina Sea. It was investigated in 1966, 1970–1971, and 2002–2005. An area of 736 m^2 was uncovered during the archaeological excavations. No ^{14}C dates were obtained, however (Rimantienė 2005; Juodagalvis 2006). Only 1 sherd with adhered food remains was found during inspection of the Šventoji 26 materials. The profile and ornamentation with pits and toothed stamp impressions resemble Typical Combed Ware as well as other Combed-like ceramics in the East Baltic.

Nida site (55°17′52.53″N, 20°58′48.46″E) is situated on the SW edge of coastal Lithuania, in Curonian Spit. It is the largest and most famous site of Bay Coast culture in Lithuania. The site has been

known since 1833. In 1973–1978, an area of 4640 m^2 was uncovered in which about 100,000 ceramic sherds and 6000 stone artifacts and flakes were collected. Seventy-seven fireplaces and 300 postholes were identified and 8 ^{14}C dates were made (Rimantienė 1989; Mažeika and Petrošius 1998; G I Zaitseva, personal communication, 2010). After calibration of the ^{14}C dates, a very wide chronological interval became evident, i.e. about 11,170–930 cal BC. However, the head of excavation, R Rimantienė, excluded the youngest and oldest ^{14}C dates due to possible dating errors. A large portion of Nida's huge archaeological collection was reviewed during the current project. A few dozen sherds were recognized as suitable for direct AMS dating. It might be supposed that sherds with preserved food crust came from the deepest and most waterlogged parts of the cultural layer, i.e. littoral of the former lagoon. Five samples of Bay Coast Ware, including sherds with some elements common to Globular Amphorae style, were chosen for AMS dating.

Daktariškė 5 site (55°47′54.82″N, 22°23′15.68″E) is situated in W Lithuania near Lake Biržulis. The site has a higher area used as a dwelling section and a lower part with waterlogged refuse layers. It was investigated in 1987–1990, and an area of 648 m^2 was uncovered. More than 11,000 ceramic fragments, 326 flints, 132 amber artifacts, many stone net sinkers, and various bone tools were collected during the excavations. Five ^{14}C dates were obtained from wood samples (Butrimas and Ostrauskienė 2004). The site's age falls into a period of 4500–2410 cal BC. Four sherds with stylistic and technological differences were chosen for AMS dating. The sherds represent 4 styles of Neolithic pottery, i.e. Combed-like, Narva, Textile, and Globular Amphorae Wares.

Žemaitiškė 2 site (55°15′36.81″N, 26°6′29.66″E) is located in the NE Lithuania, near Lake Kretuonas. It was investigated in 1979, 1980, 1983, and 2000–2001. An area of 403 m^2 was uncovered. More than 1000 vertical wooden piles sticking through lake sediments were registered during field work. Fragments of wooden fishing equipment, organic-tempered pottery, flint artifacts, and animal bones were also recovered from a waterlogged refuse layer. Eleven ^{14}C dates were obtained mostly from wooden piles (Girininkas 2004). Lake littoral was used for fishing with stationary equipment and also as dumping area at least since 7530–7360 cal BC, while the most active phase of human activities could be placed between 4940 and 1750 cal BC there. Charred food crust was well preserved on plenty of sherds. However, the site chronology had already been well studied. Therefore, a single sherd from a thick-walled textile-impressed pot was chosen solely for AMS dating.

Žemaitiškė 3 site (55°15′34.26″N, 26°6′58.76″E) was investigated in 1984–1985. An area of 240 m^2 was uncovered. Wooden piles, ceramics of the Late Narva and Textile styles, and other artifacts and ecofacts were collected at littoral sediments (Girininkas 1990). Two ^{14}C dates were produced for wood and charcoal samples (Antanaitis-Jacobs and Girininkas 2002). In addition, 3 AMS dates were obtained on charred food crust scraped out of pottery (Piezonka 2008). According to previously published data, the site Žemaitiškė 3 should be dated to 4650–2920 cal BC. There were a lot of ceramic sherds with preserved charred food remains at Žemaitiškė 3. In 2010, a single sherd from a thin-walled textile-impressed pot was chosen for AMS dating.

Žalioji site (54°57′52.98″N, 24°56′14.82″E) represents a dwelling site in the inland milieu. In 1952, enormous ceramic concentrations were noticed where sands had been windblown. The site was investigated in 1953 and 1958. The total area excavated is not clear today because only ceramic concentrations were excavated, leaving the interspaces unexplored. However, it seems that more than 12 ceramic concentrations were investigated. They were 3–5 m in diameter and distributed at distances of a few meters or more. Almost every ceramic concentration was associated with sunken fireplaces full of juniper and pine charcoals. Very fragile clay masses with abundant coarse granite and the absence of any decoration were characteristic features of ceramics that were later called either Žalioji or Žalioji-Bratoniškės Ware (Kulikauskienė 1958; Rimantienė 1999a). Food residues

have not been preserved on Žalioji Ware sherds. A single large piece of charcoal has been taken from the "hearth of 5th building." However, all ceramics found at the Žalioji site are stylistically uniform and the ^{14}C date should be addressed to the best-reconstructed pots with a high probability.

RESULTS AND DISCUSSION: CHRONOLOGY OF POTTERY STYLES

Twenty-three samples from 14 Lithuanian prehistoric sites were dated by the ^{14}C method in 2010–2011 (Table 1). Twenty-two samples of charred food remains and burned animal and human bones found at 13 prehistoric sites investigated in 1966–2006 were dated by ^{14}C AMS. A single charcoal sample from the Žalioji site excavated in 1953 was also dated by conventional ^{14}C. The 23 dates split into 2 periods, i.e. 4230–2570 and 790–380 cal BC (Figure 2). Ceramics from the period 2500–1500 cal BC (Late Corded and Late Narva Wares) revealed no good samples for direct dating, while the period of 1500–800 cal BC remains a very obscure timespan in Lithuanian archaeology. Few ceramic materials bearing stylistic traits of Trzciniec and post-corded groups might be dated to that period based on typological background. However, no suitable sherds for AMS dating have been found at Lithuanian museums. The beginning of the Bronze Age is also unclear in the other Baltic countries. This is surprising because in Fennoscandia and Russia, this timeframe represents the active period of development of trade contacts and societies (Lavento 2001), so this needs to be investigated further.

Table 1 AMS (dates nr 1–22) and conventional ^{14}C (date nr 23) dating results.

Nr	Site	Type of sample	Lab code	^{14}C age (BP)	δ^{13}C (‰)	cal BC (1 σ)
1	Žemaitiškė 2	Charred crust	Hela-2470	4351 ± 32	–30.4	3010–2910
2	Žemaitiškė 3	Charred crust	Hela-2566	5319 ± 35	–34.8	4230–4060
3	Daktariškė 5	Charred crust	Hela-2471	5115 ± 34	–28.8	3970–3810
4	Daktariškė 5	Charred crust	Hela-2599	4862 ± 36	–29.1	3695–3640
5	Daktariškė 5	Charred crust	Hela-2573	4661 ± 32	–27.6	3510–3370
6	Daktariškė 5	Charred crust	Hela-2472	4370 ± 32	–28.3	3015–2920
7	Nida	Charred crust	Hela-2467	5041 ± 34	–31.2	3940–3785
8	Nida	Charred crust	Hela-2474	5005 ± 34	–32.1	3910–3710
9	Nida	Charred crust	Hela-2469	4946 ± 34	–31.2	3770–3660
10	Nida	Charred crust	Hela-2468	4917 ± 34	–30.5	3710–3650
11	Nida	Charred crust	Hela-2475	4854 ± 34	–28.0	3690–3540
12	Šventoji 1	Charred crust	Hela-2476	4625 ± 32	–26.3	3500–3360
13	Šventoji 2	Charred crust	Hela-2477	4507 ± 32	–26.5	3340–3110
14	Šventoji 3	Charred crust	Hela-2461	4827 ± 33	–26.5	3650–3540
15	Šventoji 3	Charred crust	Hela-2462	4756 ± 32	–25.1	3630–3520
16	Šventoji 3	Charred crust	Hela-2465	4783 ± 32	–26.4	3640–3530
17	Šventoji 4	Charred crust	Hela-2464	4805 ± 33	–27.1	3640–3530
18	Šventoji 26	Charred crust	Hela-2463	4835 ± 34	–27.0	3660–3540
19	Karaviškės 6	Burned animal bones	Hela-2581	4084 ± 31	–25.0	2840–2570
20	Paveisininkai cemetery, grave 12	Cremated human bones	Hela-2480	2528 ± 30	–24.6	790–570
21	Kernavė cemetery, grave 5	Cremated human bones	Hela-2578	2518 ± 30	–22.6	770–560
22	Naudvaris cemetery, grave 1	Cremated human bones	Hela-2579	2317 ± 30	–19.7	405–380
23	Žalioji	Charcoal	Vs-2028	2470 ± 50	—	760–515

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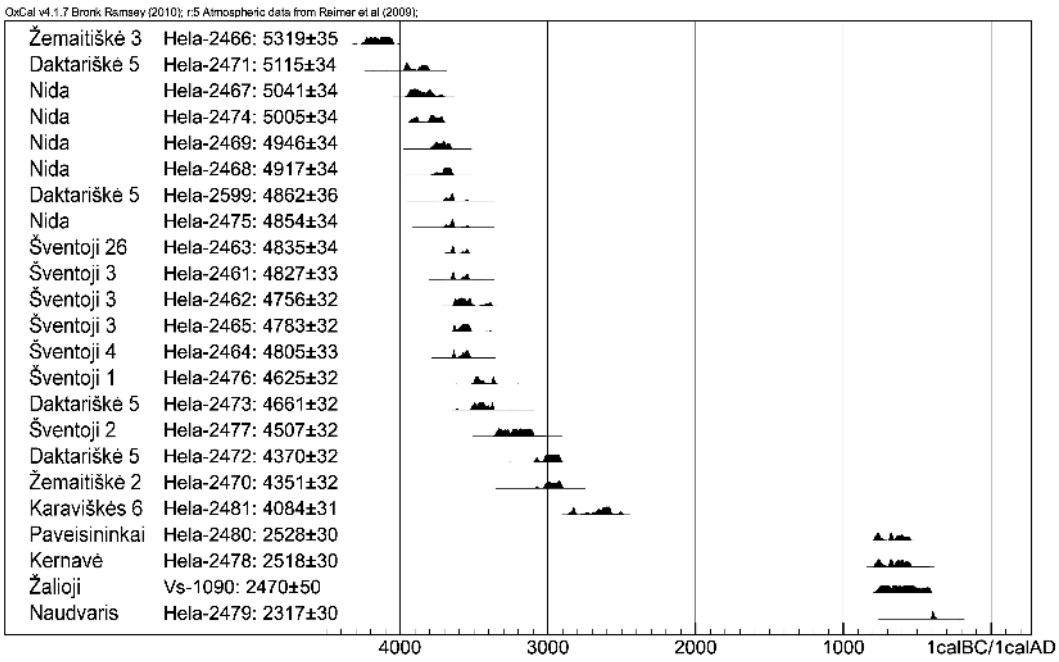

Figure 2 Comparison between calibrated ^{14}C dates

The beginning of the Neolithic is associated with the appearance of ceramic technology in the East Baltic. It is generally assumed that this moment preceded a shift from a hunter-gatherer economy to agriculture. The date 5500/5300 cal BC was proposed for the beginning of the Neolithic in Lithuania (Antanaitis-Jacobs and Girininkas 2002). However, the date was not confirmed by the oldest direct dates of Lithuanian ceramics. Food crust on ceramics demonstrated a younger age. Today, 4650–4520 (Piezonka 2008) and 4230–4060 cal BC are the oldest direct dates of Lithuanian ceramics, both coming from the Žemaitiškė 2 site. We cannot move away from the hypothesis that ceramic production began earlier, but we simply do not have such old radiometric dates available in Lithuania yet.

Three sherds with textile or textile-like impressions were dated during the current project. Thin-walled sherds from the Žemaitiškė 3 and Daktariškė 5 sites demonstrated older ages (4230–4060 and 3695–3640 cal BC, respectively) compared to the date of a thick-walled vessel from the Žemaitiškė 2 site (3010–2910 cal BC). The result is of particular importance: 4230–4060 cal BC is the earliest date for textile-impressed pottery in the East Baltic. The dating has been achieved from the inland context, however. It should imply that the beginning of the whole phenomenon in Europe originated somewhere in the SE part of eastern Europe, but only if the AMS dates of food remains were not greatly influenced by the freshwater reservoir effect (see discussion below). Even the youngest date of textile-impressed pottery from Lithuania (3010–2910 cal BC) points to the earliest stage of Textile Ware in the East Baltic (see Kriiska et al. 2005). New AMS dates from NE and W Lithuania demonstrate that Narva Ware was not replaced by Textile Ware in the 3rd millennium cal BC as has been previously proposed (Brazaitis 2005a). It seems that Narva Ware and textile or textile-like impressed ceramics coexisted in the 4th millennium cal BC in the SE Baltic.

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Narva ceramics from W Lithuania (Daktariškė 5, Šventoji 3 and 4 sites) were dated by 5 AMS dates to a period of 3650–3370 cal BC. Two previously published AMS dates from NE Lithuania (Piezonka 2008) expand the chronology of Narva Ware to the 5th millennium cal BC, i.e. 4650–3970 cal BC. We can expect the beginning of the Narva style in the western part of Lithuania to be later than in the eastern part. Four AMS dates from coastal Šventoji 3 and 4 sites fall into a very narrow range of 3650–3520 cal BC, while wood and bone dates suggest a chronology of 4040/3700–2580 cal BC there (Rimantienė 2005). At the Daktariškė 5 site, a Narva vessel ornamented with knot/plait impressions demonstrated a slightly younger age (3510–3370 cal BC) compared to the Šventoji sites. The elongated AMS chronology (by combining new results with previous dates presented by Piezonka 2008) and wide stylistic variations of Narva Ware at inland sites indicate that classification of porous pointed-bottomed ceramics could be elaborated and more stylistic groups might be distinguished.

Two sherds dated by AMS were classified as Combed-like Ware. Profile and ornamentation (pits and toothed stamp) of the dated vessel from the Šventoji 26 site resemble Typical Combed Ware, though clay mass with mollusk shells and chamotte is not common for that type of ware. A sherd from Šventoji 26 demonstrated an age of 3660–3540 cal BC. A theory that the Šventoji 26 site was later in comparison to other Šventoji sites (Rimantienė 2005) was not proven by direct pottery dating. The Šventoji 26 site is situated only 1.5 km away from Šventoji 3 and 4 sites where Narva ceramics were dated almost to the same period of 3650–3520 cal BC. A similar ^{14}C chronology for different ceramic styles may be evidence of overlapping material culture and multilinear social developments in the coastal area within communities characterized by porous clay mass and pointed-bottomed ceramics. Another vessel of Combed-like Ware was found among the Daktariškės 5 site materials. It was decorated by a toothed stamp. The AMS date of food residues demonstrated an age of 3970–3810 cal BC. The date is in good agreement with food residue dates for ceramics with some Typical Combed Ware traits (i.e. so-called Early Sārnate Ware) in SW Latvia (Ua-15984: 5065 ± 75, 3960–3790 cal BC, Bērziņš 2008: Table 2).

The Bay Coast culture (*Pamariai*, *Haffküstenkultur*, *Rzucewo*) has been explained as a result of interaction of the "indigenous" Narva culture and "foreign" Pan-European Horizon of Corded Ware in the beginning of 3rd millennium cal BC (Rimantienė 1980, 1984, 2005). New AMS dates from the Nida site hardly questioned the concept. Five dates of charred food remains fell into a period of 3940–3540 cal BC. Those dates are older by 200–400 ^{14}C yr BP than the earliest ^{14}C dates made on terrestrial materials from Nida (Rimantienė 1989). The oldest Bay Coast sites in NE Poland and the Kaliningrad region were ^{14}C dated to ~3500–3000 cal BC (Mazurowski 1996, 1999; Król 2003; Saltsman 2004, 2009). All these dates support the Bay Coast phenomenon preceding the Corded Ware/Battle Axe horizon in the coastal zone of the SE Baltic. Moreover, the typologically constructed idea of lateness of the Nida ceramics compared to other Bay Coast sites (Girininkas 2004; Brazaitis 2005b) may be also somewhat misguided. Dates from food remains (3940–3540 cal BC) as well as charcoal samples (Vs-321: 4630 ± 120 and Vs-631: 4620 ± 110; Mažeika and Petrošius 1998; 3630–3120 cal BC) demonstrated the site had been used during the oldest stage of the Bay Coast phenomenon as well as during later times up to ~1000 cal BC (Le-1976: 2850 ± 40, 1110–930 cal BC; date provided by G I Zaitseva). A mixture of some stylistically different and possibly chronologically distant styles is visible when looking at Nida ceramics. The narrow range of AMS dates does not prove short use of the site. It was just not possible to date sherds of other and possibly younger stylistic groups due to the lack of food residues on those sherds.

Three AMS dates were obtained for Globular Amphorae Ware. Two coastal sites, Šventoji 1 and Šventoji 2, produced intervals of 3450–3360 and 3340–3110 cal BC, while a sample from the inland

site Daktariškė 5 was dated to 3015–2920 cal BC. The AMS dates do not seem strange within the context of the sites. However, they appeared older by several hundred yr BP when compared to the traditional Globular Amphorae chronology proposed for coastal Lithuania (Szmyt 2001). In terms of only new AMS dates, it seems that the Globular Amphorae chronology extends the Bay Coast chronology without any pause. Stylistic similarities between those styles and ^{14}C dates allow us to speculate about a spread of Globular Amphorae style from the coastal zone with Bay Coast sites toward the inland part of the country and also to the north along the Baltic coast up to the Šventoji River. One more matter may be discussed here. The Narva AMS chronology (3970–3530 cal BC) seems to overlap with the Bay Coast chronology (3940–3540 cal BC) in coastal Lithuania. However, dated materials were found in 2 regions, i.e. Šventoji and Nida, with a distance of 84 km between them (Figure 1). Globular Amphorae AMS chronology (3450–3110 cal BC) does not overlap with AMS dates of Narva and Combed-like Wares (3970–3530 cal BC) in the Šventoji region. It seems that very different cultural traditions of organic-tempered pointed-bottomed and mineral-tempered flat-bottomed ceramics did not coexist within the limits of this single ecosystem, which was a lagoonal lake in the case of the Šventoji region. Today, the occurrence of Narva/Combed-like and Globular Amphorae/Bay Coast ceramics in the same contexts should be recognized as a mechanical mixture of asynchronous materials. Some observations on stratigraphy made at Šventoji 2 and 4 sites also agree with the idea of the chronological nature of stylistic differences there (Rimantienė 2005).

The question of pronounced change in ceramic production gets even more intriguing when looking at the other spheres of material culture, economy, and settlement pattern in the Šventoji region. During the Middle Neolithic (4200–2900 cal BC), all communities in the region based their economies on seal hunting and freshwater fishing (Rimantienė 1989; Daugnora 2000; Stančikaitė et al. 2009), while weak signs of agricultural activities come from pollen analyses only. Substantial changes were not documented for fishing and hunting equipment yet. The settlement pattern also demonstrates continuity with some expansion expressed in the discovery and use of new fisheries and dwelling areas (Piličiauskas et al., forthcoming). A change in ceramic production may indicate some fundamental shift to an agricultural mentality rather than to a new type of economy in the case of coastal Lithuania.

The term Corded Ware is used very diversely in the East Baltic. An attempt at direct AMS dating of chamotte-tempered Corded Ware with very characteristic wavy mouldings (collars) was made within the dating project. However, no food residues on such ceramics have been found in Lithuania. A small pit containing Corded Ware sherds and burned animal bones investigated at Karaviškės 6 site in SE Lithuania has been targeted. AMS dating on bones revealed a date of 2840–2570 cal BC. However, that date fits well with the previous chronology of Corded Ware in the East Baltic (Antanaitis-Jacobs and Girininkas 2002). A very characteristic vessel type of the style—S-profiled pot with collars—was ^{14}C dated in Poland to 2930–2680 and 2460–2235 cal BC (Czebreszuk and Szmyt 2001). That uniform pottery style was also found all over the East Baltic; however, no more absolute datings of it are available.

In addition to Neolithic ceramics, 3 burial sites of the Early Metal period (1800–1 cal BC) were also dated by AMS during the current project. Cremated human bones from ceramic urns were sampled. The first absolute datings at the Kernavė and Paveisininkai cemeteries produced ages of 770–560 and 790–570 cal BC, respectively. A new AMS date from Naudvaris cemetery (405–380 cal BC) is quite later than an earlier ^{14}C date (Ki-10641: 2750 ± 60, 970–830 cal BC). Both dated graves were situated side-by-side. They share similar structures and ceramic traits. The excavated area does not demonstrate the high degree of disturbance that should be common in the case of a cemetery used

over a very long time. Thus, we believe that the previous conventional ^{14}C date should be revised by the new dating.

The conventional ^{14}C date obtained for the dwelling site Žalioji (760–515 cal BC) is 600–800 yr younger than previously thought. In the traditional culture-historical approach, pottery of the Žalioji type was considered a cultural and genetic bridge connecting Neolithic and Iron Age cultures through the dark period of the Early and Middle Bronze Age. The Žalioji type was dated to the 2nd millennium BC by the typological method only or a proposed chronology was based on a single ^{14}C date (Vs-324: 3540 ± 90 BP, 2010–1750 cal BC) from the Žemieji Kaniūkai site (Girininkas 1979; Luchtanas 1992b; Rimantienė 1999a,b; Grigalavičienė 1995). We were unable to find any argument why the ^{14}C date from the Žemieji Kaniūkai site (Jablonskytė-Rimantienė 1963) should belong to the Žalioji type or period. It is a multiperiod, non-stratified site with mixed asynchronous materials in the sandy cultural layer. D Brazaitis was the first researcher to question the traditional dating of Žalioji Ware. He proposed that unfortified sites with Žalioji-type pottery coexisted with the first hillforts during the Late Bronze Age (Brazaitis 2005a). The new ^{14}C date supports that view. Pottery of similar technological and stylistic traits is also known in the Lake Luokesa area not far from the Žalioji-type pottery distribution area in NE Lithuania. Two pile dwelling sites there were dated to ~800–400 cal BC (Menotti et al. 2005).

SOME REMARKS ON WATER RESERVOIR EFFECTS

Soon after the first datings on food remains were made, it became evident that the AMS method often gives an earlier chronology for the material than what had been assumed before. Marine and freshwater reservoir effects were addressed for the explanation. Within the carbon cycle, dissolved inorganic carbon (DIC) carries the fossil ^{14}C-dead carbon (the hardwater effect, see e.g. Phillipsen et al. 2010 and references therein), whereas dissolved organic carbon (DOC) brings in the younger material due to decomposition of organic matter. It was estimated that marine food can make ^{14}C ages up to 400 yr older (Bronk Ramsey 2008). However, zooarchaeological data does not prove the significant use of marine fish at the coastal Stone Age sites in Lithuania. The high importance of freshwater fish and seals is evident instead (Rimantienė 1989; Daugnora 2000; Stančikaitė et al. 2009). ^{13}C and ^{15}N isotope measurements of human and animal bones clearly indicate a Mesolithic-Neolithic diet that largely consisted of freshwater fish. Only the Corded Ware people's diet was based on animal protein (Antanaitis-Jacobs et al. 2009).

Freshwater reservoir effects have not yet been investigated in Lithuania. No such research was performed during the current project. Plant fiber remains from repair holes in pottery represent good material for comparison of the ^{14}C ages of food and plant remains from the same sherd. However, all such samples had been treated with various conservation materials prior to the beginning of the dating project. The idea was abandoned due to the lack of methodology in reliable identification and removal of outside materials from samples. We had no opportunities to excavate new ceramics during the current project either. Despite that, some presumptions due to the validity of AMS dates on food remains may be proposed. Research on the freshwater reservoir effect performed in other countries, as well as observation and estimation of age differences between new AMS and previous ^{14}C context dates, are very helpful here.

According to Fischer and Heinemeier (2003), a dependence on a particular type of diet is possible to infer from measurements of δ^{13}C in charred food remains. A simplified picture can be described as follows. Terrestrial organic matter has typically δ^{13}C of about –26‰. The less negative δ^{13}C values may indicate marine influence, whereas the more negative values may be evidence of a high portion of freshwater food in the paleodiet. The δ^{13}C data in this work shows a trend from very low val-

ues (–35‰) from the Žemaitiškė 3 site at ~5500 BP towards a less negative value (–25‰) from the Šventoji 3 site at ~4600 BP (Figure 3). It seems clear that the pure marine influence is minimal. However, the data leaves the possibility for a significant freshwater effect, provided it is present in these Lithuanian contexts.

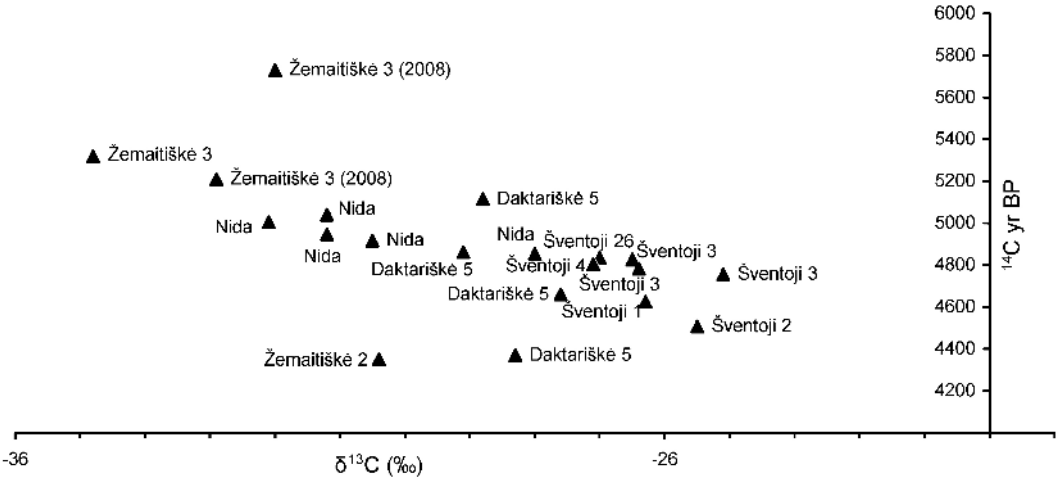

Figure 3 Distribution of $\delta^{13}C$ values recorded in charred crusts of Lithuanian prehistoric pottery. Two AMS dates and corresponding $\delta^{13}C$ values were included from Piezonka (2008).

Food remains at the Šventoji 3 and 4 sites revealed AMS dates (4830–4760 BP) that are only slightly younger compared to a date obtained from freshwater fish bones at the Šventoji 4 site (Tua-2076: 4875 ± 65 BP, Rimantienė 2005). The sample was taken from a refuse layer (gyttja) containing a great number of fish skeletons, including burned bones and small charcoal pieces. Looking from another point of view, new AMS dates from the Šventoji 3 and 4 sites are 300–400 yr BP older than the main group of contextual dates made on wooden artifacts. All that lets us speculate about a reservoir effect of up to 300–400 yr BP in the case of the Šventoji region. It could be found that the supposed value is in a good accordance with results from previous freshwater reservoir studies (Cook et al. 2001; Fischer and Heinemeier 2003; Boudin et al. 2009). However, it is important to note that the freshwater effect is site-dependent.

The coastal Nida site is located on a bank of the large Currish Lagoon, which is supplied with water by the largest Lithuanian river—the Nemunas. The Nemunas River runs in a deep valley and groundwater comprises roughly 35% of the entire water yield (Rainys 2009). It is very likely that charred remains of freshwater fish from Currish Lagoon predominates the AMS-dated food crust at the Nida site. New AMS dates appeared 400–500 yr BP older than the earliest charcoal or wood dates from the same site. This all goes to show that we can expect a freshwater reservoir effect of similar size or even greater there. A reservoir effect of up to 800 yr BP has been documented recently from coastal Germany (Olsen et al. 2010).

The impact of the freshwater reservoir effect on AMS dates from other inland sites remains obscure. As for the Žemaitiškė 3 site, a very negative $\delta^{13}C$ value (–34.8‰) may be recognized as a sign of freshwater food. Several previous AMS samples (Piezonka 2008) also demonstrated extreme negative $\delta^{13}C$ values (Figure 3). The surprisingly old ^{14}C age (4230–4060 cal BC) of a textile ceramic also seems suspicious. However, the ^{14}C date of a wooden artifact (Bln-2594: 5510 ± 60, 4450–4270

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cal BC, Antanaitis-Jacobs and Girininkas 2002) is even older than AMS dates of food remains. Some precedents were documented when charred food remains produced only slightly older dates than wooden artifacts or surrounding sediments (e.g. Zaretskaya et al. 2005: Figure 10).

To summarize, the AMS dates of food residues within the Baltic Sea basin seem often to yield earlier dates compared to their terrestrial sample counterparts. It is clear that this fairly poorly studied phenomenon will require deeper attention in the future, possibly with a larger, multinational effort.

CONCLUSION

The aim of this paper was to understand and reevaluate the prehistoric ceramic sequence in Lithuania based on typology. In particular, AMS dates related to prehistoric ceramics have indicated the weakness of earlier models. They indicate problems with the evolutional approaches applied in building the pottery sequences when using the conventional ^{14}C datings of contextual materials as well.

The beginnings of several ceramic types proved to be earlier than what had been assumed on the basis of traditional chronology (Figure 4). An example of this was corded ceramics of the Bay Coast style, which had a surprisingly old appearance. Today, we can speculate about the considerable impact of the SE Baltic communities on the formation of Corded Ware cultural and social phenomena. As some cultural elements are very common in Corded Ware (e.g. cord impressions, wavy mouldings), they may have been invented and developed during the 4th millennium cal BC in the SE Baltic. The origin of Globular Amphorae Ware should be revised if the very old AMS dates of the Bay Coast Ware can be confirmed by future research. Affluent coastal communities living in the region should be treated as influential actors in the formation of pan-European traditions in ceramic making, amber production, and other fields of prehistoric activity.

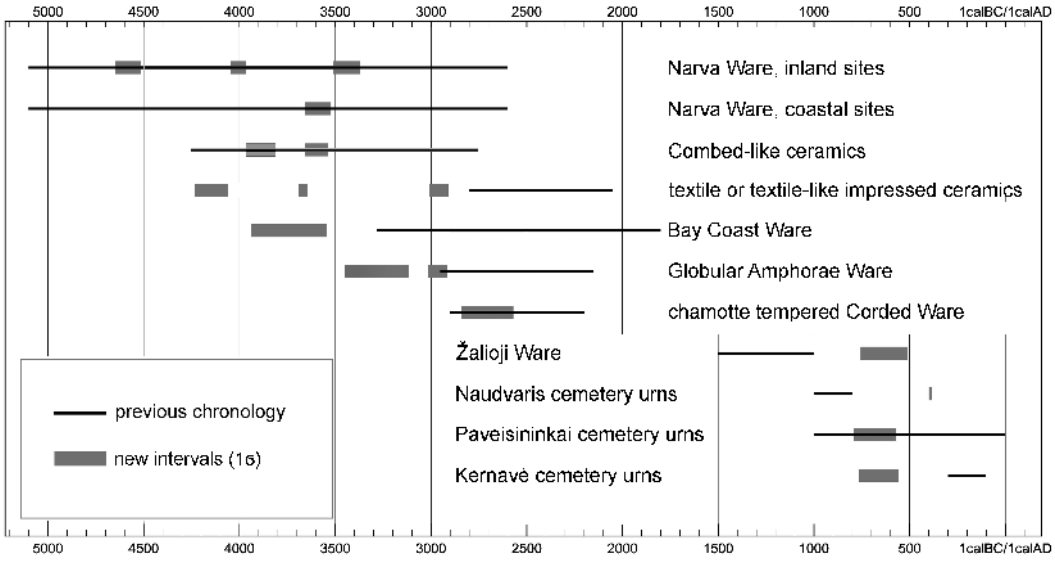

Figure 4 Comparison between previous typological-^{14}C/typological chronology of prehistoric ceramics and chronological ranges proposed by new AMS and conventional ^{14}C datings, including dates of food residues on ceramics. Previous chronology according to Brazaitis (2002), Kulikauskas (1982), Luchtanas (1992), Rimantienė (1999a,b, 2005), and Szmyt (2001). Ranges of food residue AMS dates by Piezonka (2008) are represented here together with the results of the current project.

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The same question can be posed for the textile-impressed ceramics that produced the oldest AMS dates known in the East Baltic. On the other hand, according to AMS datings of food residues, the period when the ceramic types were in use was in some cases shorter than in the earlier sequences. For instance, this was visible in the case of Narva Ware in coastal sites. However, some surprisingly old AMS dates of food residues may also indicate a remarkable freshwater reservoir effect that has not yet been investigated in Lithuania. An examination of the composition of food residues as well as paired ^{14}C dates of food residues and terrestrial materials are particularly necessary in order to establish a detailed and trustworthy ceramic chronology based on direct AMS dates. So far, the number of dated samples is too small to confidently allow the establishment of the sequence. The results are still extremely encouraging, as they provide a good basis for future work when sharpening the chronology and comparing the results with the larger sequences in Europe. Further steps might be statistical classification of prehistoric ceramics, in particular within geographically and chronologically wide cultural phenomena, and also Bayesian chronological modeling.

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REFERENCES

Antanaitis-Jacobs I, Girininkas A. 2002. Periodization and chronology of the Neolithic in Lithuania. *Archaeologia Baltica* 5:9–40.

Antanaitis-Jacobs I, Richards M, Daugnora L, Jankauskas R, Ogrinc N. 2009. Diet in early Lithuanian prehistory and the new stable isotope evidence. *Archaeologia Baltica* 12:12–30.

Bērziņš V. 2008. Sārnate: living by a coastal lake during the East Baltic Neolithic. *Acta Universitatis Oulensis* B86.

Boudin M, Van Strydonck M, Crombé P. 2009. Radiocarbon dating of pottery food crusts: reservoir effect or not? The case of the Swifterbant pottery from Doel "Deurganckdok." In: Crombé P, Van Strydonck M, Sergant J, Bats M, Boudin M, editors. *Proceedings of "Chronology and Evolution within the Mesolithic of North-West Europe*." Brussels, 30 May–1 June 2007. Cambridge: Cambridge Scholars Publishing. p 727–45.

Brazaitis D. 2002. Narviškos keramikos stiliai rytų Lietuvoje. *Lietuvos Archeologija* 23:51–72.

Brazaitis D. 2005a. Ankstyvasis metalų laikotarpis. In: Girininkas A, editor. *Lietuvos istorija. Akmens amžius ir ankstyvasis metalų laikotarpis. I tomas*. Vilnius: Baltos lankos. p 251–317.

Brazaitis D. 2005b. Agrarinis neolitas. In: Girininkas A, editor. *Lietuvos istorija. Akmens amžius ir ankstyvasis metalų laikotarpis. I tomas*. Vilnius: Baltos lankos. p 197–250.

Brazaitis D. 2007. Šventosios 1-osios, 4-osios ir 36-osios radimviečių ir jų aplinkos tyrinėjimai. *Archeologiniai tyrėinjimai Lietuvoje 2006 metais*:35–42.

Brazaitis D. 2008. Žvalgomieji tyrinėjimai Šventojoje. *Archeologiniai tyrinėjimai Lietuvoje 2007 metais*:32–4.

Bronk Ramsey C. 2008. Radiocarbon dating: revolutions in understanding. *Archaeometry* 50(2):249–75.

Bronk Ramsey C, Dee M, Lee S, Nakagawa T, Staff RA. 2010. Developments in the calibration and modeling of radiocarbon dates. *Radiocarbon* 52(3):953–61.

Butrimas A, Ostrauskienė D. 2004. Biržulio apyežerio neolito gyvenviečių virvelinė keramika. *Acta Academiae Artium Vilnensis* 34:121–44.

Cook GT, Bonsall C, Hedges REM, McSweeney K, Boroneant V, Pettitt P. 2001. A freshwater diet-derived ^{14}C reservoir effect at the Stone Age sites in the Iron Gates Gorge. *Radiocarbon* 43(2A):453–60.

Czebreszuk J, Szmyt M. 2001. The 3rd millennium BC in Lujawy in the light of ^{14}C dates. In: Czebreszuk J, Müller J, editors. *Die Absolute Chronologie in Mitteleuropa 3000–2000 v.Chr. The Absolute Chronology of Central Europe 3000–2000 BC*. Poznań, Bamberg, Rahden. p 177–208.

Daugnora L. 2000. Fish and seal osteological data at

Šventoji sites. *Lietuvos Archeologija* 19:85–101.
Fischer A, Heinemeier J. 2003. Freshwater reservoir effect in ^{14}C dates of food residue on pottery. *Radiocarbon* 45(3):449–66.
Girininkas A. 1979. Šiaurės rytų Lietuvos akmens amžiaus paminklai. 3. Bratoniškių paleolitinė stovykla ir žalvario amžiaus gyvenvietės. *Mokslų akademijos darbai* 4(69):83–94.
Girininkas A. 1990. *Kretuonas: Middle and Late Neolithic*. Lietuvos Archeologija 7. Vilnius: Mokslas. In Russian.
Girininkas A. 2004. Žemaitiškės 2-oji polinė gyvenvietė. *Istorija* LXII:26–32.
Grigalavičienė E. 1995. *Žalvario ir ankstyvasis geležies amžius Lietuvoje*. Vilnius: Mokslo ir enciklopedijų leidykla.
Jablonskytė-Rimantienė R. 1963. Žemųjų Kanikų IV–I tkstantmečių pr. m. e. stovyklos. *LTSR Mokslų Akademijos darbai* 1(14):65–90.
Jankauskas R. 1992. Degintinių kapų iš Kernavės Pajautos slėnio antropologinė analizė. *Lietuvos Archeologija* 9:39–40.
Juodagalvis V. 2006. Šventosios archeologinis kompleksas. *Archeologiniai tyrinėjimai Lietuvoje 2005 metais*: 9–12.
Kriiska A, Lavento M, Peets J. 2005. New AMS dates of the Neolithic and Bronze Age ceramics in Estonia: preliminary results and interpretations. *Estonian Journal of Archaeology* 9(1):3–31.
Kriiska A, Lougas L, Lohmus M, Mannermaa K, Johanson K. 2007. New AMS dates from Estonian Stone Age burial sites. *Estonian Journal of Archaeology* 11(2):83–121.
Król D. 2003. Badania archeologiczne w Rzucewie, stanowisko 1, gmina Puck, województwo pomorskie. In: Fudziński M, Paner H, editors. *Od epoki kamienia do okresu rzymskiego. XIII Sesja Pomorzoznawcza*. Volume 1. Gdańsk. p 35–40.
Kulikauskas P. 1982. *Užnemunės piliakalniai*. Vilnius: Mokslas.
Kulikauskienė R. 1958. *Lietuvos archeologiniai paminklai ir jų tyrinėjimai*. Vilnius: Mokslas.
Lanting JN, Aerts-Bijma AT, van der Plicht J. 2001. Dating of cremated bones. *Radiocarbon* 43(2A):249–54.
Lavento M. 2001. Textile ceramics in Finland and on the Karelian Isthmus. Nine variations and fugue on a theme of C. F. Meinander. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 109.
Luchtanas A. 1992a. Ankstyvojo geležies amžiaus Kernavės kapinynas. *Lietuvos Archeologija* 9:35–9.
Luchtanas A. 1992b. Rytų Lietuva I tkst. pr. m. er. *Lietuvos Archeologija* 8:56–85.
Mažeika J, Petrošius R. 1998. Archeologinių radinių radioanglies amžius. *Lietuvos Archeologija* 15:473–83.
Mazurowski RF. 1996. Prywatne zbiory zabytków bursztynowych z obozowisk kultury rzucewskiej w Niedwiedziówce, woj. elblskie. In: Nowakowski W, editor. *Concordia. Studia ofiarowane Jerzemu Okuliczowi-Kozarynowi w szedziesit pit rocznic urodzin*. Warsaw. p 171–82.
Mazurowski RF. 1999. Exploitation and working of amber during the Late Neolithic period in the uawy region. In: Kosmowska–Ceranowicz B, Paner H, editors. *Investigations into Amber. Proceedings of International Interdisciplinary Symposium: Baltic Amber and Other Fossil Resins. 1997 Urbs Gyddanycz*. Gdańsk, 2–6 September 1997. Gdańsk: The Archaeological Museum, Museum of the Earth, Polish Academy of Sciences. p 121–9.
Menotti F, Baubonis Z, Brazaitis D, Higham T, Kvedaravicius M, Lewis H, Motuzaite Matuzeviciute G, Pranckenaite E. 2005. The first lake-dwellers of Lithuania: Late Bronze Age pile settlements on Lake Luokesas. *Oxford Journal of Archaeology* 24(4):381–403.
Olsen J, Heinemeier J, Lübke H, Lüth F, Terberger T. 2010. Dietary habits and freshwater reservoir effects in bones from a Neolithic NE German cemetery. *Radiocarbon* 52(2):635–44.
Phillipsen B, Kjeldsen H, Hartz S, Paulsen H, Clausen I, Heinemeier J. 2010. The hardwater effect in AMS ^{14}C dating of food crust on pottery. *Nuclear Instruments and Methods in Physics Research B* 268(7–8):995–8.
Piezonka H. 2008. Neue AMS-daten zur frühneolithischen keramikentwicklung in der Nordosteuropäischen waldzone. *Estonian Journal of Archaeology* 12(2): 67–113.
Piličiauskas G. 2006. Karaviškių 6-oji gyvenvietė. *Archeologiniai tyrinėjimai Lietuvoje 2005 metais*:14–8.
Piličiauskas G, Mažeika J, Gaidamavičius A, Vaikutienė G, Bitinas A, Skuratovič Ž, Stančikaitė M. Forthcoming. New archaeological, paleoenvironmental, and ^{14}C data from Šventoji Neolithic sites, NW Lithuania. *Radiocarbon* (in press).
Price TD, Gebauer AB. 2005. *Smakkerup Huse. A Late Mesolithic Coastal Site in Northwest Zealand, Denmark*. Aarhus: Aarhus University Press.
Pukienė R. 2004. Žemaitiškės 2-osios polinės gyvenvietės medinių konstrukcijų anatominė analizė. *Lietuvos Archeologija* 26:99–104.
Rainys A. 2009. Nemunas. In: Razumas V, editor. *Visuotinė lietuvių enciklopedija XVI*. Vilnius: Mokslo ir enciklopedijų leidybos centras. p 224.
Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Burr GS, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Hajdas I, Heaton TJ, Hogg AG, Hughen KA, Kaiser KF, Kromer B, McCormac FG, Manning SW, Reimer RW, Richards DA, Southon JR, Talamo S, Turney CSM, van der Plicht J, Weyhenmeyer CE. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51(4): 1111–50.
Rimantienė R. 1980. *Šventoji. Pamarių kultros gyven-*

vietė. Vilnius: Mokslas.
Rimantienė R. 1984. *Akmens amžius Lietuvoje*. Vilnius: Mokslas.
Rimantienė R. 1989. *Nida. Senųjų baltų gyvenvietė*. Vilnius: Mokslas.
Rimantienė R. 1999a. Žaliosios žalvario amžiaus gyvenvietė. *Lietuvos Archeologija* 16:217–28.
Rimantienė R. 1999b. Neolitas ir ankstyvasis žalvario amžius pietų Lietuvoje. *Lietuvos Archeologija* 16:19–29.
Rimantienė R. 2005. *Die Steinzeitfischer an der Ostseelagune in Litauen*. Vilnius: Litauisches Nationalmuseum.
Saltsman EB. 2004. *Corded Ware Culture Sites in Kaliningrad Region*. Kaliningrad: KGU. In Russian.
Saltsman EB. 2009. Results of investigation of Corded Ware Culture sites in coastal zone of Wisla Bay. *Baltic Researches* 4:94–107. In Russian.
Šiaulinskas R. 2006. Naudvario kapinynas. *Archeologiniai tyrinėjimai Lietuvoje 2005 metais*:121–3.
Stančikaitė M, Daugnora L, Hjelle K, Hufthammer AK. 2009. The environment of the Neolithic archaeological sites in Šventoji, Western Lithuania. *Quaternary International* 207(1–2):117–29.
Szmyt M. 2001. The absolute (radiocarbon) chronology of the central and eastern groups of the Globular Amphorae Culture. In: Czebreszuk J, Müller J, editors. *Die Absolute Chronologie in Mitteleuropa 3000–2000 v.Chr. The Absolute Chronology of Central Europe 3000–2000 BC*. Poznań, Bamberg, Rahden. p 25–80.
Timofeev VI. 1992. Some problems of the chronology of the Eastern Baltic region. In: *Cultural Heritage of the Finno - Ugrians and Slavs*. Tallinn. p 9–23.
Timofeev V, Zajceva G, Possnert G. 1995. Neolithic chronology in the South - Eastern Baltic area in a view of C14 accelerator datings. *Fornvännen* 90(1):207–12.
Timofeev VI, Zaitseva GI, Lavento M, Dolukhanov P, Halinen P. 2004. The radiocarbon datings of the Stone Age - Early Metal period on the Karelian isthmus. *Geochronometria* 23:93–9.
Zaretskaya NE, Zhilin MG, Karmanov VN, Uspenskaya ON. 2005. Radiocarbon dating of wetland Meso - Neolithic archaeological sites within the Upper Volga and Middle Vychegda. *Geochronometria* 24:117–31.