



FORN VÄNNEN

JOURNAL OF
SWEDISH ANTIQUARIAN
RESEARCH

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http://kulturarvsdata.se/raa/fornvannen/html/2015_227

Fornvännen 2015(110):4 s. 227-240

Ingår i samla.raa.se

A cross-check of radiocarbon dates from Stone Age sites in Northern Sweden

By *Therese Ekholm*

Ekholm, T., 2015. A cross-check of radiocarbon dates from Stone Age sites in Northern Sweden. *Fornvännen* 110. Stockholm.

This study compares the results from radiocarbon measurements performed on charcoal and burnt bone from the same contexts in order to assess the reliability of the two materials for dating. The study deals with seven Mesolithic sites in Norrland and Dalecarlia, an area where datable organic material is difficult to find. The bone samples have been chosen for the study and the charcoal samples are mainly from previous work. The study shows that both materials are suitable for dating as long as they are sampled correctly and with knowledge of the errors that can occur.

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In the late 1990s a new method made it possible to carbon date burnt bones (Lanting & Brindley 1998). This has changed our chronology and understanding of the arrival of both humans and animals to Norrland, the northern three quarters of Sweden. It has been shown that bone is more reliable for dating archaeological sites than wood because of its negligible intrinsic age (Lanting et al. 2001, p. 249; Hedman 2009, p. 5), which is the age of the sampled organism. Much radiocarbon-dated wood from long-lived tree species suffers from the Old Wood Effect. A similar problem is curation or storage age, when objects have been kept in use or circulation for long periods (Brock & Dee 2013, p. 41). In addition burnt bones found in a sunken feature are more likely to represent human action and connect people's activities to a particular site, while charcoal can result naturally from, for example, a forest fire at any time during a site's formation process.

One of the problems of dating prehistoric sites in Norrland is how to argue for an association between radiocarbon dates and artefacts. Due to

thin vegetation, prehistoric sites are often found right beneath the top soil, which complicates the interpretation of the stratigraphy. The assemblages often represent palimpsests of material from several periods making the relation of dates, features and artefacts difficult. Furthermore, due to the decomposition of organic materials in the acid soil, artefacts made of wood and unburnt bones are rarely found in sunken features (Borg et al. 1994, p. 97 f; Björdal 1999, p. 120 f; Christensson 1999, p. 172 f) where burnt bones do survive (Lanting & Brindley 1998, p. 7). For decades the only method available for dating these sites was radiocarbon dating of charcoal, especially the sites excavated during the expansion of hydroelectric power in the 1940s through 70s (Iregren & Ekman 1984). Most sites are chronologically mixed, and so even at sites with stratigraphy such as Rappasundet, Döudden/Varghalsen, Garasetlet (Knutsson 1993, p. 25; Bergman 1995a, p. 143 ff; 111 ff) it is often difficult to distinguish which feature belongs to which period. At all of these inland sites it is therefore important to do a care-

ful contextual analysis of the provenance of artefacts and samples for radiocarbon analyses.

This study deals with two problems of the chronology which can be elucidated by systematic radiocarbon dating of burnt bones.

1. Due to the difficulty of identifying the sources of charcoal found at a prehistoric site, it is uncertain what event is dated. This study investigates if there is any difference in the dates of burnt bone and charcoal taken from the same feature, and if the charcoal therefore is connected to the activity in which the feature was involved.
2. The intrinsic age of the charcoal sample is often unknown, which may be one reason why dates obtained from charcoal often seem misleading. This study investigates if there is a systematic error here that can be controlled for by using bone dates as a baseline.

Bones are however not unproblematic. Bones lying in the soil can become contaminated by absorbing bicarbonate from the surrounding sediments and the results may thus show a later date. This does not affect bones burnt at more than 600 °C, provided that the bones are burnt before they end up in the soil (Lanting & Brindley 1998, pp. 2, 6; Olsen et al. 2008, p. 792). Bones from animals that live in the sea or feed on animals from marine habitats may yield dates exceeding their actual age, due to the reservoir effect. It is therefore important to choose terrestrial over marine animals for analysis, as well as animals with a terrestrial diet over those feeding on marine sources (Lanting & van der Plicht 1998, p. 151; Lanting et al. 2001, p. 249 f; Hedman 2009, p. 5). This does not, however, affect burnt bones as much as it does unburnt bones. Because structural carbonate, which is used when dating burnt bones, originates from the whole diet (Lanting & Brindley 1998, pp. 6).

Previous studies

Studies comparing radiocarbon dates from burnt bones and other burnt materials have been undertaken several times and with different results, such as in Lanting et al. 2001, Olsen et al. 2008 and Ol-

sen et al. 2013. In 2001 radiocarbon dates obtained from burnt bones were compared to measurements on charcoal from the same context. In some cases the charcoal looked older, which was explained by reference to a higher intrinsic age of the sample (Lanting et al. 2001).

The famous Early Bronze Age oak-coffin grave from Egtved in Denmark contained both an inhumation and a cremation in a bark bucket. Olsen et al. (2013) have compared the radiocarbon date of the jawbone from the cremated individual, a five-year-old child, with the dendro-chronological date (1370 BC) of the log coffin. Rather unusually, they converted the dendro date backwards into an uncalibrated BP date by means of the IntCal09 radiocarbon curve (Reimer et al. 2009) and got 3054±16 BP. Two combined samples from the child's jawbone yielded a date in 3127±20 BP. The difference between the coffin and the bone was 73±26 radiocarbon years, the bone being older.

Olsen et al. suggest that the child was cremated in connection with the funeral of the Egtved woman, because remains of the funeral pyre were found in the bark bucket. No such remains, they argue, would have been there if the deposition of the child's remains represented reburial of a long-dead individual (Olsen et al. 2013, p. 31 f). The charcoal from the cremation found with the burnt bones were not radiocarbon dated, as these remains were assumed to produce identical results. This was because of the intrinsic age of the wood used as fuel which, according to the authors, was transferred to the bones by means of CO₂. To prove this, the radiocarbon date of the burnt bone was instead compared to the dendrochronology on the oak coffin. The results showed that the burnt bone was older than the coffin after the reservoir effect was excluded. This outcome was interpreted to mean that the burnt bone had been contaminated by the intrinsic age of the wood used as fuel for the cremation (Olsen et al. 2013, p. 33).

This comparison of radiocarbon dating and dendrochronology is not unproblematic as the authors assumed that the two deaths were contemporaneous. The bucket with the cremated material could have been unearthed intact from its first burial place and placed in the oak coffin as a secondary burial event. The cremated bone

is, furthermore, an unreliable sample because it derives from the spongy part of the jaw bone. It is not advisable to use spongy bone tissue for radiocarbon dating as its cavities can trap other materials such as radiocarbon date charcoal and roots (Borg et al. 1994, p. 97). Solid bones are more suitable for dating. Since all the bones in the bucket derive from a child and children's bones are overall very spongy, the samples were not suitable to use as a foundation to build arguments concerning the reliability of radiocarbon dating.

In a 2008 study, Olsen et al. compare radiocarbon dates on burnt bones with radiocarbon dates on other materials from the same contexts, such as charcoal and pitch, and also with dendrochronology. The dendrochronological case is nearly the same as in the 2013 study of the Egtved grave, but with another bone sample from the same jaw. The pitch was used to seal funerary urns and these dates were compared with the dates of the burnt bones inside the containers. In total six urns were dated and in all cases, except one where the pitch was older, the results were consistent. The compared bone and charcoal samples showed close correspondence since one comparison differed only by one hundred years and two by two hundred years, the charcoal being the oldest in all cases. The interpretation of the results is that the wood was affected by the Old Wood Effect, an older intrinsic age. In these cases no transferred intrinsic age by CO₂ obviously affected the bones as it may have done in the study of the Egtved grave. A test with several samples taken from different parts of a skeleton with different degrees of combustion, from black, charred bones without burn cracks to white bones with distinct burn cracks, was done and resulted in various dating results. The samples exposed to higher temperatures showed earlier dates, from 3576±29 BP on charred bones to 3756±28 BP on cremated bones (Olsen et al. 2008, p. 795 f). Since there are two different ways of dating bones, whether they are burnt or unburnt, a suggestion is to never use charred bones for the reason that they are neither quite burnt or unburnt. None of the studies recounted above strengthen the case for the idea that the Old Wood Effect might be able to transfer from wood to burnt bones.

Contract excavations for the E4 highway north of Uppsala in 2002–2004 occasioned a comparative study (Guinard 2006) of radiocarbon dates for a number of Stone Age contexts including the sites Stormossen, Bålmyren and Postboda 2, and hazelnut shells, seal bones as well as charcoal. The aim was to study whether any systematic pattern in the reservoir effect could be discerned. It was assumed that the seals would have acquired a reservoir. The dates of the bones from four contexts at Stormossen were, as expected, consistently too early. The radiocarbon measurements of the seal bones from the Mesolithic sites Bålmyren and Postboda 2, however, gave later dates than the hazelnut shells from the same contexts, which Michel Guinard does not discuss further. In the contexts with the overall earliest dates the reservoir effect was the greatest, but the climate, the salinity of the water and local deviations all contribute to the size of the reservoir effect. Also, a larger study would be needed before any major conclusions about the reservoir effect could be reached. To sum up the basis for a study of the credibility of radiocarbon dates on charcoal and burnt bones, in this paper I will consider the following: 1) Bones burnt at more than 600 °C, 2) From terrestrial animals, 3) Avoiding spongy parts of bones, 4) Controlling for variations in the burning temperature.

Aims

The aims of this study are to investigate whether there is a systematic difference between radiocarbon dates performed on a) charcoal, and b) burnt bone from the same context on Stone Age Sites in northern Sweden. The contexts from which the samples are taken have to be sealed, which means that they have been covered right after they were used. At least there has to be no sign of later activity disturbing the feature. As mentioned earlier, there is some difficulty in finding datable material at these sites. Therefore, it is important to have several different dating methods available. If it can be shown that the charcoal and the bone from secure contexts date the same event, then charcoal dates from such contexts, from analyses performed during the decades before burnt bone could be dated reliably, can be used with some confidence. This is important for the

great body of data that we have from inland sites in northern Sweden (Biörnstad 2006).

By dating selected samples of burnt bone from contexts which have already been dated with charcoal, we can begin an interesting discussion of the usefulness of the early analyses from northern sites. Besides enhancing the number of dated contexts, the dates can one day be used to investigate if construction traditions visible in the features at a site can be linked to any systematic differences in space and time. If so, then undated features could be assigned a preliminary date using a typological strategy. It presumes that the bone samples, as discussed, have a high quality, are solid, hard-burnt, and are highly crystallised with no organic components retained (Olsson et al. 2008, p. 792). The animal species must also be known to be one without a reservoir effect (Persson 1999, p. 28; Hedman 2009, p. 5). Dating of burnt bone will, in such a case, be able to provide valuable information about sites that might otherwise not be reliably dated.

This study is a pilot study for a larger PhD project addressing the establishment of animal species in Norrland as the Weichselian ice cap withdrew. With radiocarbon dates of burnt animal bone from separate archaeological contexts, not only the date of habitation, but also the timing of the species occupation of the landscape will be identified. Only those species that are linked to certain cultural traditions and therefore were deposited on Mesolithic sites in Norrland are discussed, as they are the only animals visible in the archaeological record. By studying the faunal bone assemblages from the sites the trajectory of human adaptation to new environments and variations in people's cultural practices of animal resource exploitation can be studied. By dating bones from these sites, a higher chronological resolution for cultural practices, illustrated by the stone technology, will also be established. The data provides further new information that will be merged into recent studies of when people came and adjusted to the new landscape, and where they came from (Sørensen et al. 2013).

Based on radiocarbon dates the next step is to explore the possibility of building a typology of features identified on Mesolithic sites in the north, where some animal species are associated with

certain characteristics of construction, and ultimately connect these two with the lithic material. The latter would, in a later phase, allow an analysis of cultural ecology during the Mesolithic in Norrland.

Selection of sites

The analysed sites, in Norrland, Sweden, discussed in the article, were selected primarily for their chronology and sealed contexts, where charcoal and burnt bones were found together. The three exceptions are Kangos, and feature 8 (A8) at Garaselet, where bones were found in association with the feature, and Lappviken, where no charcoal has been dated. At Lappviken the lithics serve to indicate the time of occupation. All sites are Mesolithic, 8000–4000 cal BC, and have been selected for geographical coverage.

The sites

The objects under study were initially bone assemblages from nine dated Mesolithic sites (fig. 1). Seven sites are in inland Norrland: Aarevaara, Kangos, Dumpokjauratj, Garaselet, Lappviken, Rastklippan and Högländ. Two are in Dalecarlia: Orsand and Tjärna. Upon further study I excluded Aarevaara (Raä Pajala 1276–1277) and Rastklippan (Raä Sorsele 1000) due to the high fragmentation rate of the bones, with fragments too small for radiocarbon dating. The bone samples dated for the study weighed a minimum of 1 gram.

Kangos

The site at Kangos (Raä Junosuando 22) was located at River Lainioälven in Norrbotten. The artefact finds are characterised by quartz worked both with platform and bipolar technology (Östlund 2004, p. 9). On the site only one feature (A1) was found, a hearth pit with finds in the pit and in association with it. Bones were found in the hearth and down-slope from it, in square x354/y195 and in the southwest part of square x354/y196. Most of the lithics outside the hearth occurred in squares x353/y195 and x354/y196. Rain water may have moved bones and lithics down-slope from the hearth (Östlund 2004, p. 6 f). The bones were analysed by Leif Jonsson in 2004. Of reindeer (*Rangifer tarandus*) there was a mandible, a talus and the middle toe bone (*pha-*

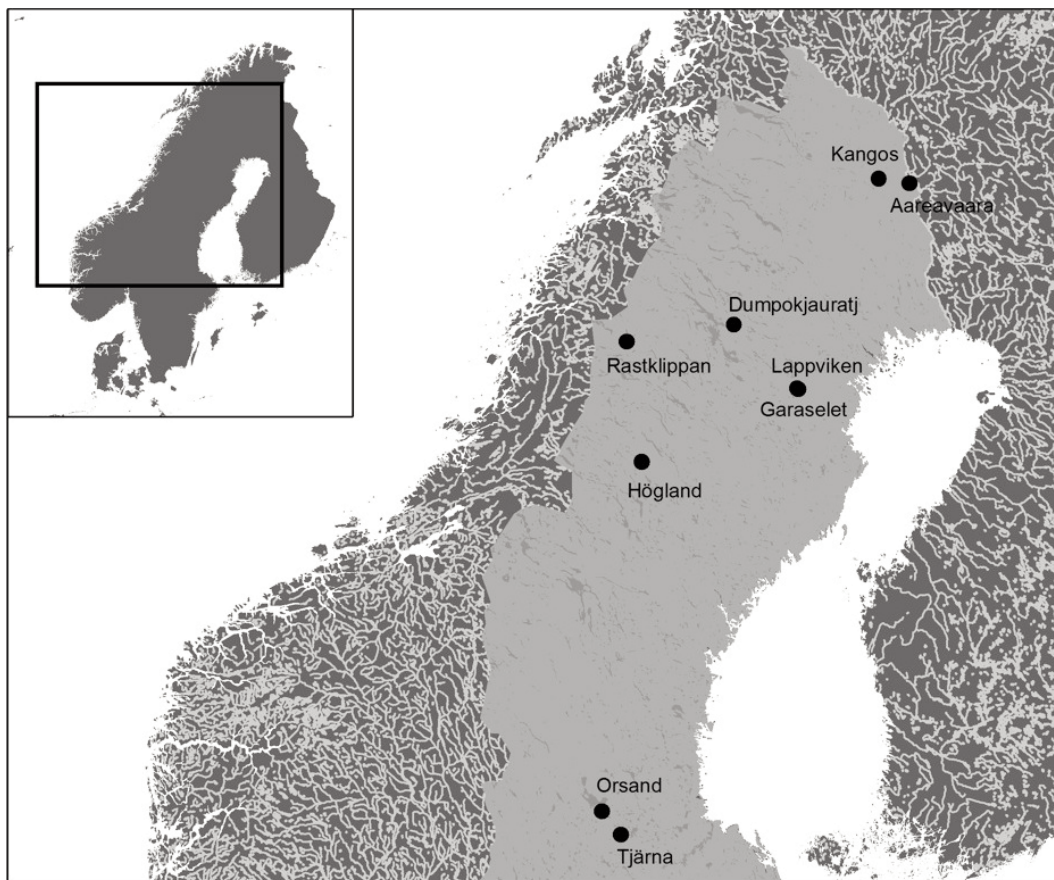


Fig. 1. The studied Mesolithic sites. By Michel Guinard.

lanx II) from a dewclaw. These are the small toes on the front hoof that are attached to the smaller metacarpals (*telemetacarpalia*) behind the main metacarpal. Of pike (*Esox lucius*) there was the right-hand part of the cranium (*cleithrum*) and left mandible (*dentale*). Olof Östlund's interpretation of the site (2004, p. 9) is that it was a temporary hunting/fishing site where tools of quartz, greenstone and slate were made and at least one reindeer and one pike were cooked.

Dumpokjauratj

The site at Dumpokjauratj in Lapland (Raä Arjeplog 1568) had a cooking pit (A1), two hearths (A2–3; Bergman 1995b, p. 3), two hearth pits (A5–6), a waste pit (A7; Bergman 2003a, p. 3) and an accumulation of charcoal (A4; Bergman, 2001, p.

5). It is located by Lake Dumpokjauratj which is part of the same water system as Lakes Gublijaure, Lullebådne, Kakel and Hornavan. The lithics are, as at Kangos, both platform and bipolar (Bergman 2003a, p. 6; 2003b, p. 5 f). The two hearth pits had been cleaned out several times, and so Ingela Bergman's interpretation (2003a, p. 3) is that the site was a temporary dwelling site used on multiple occasions. The features of interest here are A4 and A5. Only charcoal was found in what was left of A4, but in its reddish top layer – disrupted by uprooted trees, erosion and site preparation – a bone scatter was found and interpreted as belonging to A4. In A5 burnt bones, flakes, fire-cracked stones and charcoal were found (Bergman 2003a, p. 14; 2003b, p. 14).

The bones were analysed by Mats Eriksson

and Maria Vretemark (2003). They are mainly elk (*Alces alces*; Eriksson ms.) and reindeer, but also a few fragments of fox (*Vulpes vulpes*), beaver (*Castor fiber*), indeterminate bird and pike (Vretemark 2003, p. 1).

Garaselet

The site at Garaselet in Västerbotten (Raä Jörn 79) has yielded Mesolithic to Middle Neolithic dates, with a variety of features in the form of cooking pits, hearths, pits and more recent structures such as a forge, a fire pit and features from Sami activities (Sundqvist ms.). The site is on the south bank of the Garaselet inlet in River Byskeälven (Knutsson 1993, p. 17). Features A6 and A8 were of special interest. A6 was a cooking pit with plenty of bones, fire-cracked stones, charcoal and flakes mainly of porphyry. A8 was a hearth with charcoal and bones (Sundqvist ms.). The bones were analysed by Margareta Backe in 1990 and consisted of elk, beaver, reindeer, bear (*Ursus arctos*), otter (*Lutra lutra*), black-throated diver (*Gavia arctica*, Sw. *storlom*), goose (Anserinae sp.), diving ducks (Aythyinae sp.), pike, carp (Cyprinidae sp.), bream (*Abramis brama*, Sw. *braxen*), ide (*Leuciscus idus*, Sw. *id*), perch (*Perca fluviatilis*, Sw. *abborre*) and grayling (*Thymallus thymallus*, Sw. *harr*).

Lappviken

The site at Lappviken in Västerbotten (Raä Jörn 66) is near Garaselet on the northern shore of the Lappviken inlet in the same river. No published excavation report is available, but Kjel Knutsson (1993) has discussed the site in a paper. The bones from Lappviken were analysed by Margareta Backe and consist of elk, beaver, indeterminate bird and pike. Only bone lists are available and no detailed analysis has been done of the material.

Högland

The site at Högland in Västerbotten county, southern province of Lapland (Raä Dorotea 181) was divided into three areas, with two features, A1–2. A1 was a pit in area 1, with artefacts of quartz and quartzite and burnt bones. The latter are too small for radiocarbon dating. A2 was a pit in area 3 with burnt bones and fire-cracked stones. Jan Melander and Jan-Erik Wallin (1981, p. 5 ff) interpreted the site as having been used several

times, where the two features in areas 1 and 3 represented temporary sites where humans hunted their prey, cooked and made tools. Area 2 was also a temporary site, but much more ephemeral than areas 1 and 3. The bones from Högland had not been analysed by the time of the publication of this paper.

Orsand

The site at Orsand in Dalecarlia (Raä Leksand 2001) had a cooking pit A255 and two bone features A272 and A268. It was on the eastern shore of Lake Siljan and was interpreted as a temporary dwelling site (Guinard 2013). I analysed the bones from Orsand in 2013, but the results have not yet been published. The represented species are indeterminate mammal, indeterminate deer (Cervidae sp.), carp (Cyprinidae sp.) and perch.

Tjärna

The site at Tjärna in Dalecarlia (Raä Borlänge 40) had a Mesolithic feature (A140) which was damaged by a trench on the western side. In the destroyed part, fire-cracked stones and slag were found, probably from an iron manufacturing site nearby. In the intact eastern part of the feature were burnt bones and fire-cracked stones (Sandberg 2001). The bones were analysed by Barbro Hårding in 2001 and consisted of cattle (*Bos taurus*), pig (*Sus domesticus*), sheep (*Ovis aries*) and elk.

Selection of bone samples

I chose seven already dated Mesolithic sites for this investigation. The burnt bones selected for dating should, as far as possible, be of the same species. The different contexts in which the bones were found should also be similar to one another. Before the bones were radiocarbon dated the previous osteological analyses had to be verified to ensure that the determination in the list corresponded with the chosen bone. When there was no osteological analysis I did one myself, but only of the bones to be dated. All radiocarbon measurements were performed with AMS at the Ångström Laboratory in Uppsala and calibrated with OxCal v4.2.4 (Bronk Ramsey 2013), using the IntCal13 dataset (Reimer *et al.* 2013). All dates in tab. 1 and 2 are uncalibrated. From Kangos a middle

Site	Context	Sample	Species	Lab no.	$\delta^{13}\text{C}$ (‰) VPDB	^{14}C age BP	Date of analysis
Kangos	x354/y195	Bone	Reindeer	Ua-47234	-24,0	8786±59	2013.11.15
Kangos	A1	*Charcoal	Willow	Ua-47137	-25,3	8793±63	2013.11.11
Kangos	A1	Bone	Unknown (Reindeer?)	¹ Ua-23818	-26,0	8720±60	2005.01.28
Kangos	A1	Bone	Unknown (Reindeer?)	¹ Ua-23266	-27,3	8555±65	2004.10.18
Dumpokjauratj	A4	Bone	Elk	Ua-43894	-26,8	7574±49	2012.06.13
Dumpokjauratj	A4	Bone	Elk	Ua-43895	-28,6	7707±50	2012.06.13
Dumpokjauratj	A4	Charcoal	Pine	⁴ Ua-17338		8000±80	
Dumpokjauratj	A4	Charcoal	Pine	⁴ Ua-17339		8010±75	
Dumpokjauratj	A5	Bone	Reindeer	³ Ua-23917		8450±55	
Dumpokjauratj	A5	Charcoal	Poplar	⁴ Ua-19212		8630±85	
Dumpokjauratj	A5	Charcoal	Willow/Poplar	⁴ Ua-17340		8445±90	
Dumpokjauratj	A5	Charcoal	Willow/Poplar	⁴ Ua-18265		8250±85	
Garaselet	A6	Bone	Elk	Ua-48180	-28,1	6525±41	2014.03.17
Garaselet	A6	Charcoal	Unknown	⁴ Ua-2060		5920±80	
Garaselet	Bone feature	Bone	Elk	Ua-48181	-30,1	6657±40	2014.03.17
Garaselet	A8	Charcoal	Unknown	⁴ Ua-2061		6190±90	
Lappviken	Bone feature	Bone	Elk	Ua-43896	-27,0	6492±47	2012.06.13
Lappviken	Bone feature	Bone	Elk	Ua-43897	-25,8	6319±45	2012.06.13
Högländ	Bone feature	Bone	Elk	Ua-43892	-23,5	5975±40	2012.06.13
Högländ	A2	Bone	Elk	Ua-43893	-25,6	7593±50	2012.06.13
Högländ	A2	Charcoal	Unknown	⁵ St-7709	-25,6	7715±105	1981.02.02
Orsand	A272	Bone	Mammal	Ua-48269	-27,9	8272±52	2014.03.21
Orsand	A268	Bone	Carp fish	Ua-48268	-21,4	6326±54	2014.03.21
Orsand	A268	*Charcoal	Pine	Ua-48827	-25,6	6315±49	2014.06.25
Orsand	A255	*Charcoal	Pine	Ua-48826	-25,7	5946±43	2014.06.25
Orsand	T24	Bone	Unknown	⁶ Ua-38765		9089±207	
Tjärna	A140	Bone	Deer	Ua-48267	-20,4	7982±52	2014.03.21
Tjärna	A140	Charcoal	Pine	⁷ GrN-26531		7960±35	2001.10.04

* ^{14}C analyses of charcoal done for this study where no charcoal had previously been dated.

¹(Östlund 2004, Appendix 6:1) ²(Bergman *et al.* 2004, p. 165) ³Silvermuseet dnr 1998/015 ⁴(Knutsson 1993, p. 30) ⁵(Melander & Wallin 1981, Appendix) ⁶(Lindberg & Sandberg 2010, p. 14) ⁷(Sandberg ms. 2001)

Tab. 2. All radiocarbon measurements done on the features under study here.

from a bone feature in area 2. The other sample was from the distal part of a *metapodium*, collected from A2. This feature had previously been dated with charcoal to 7715±115 BP (Melander & Wallin 1981, p. 7).

From Orsand, one bone sample from each bone pit was selected: an undetermined element

of an undetermined mammal from A272 and six vertebrae from carp fish from A268. From the latter bone pit a charcoal sample was also selected, and furthermore a charcoal sample from the cooking pit A255. Both of the charcoal samples were of pine. In a previous study several indeterminate burnt bones had been put together and

dated as one sample without any particular context. This analysis yielded 9089 ± 207 BP. Two charcoal samples had also been dated previously: one of pine at 1018 ± 30 BP and one of birch at 1202 ± 30 BP (Lindberg & Sandberg 2010, p. 14). From Tjärna, a bone was selected from the seemingly undisturbed part of the only feature (A140): an outer *malleolus*. The previous species determination was elk, but after reexamination I changed this to undetermined deer (*Cervidae* sp.) because it did not conform to the reference material. The feature had previously been carbon dated with charcoal to 7960 ± 35 BP (Sandberg 2001).

Results

All results from the radiocarbon measurements of burnt bones performed for this study are in tab. 1. In additions to the dates the $\delta^{13}C$ values are

given. Note that burning lowers the $\delta^{13}C$ values (Olsen et al. 2008, p. 796; Snoeck et al. 2014, p. 595).

The dates for this study are presented together with previously acquired dates from each context in tab. 2 and fig. 2. They essentially agree with each other, with the following qualified exceptions.

The two radiocarbon dates on burnt bones from A4 at Dumpokjauratj are consistent with each other, but compared with the charcoal dates for the same contexts the bone samples are 300–400 radiocarbon years younger.

Previously, A5 at Dumpokjauratj has been radiocarbon dated with one burnt bone sample and three charcoal samples. The bone sample and the middle charcoal sample in fig. 2c gave fairly consistent dates, the first charcoal sample being slightly earlier and the last one slightly later. The

Fig. 2 a–c.

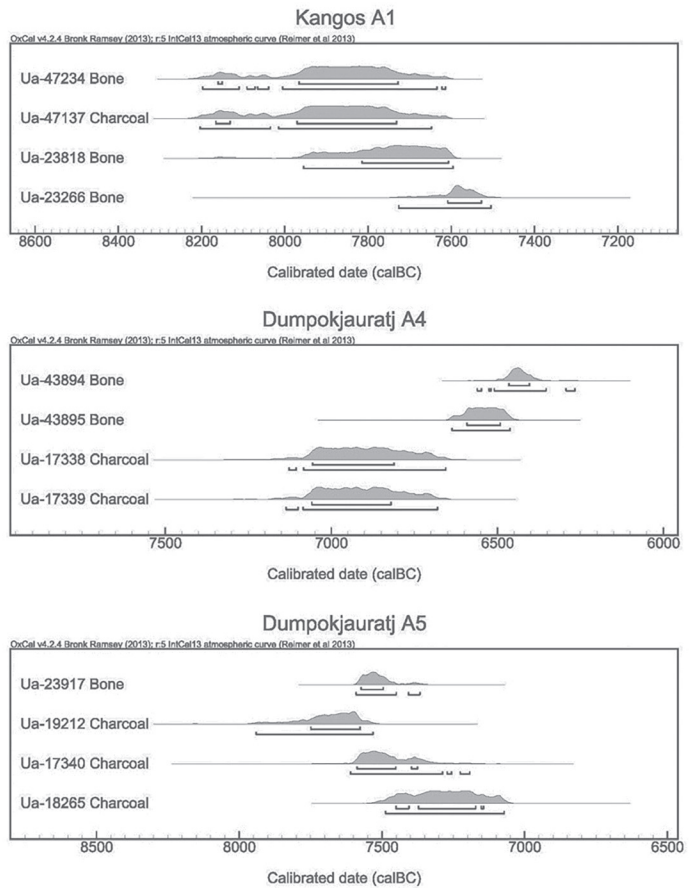
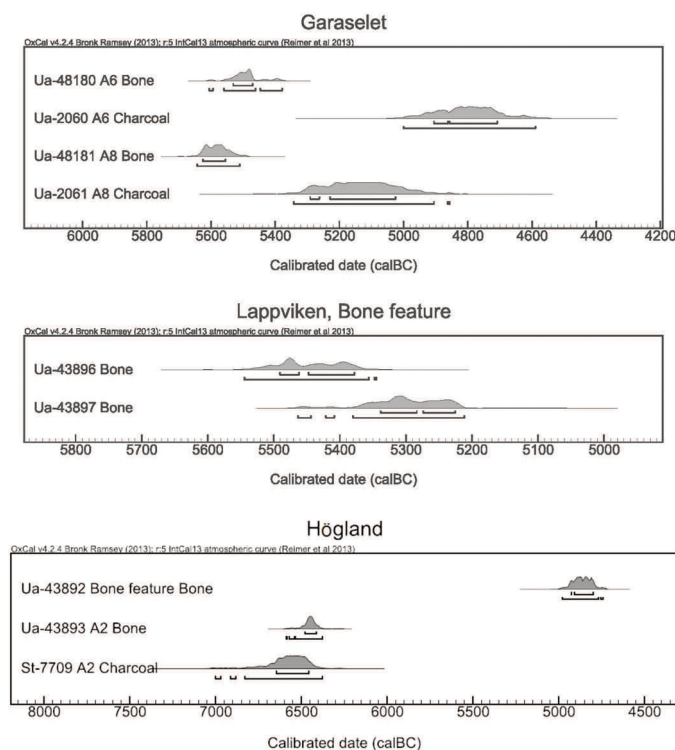


Fig. 2. All the radiocarbon dates used for the study.



difference between charcoal and bones in A5 is not as obvious as in A4.

A cooking pit, A6, at Garaselet has previously been radiocarbon dated with charcoal and for this study also with burnt elk bone. The bone gave a date that is nearly 600 radiocarbon years earlier than the charcoal (fig. 2d). A hearth, A8, at Garaselet has also previously been dated with charcoal, and for this study also with burnt elk bone from a bone feature associated with the hearth. The bone from the bone feature is about 500 radiocarbon years earlier than the charcoal from the hearth (fig. 2d).

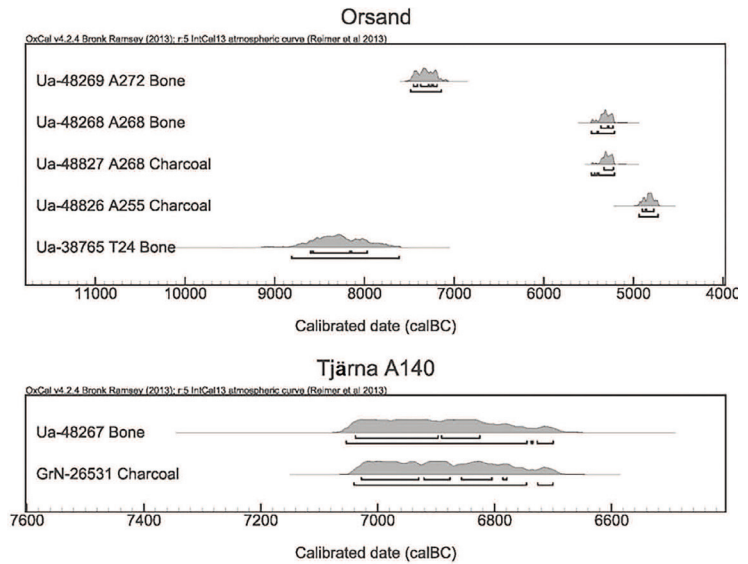
No charcoal samples from Lappviken have been dated. As noted, however, the site has been placed typologically around 6000 BP. In this study two bones from the same context were dated, differing by only 100–250 radiocarbon years (fig. 2e). The dates match Knutsson's typological dating.

There was already a carbon date on charcoal from A2 at Högland. For this study one bone sample from A2 and one from a bone feature were selected from different areas on the site. The

dates differ by 100 radiocarbon years between the two samples from A2, but the sigma is ± 105 on the charcoal sample and ± 50 on the bone sample. Both samples are likely to represent the same event. The bone sample from the bone feature is 1600 radiocarbon years later than the one from A2, and is thus from a different use phase (fig. 2f).

At Orsand, two bone samples from two different bone pits and two charcoal samples, one from the bone pit with carp bones and one from the hearth were dated for this study. The results show that the pit with mammal bones (A272) is 2000 radiocarbon years older than the pit with carp bones (A268). The charcoal sample from A268 was dated to the same period as the carp bones, and the charcoal sample from the hearth is almost 400 radiocarbon years later than the samples from A268. A radiocarbon date on burnt bones from a previous study is 800 radiocarbon years earlier than the earliest date achieved in the present study (fig. 2g). However, this analysis was done on an unknown number of combined samples and is therefore somewhat unreliable.

Fig. 2 g-h.



Discussion

Where people burned old wood, dates on charcoal can be expected to be earlier than dates on bone. This may be the case for A4 at Dumpokjauratj. The two bone samples from A4 at Dumpokjauratj gave consistent dates, but compared with the charcoal dates, they are later. Another explanation may be that the charcoal itself is not the result of human action but accidentally ended up in the feature when it was used. If so, the charcoal must have been burnt before the human activity that created the bone assemblage. According to Bergman et al. (2004, p. 166) the stratigraphy in the features showed that each was used several times, which may explain the varied dates. The bones were higher up in the stratigraphy in A4 than the charcoal, and so they may derive from later use of the feature.

The stratigraphy in Dumpokjauratj A5 demonstrates re-use of the feature even more clearly, where the three charcoal samples are earlier, coeval and later than the bone sample. However, the earlier charcoal may have a high intrinsic age and thus be coeval with the burnt bone. The earliest charcoal might also, if the feature has been re-used, belong to an earlier occasion. As the many radiocarbon dates from the site shows, Dumpokjauratj was used several times (Bergman et al. 2004, p. 165). The results from Dumpokjauratj

may thus help explain the results from the other sites in the study.

At Garaselet, for example, two or more use phases have previously been identified: one at 8000 BP and the other at 6000 BP (Knutsson 1993, p. 29 f). Two features from the later phase were analysed in this study. A6 had previously been dated with charcoal, and this study adds burnt bone. It turns out that the burnt bone is nearly 600 radiocarbon years earlier than the charcoal. According to Olsen et al. (2008, p. 792), bones can absorb bicarbonate from the ground, causing an earlier radiocarbon date. This does not however affect burnt bones. Old bones that had been lying on the ground for a long time were probably not used as fuel, and so the interpretation should be that A6 had been re-used.

A8 at Garaselet, a hearth, had also previously been dated with charcoal. No bones from feature 8 could be dated because of the fragmentation level, and so a bone from a bone feature associated with the hearth was dated. The bone was 450 radiocarbon years earlier than the charcoal and the hearth and the bone feature seem to have no relation. Since the bone dates from A6 and the bone feature match each other and the charcoal dates from A6 and A8 match each other, the connections in this case are among the charcoal dates and among the bone dates, respectively. This

suggests two different phases in the later use period at Garaset: a »bone phase» and a »charcoal phase», where A6 was re-used.

This study suggests that when people needed a cooking pit or a hearth and there was one already on the camp site, they would use what was already there. As long as a place lives in the memory of a group of people who visit it, it will probably be used in a similar manner every time. What we see in the archaeological record may be one feature, but what actually happened there may have gone on, on several occasions, for a long time. Mattias Ahlbeck (1995, p. 42) calls it »contextual contemporaneity» (sw. *kontextuell samtidighet*). The contexts are not always as simple and sealed as we would like to think, and the re-use of a feature is not always visible, especially with early features which have undergone geological change for thousands of years.

Another reused site is Högland. The dates show that the charcoal and the bone in A2 derive from the same event, while the bone feature on the same site represents an event 1600 years later.

The samples from Kangos and Tjärna show the opposite. Here the bones and the charcoal represent the same events.

Conclusion

There is no systematic difference between radiocarbon dates on charcoal and radiocarbon dates on burnt bones from the same contexts. But they do not differ very much in relation to the statistical uncertainty. This indicates that as long as the samples are taken with accuracy and with knowledge of the error sources, and as long as the sample represents the actual object, it does not matter if the sample is charcoal or burnt bone. Both materials date the use of the feature.

Where charcoal and bones did not yield consistent dates, it has been possible to offer two interpretations:

1. Intrinsic age: old wood used as fuel.
2. Re-used sites and features.

The intrinsic age can be a problem when later contexts are dated and give precise dates with short error bars. When earlier sites are dated, the intrinsic age often fits inside the error bar. The

main problem with charcoal samples from earlier sites is that we cannot be sure if they derive from human action. Only people however burn bones at high temperatures, so by dating burnt bones human action is also dated. If the bones are not found in situ, in association with a sunken feature or other context, contextualisation of the act in situ is impossible. The burnt bone sample itself does derive from human action, but it is impossible to infer contextual information and relate the data to artefacts, for example. As the study shows, a feature may have been re-used, even if this re-use is not apparent during excavation.

Also one must make sure that what gets dated is what is intended. Only certain artefacts or contexts of interest get dated, and if their dates are to be transferred to anything else, one must be convinced that they are securely associated. The most reliable sample is the one that derives from the object itself or is linked to it (Brock & Dee 2013, p. 41 f). Thus we can lower the risk of unexpected results, but such cannot be totally avoided. The unexpected results need not be seen as failures. It is important to think about, and be aware of, the sources of error but to accept and to not gloss over the results because of errors. Otherwise the study will be useless.

If unexpected dates come out, then we must believe in the contexts, but discuss them critically. This study shows that as long as the sample is taken from a sealed context it is reliable. Both charcoal and bone samples are useful for radiocarbon dating, and when the bones are too fragmented, it is possible to date charcoal from the same context instead. As fig. 3 shows, the samples dated for this study connect to the previously dated samples from the same contexts, with within the margins of error suggested by intrinsic age or the periods during which each site was visited. Fig. 3 also shows the contextual contemporaneity of the features and the sites, where one date represents one event and several dates represent several events during a period of use.

Thanks

Thanks to the Helge Ax:son Johnson Foundation, to the Gunvor and Josef Anér Foundation, to Åsa Lundberg, Susanne Sundström and Anders Olofsson of Västerbotten Museum, to Lage Johansson and Annika

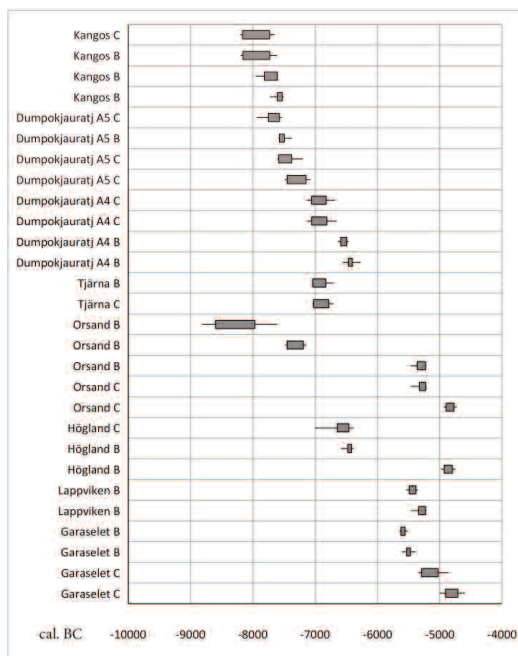


Fig. 3. Contextual contemporaneity on the sites. The diagram shows that sites and features have been used several times. The line represents 2σ and the box represents 1σ . (C=charcoal, B=bone).

Sander of Skellefteå Museum, to Ingela Bergman and Lars Liedgren of the Silver Museum, to Olof Östlund of Norrbotten Museum, to Leena Drenzel of the Swedish History Museum and to Rita Peyroteo Stjerna of the Department of Archaeology and Ancient History, Uppsala University.

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