THE AGE OF BRAINERD CERAMICS

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CLEAN WATER LAND & LEGACY AMENDMENT

Abstract

A comprehensive evaluation of Brainerd Ware was undertaken, focused on determining the dates of this ware and problems associated with the dates. This included a review of all available site data as well as a comparison of dating methods, including radiometric dating of charcoal, bone, and ceramic residues and OSL dating. As a result of this research Brainerd Ware is defined as including only ceramics with net-impressed surfaces and a new ware, LaSalle Creek Ware, is defined as including ceramics with horizontally-corded surfaces. Brainerd Ware and the associated LaSalle Creek Ware begin at approximately 2750 BP and end at approximately 1700 BP, spanning the Early Woodland. Problems with residue dates are examined in detail and recommendations given for further research. Drs. Christy Hohman-Caine and Leigh Syms served as co-principal investigators and Grant Goltz acted as project manager. This research was funded by the Minnesota Arts and Cultural Heritage Fund as part of the Statewide Survey of Historical and Archaeological Sites.

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INTRODUCTION

The Minnesota Historical Society and the Oversight Board of the Statewide Historical and Archaeological Survey have identified a number of research problems that need to be addressed relative to Minnesota archaeology. One of these problems is the age of Brainerd ceramics and related radiocarbon dating problems associated with the use of charred food remains from prehistoric ceramics. The present research addresses this problem, including a consideration of how old Brainerd ceramics are, how late these ceramics continued to be made, and the effects of carbonate contamination on dating charred food residues on prehistoric ceramics (Minnesota Historical Society RFP, "The Age of Brainerd Ceramics"; Goltz, "Proposal for the Age of Brainerd Ceramics RFP"). The specific research questions to be addressed in this report appear in Appendix A.

PREVIOUS BRAINERD WARE RESEARCH

Lloyd Wilford originally noted net-impressed pottery as a ceramic found in north-central Minnesota. Because it frequently occurred on sites that also had Blackduck pottery, Wilford (1955) and Evans (1961) suggested that it was related to the Late Woodland Blackduck Ceramic Series.

Based on research at Gull Lake Dam and in the Headwaters Reservoirs of the Mississippi, Johnson more formally defined the ware, giving it the name "Brainerd" (Johnson 1971; Johnson and Schaaf 1978; Johnson et al. 1977). In the absence of radiometric dating, Brainerd Ware was tentatively assigned to the Late Middle Woodland.

Lugenbeal then restudied ceramics from many of the northern sites Wilford had excavated and suggested that Brainerd Ware ceramics were unrelated to Blackduck and were contemporaneous with Laurel (Lugenbeal 1978). He also included horizontally- corded ceramics within the ware, based on both stratigraphic association with net-impressed Brainerd ceramics as well as what he felt were technological similarities. This latter assertion will be discussed in more detail under our re-examination of Brainerd Ware technology.

At about the same time that Wilford discussed net-impressed pottery from Minnesota, MacNeish identified net-impressed pottery in southeastern Manitoba and called it Rock Lake Net-impressed (MacNeish 1958). Vickers identified similar pottery in southwestern Manitoba (Vickers 1948, 1949, 1950). In his summary for the Handbook of Minnesota Ceramics (1979), Birk, using MacNeish as his source, notes that Brainerd Ware extends to near Lake Winnipeg in southeast Manitoba, but Rock Lake Net-impressed is not specifically mentioned. Hohman-Caine and Goltz, in their re-examination of Brainerd Ware noted that net-impressed pottery is distributed west into the Plains and north and west to Lake Winnipeg and Montana (1995). They did not address the extent of similarity amongst these net-impressed ceramics.

The disconnect between research in Minnesota and Manitoba (and elsewhere, since net-impressed pottery has also been identified in Saskatchewan and Alberta) has greatly limited our understanding of the dynamics of net-impressed ware. Norris (2007) has recently re-examined Rock Lake Ware from southern Manitoba and concluded that it is the same as Brainerd Ware. We will further examine this assertion and its implications for understanding the chronology of net-impressed pottery.

Although Lugenbeal suggested as early as the 1970s that Brainerd Ware was an early to middle Woodland ceramic type, the prevailing paradigm in Minnesota archaeology has placed it in the Late Middle Woodland, and Minnesota has been characterized as lacking an Early Woodland complex (Gibbon 1986). Consequently, once radiometric dates for Brainerd Ware became available, they forced a re-examination of the ceramic chronology of northern Minnesota. And, to complicate the matter, the oldest dates obtained for Brainerd Ware were also among the first dates associated with the pottery.

As old paradigms die hard, various reasons for rejecting the accumulating evidence have been presented. These include the assertion that AMS residue dates have been affected by the "freshwater reservoir effect", i.e. local groundwater or fish from those waters have incorporated old carbon into the sample. Another assertion is that scraping residues off ceramics has incorporated clay material that has affected dates, making them too old by a factor of up to 500 years (Kluth and Thompson 1995).

Another perceived problem with Brainerd chronology is the range of dates, which are thought to span an inordinate number of years—approximately 1,500. Coupled with this is the fact that Brainerd Ware appears to be relatively unchanged during this time, which does not meet expectations (Arzigian 2008)

Much of our understanding of the origin and development of Brainerd Ware and its culture carrier, the Elk Lake Complex, depends on first understanding the chronology, geographic distribution, and ceramic relationships of the ware. But a major paradigm shift that will allow us to truly address the cultural dynamics surrounding the Elk Lake Complex has not yet taken place. The present research aims to address some of the questions surrounding this shift.

CERAMIC WARES .

Brainerd ceramics, as previously defined, have been treated as a single ware, subdivided into two types: net-impressed and horizontally-corded, each with several varieties based on decorative motif (Birk 1979, Hohman-Caine and Goltz 1995). Since our original examination of Brainerd Ware in the mid-1990s (Hohman-Caine and Goltz 1995) a considerable body of new data has become available. For the previous study we had physically examined sherds from 59 vessels and relied on published data from approximately 200 additional vessels. For the present study we used our original data plus data from direct examination of approximately 200 new vessels. We also physically examined sherds from about 150 of the 200 vessels where we had previously used only published data. Thus, the current analysis is based on direct examination of over 400 vessels that have been previously identified as Brainerd Ware.

This work allows us to recommend some major changes in classification, separating the ceramics previously classified together into two distinct wares. This work includes a tighter, more restrictive definition of Brainerd Ware and the definition of a new LaSalle Creek Ware. Together these ware definitions include most of the ceramics previously classified under the single Brainerd Ware designation.

It is not our intention to deal here with the debate over taxonomy and the cultural reality of ceramic groupings. Rather, we are describing these ceramics using the conventional procedures in use in upper Midwest archaeology since the 1950s. Ceramics grouped together as "wares" are large groupings based primarily on technology, including the method of manufacture, clay body of the vessel, general vessel form, surface finish and basic rim form. It is assumed that basic technological similarities, as defined by the ware grouping, will indicate basic information about origins and relationships. Within a ware grouping, there may be subdivisions into types that share the same basic ware characteristics but differ in attributes that may indicate geographic and temporal differences (see Anfinson, et al. 1979 for further references and discussion).

Outside of Minnesota, ceramics resembling Brainerd Ware have been identified over a broad area of the Midwest and central Canada, most notably to the north and west. Some of these ceramics, known as Rock Lake Ware, have recently been identified as fitting the description of Brainerd Ware. We will review existing literature to examine how these ceramics might relate to the origins and trajectory of Brainerd Ware in Minnesota.

It is with these understandings that we have divided the ceramics into two distinct wares: Brainerd and LaSalle Creek. This distinction will enable us to formulate and test better hypotheses about the origins and trajectories of ceramics in Minnesota. The differences between the two wares can be summarized as follows:

<u>Method of Manufacture</u>
Existing evidence suggests that initial vessel construction for both types is by coiling. While subsequent forming and shaping of the vessels has mostly eliminated evidence for obvious coil joins, the presence of fairly regularly spaced, roughly 3 to 5 cm horizontal breakage

patterns on many vessels suggests lines of weakness that likely relate to the boundaries of coils.

After this initial construction the trajectory of further shaping and thinning of the two types diverges. Net-impressed vessels were obviously enclosed in a fine mesh net bag prior to final shaping. Examination of surface finish patterns on restored vessels and large vessel segments clearly shows a continuous pattern of the net which would be difficult to achieve if it were applied by a net-wrapped paddle or rolling of a net covered object (Figure 1). Even on vessel segments where the net impressions are complex due to lifting and re-applying the net, an overall alignment of the knot pattern remains discernable.

Figure 1: Silicone rubber peel of net impressions from restored Brainerd vessel, 21-CA-38

Once the vessel was enclosed within the net, subsequent thinning and shaping could be accomplished from the interior with a scraping tool of wood, bone or, more likely, mussel shell. Striations and wiping marks are commonly visible on the interior of many sherds.

Cord impressed vessels were not enclosed in any kind of textile container. The formed vessel was thinned and shaped by scraping and modeling with a tool until it reached the desired shape and thickness. At this point it had a smooth exterior. The surface of the vessel was then textured by rolling a cord-wrapped object over the surface of the vessel. This object was most likely rod-shaped and probably a centimeter or two in diameter. Spaced wrapping of a cord produced a slant to the wraps that is responsible for the slight obliqueness of the observed cord impressions on most vessels. The direction of wrapping the object determines the slant, left or right, of the impressions on the vessel. Multiple cord impressions resulting from a back-and-forth rolling of the cwo are typically present. Overlaps at the terminus of individual rolling actions are obvious on larger sherds or vessel segments. These become more obvious closer to the vessel base where, due to the conoidal shape of the vessel, the overlaps intersect at differing angles (Figure 2).

Figure 2: Intersecting cord marks on sherds from base of vessels.

Vessel Shape

Vessel shape differs between net-impressed and cord-impressed vessels. The dichotomy of vessel shape is directly attributable to the differing method of manufacture of the two types.

Enclosure of the net-impressed vessels within a net bag and subsequent shaping and thinning from the interior tends to produce a finished vessel that has a smooth, convex curved wall profile. From a typically slightly insloping rim section, this curve increases at the area of greatest vessel diameter and then gradually, but quite uniformly, diminishes towards the vessel base. The resulting vessel shape resembles an egg with about a third of the large end removed.

Examples of this vessel shape can be seen in the net-impressed vessels from the South Pike Bay Site (21-CA-38), the Ebert Site (21-CA-06), the Mud Lake Site (21-CA-02), the Levesque Site (21-CW-247), and Vessel # 2 from the LaSalle Creek Site (21-HB-26) (Figures 3, 4, 5, 6, and 7).

Figure 3: Net-impressed vessel from the South Pike Bay Site, 21-CA-038

(Photo of plaster cast of restored vessel)

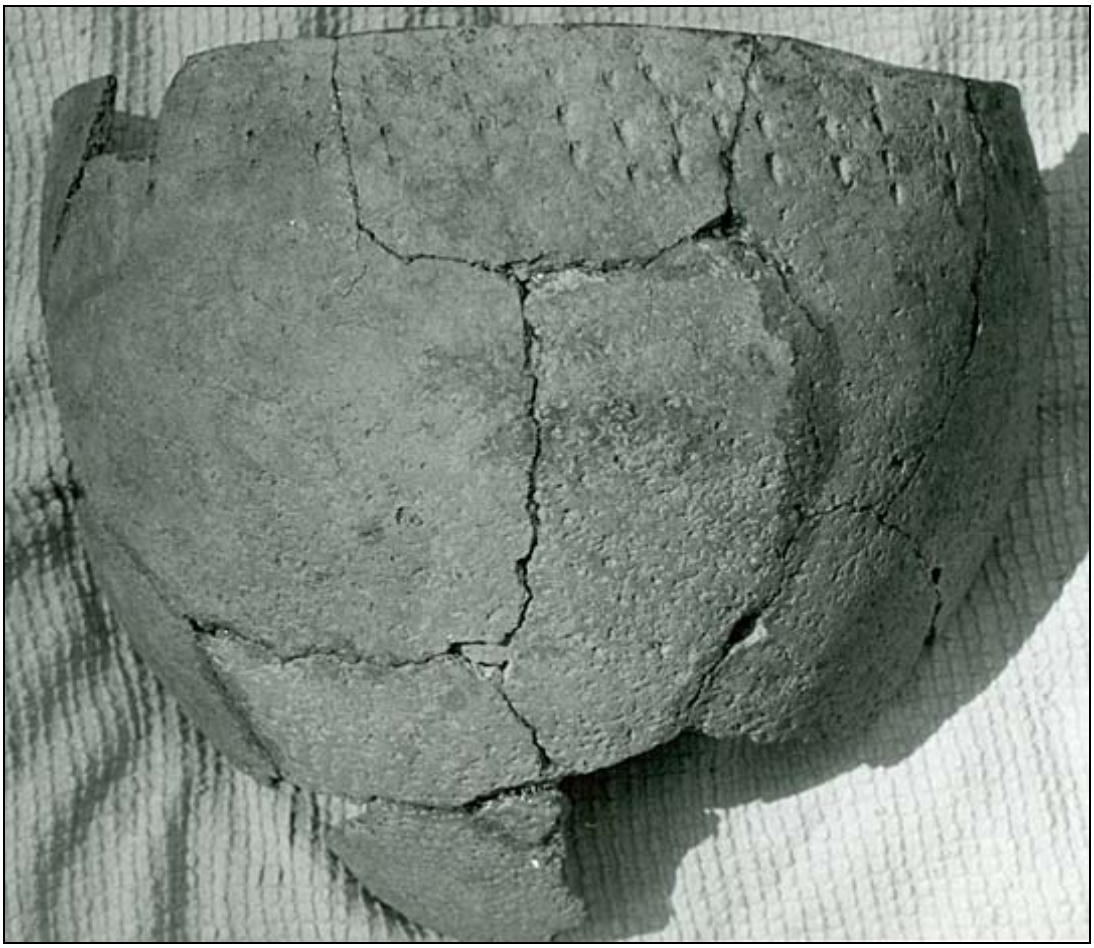

Figure 4: Net-impressed vessel from the Ebert Site, 21-CA-006

(MHS Files)

Figure 5: Net-impressed vessel from the Mud Lake Site, 21-CA-002

(Digital restoration from large restored vessel section)

Figure 6: Net-impressed vessel from the Levesque Site, 21-CW-247

(Digital restoration from restored vessel sections)

Figure 7: Vessel # 2 from the LaSalle Creek Site, 21-HB-026

(Digital restoration from restored vessel sections)

While the initial shaping and smoothing of the cord-impressed vessels results in a profile similar to that of the net-impressed vessels, subsequent application of the cord-wrapped-object alters this shape considerably. Since pressure is exerted from the exterior of the vessel, this tends to flatten the smooth curve in both the area between the greatest vessel diameter and the rim, and in the basal area below the greatest vessel diameters. The result is a profile that is somewhat irregularly flattened below the rim, retains the sharpest curve at the greatest vessel diameter, and is somewhat irregularly flattened between there and the base.

Examples of this vessel shape can be seen in the horizontally-corded vessel from the Kelnhoffer Site (21-CA-226), the Thunder Lake West Site (21-CA-738), and vessel #1 from the LaSalle Creek Site (21-HB-26) (Figures 8, 9, and 10).

Figure 8: Horizontally-corded vessel from the Kelnhoffer Site, 21-CA-226

(Reproduction from measurements of restored vessel sections)

Figure 9: Horizontally-corded vessel from the Thunder Lake West Site, 21-CA-738

(Reproduction from measurements of restored vessel sections)

Figure 10: Vessel # 1 from the Lasalle Creek site, 21-HB-026

(Digital restoration from restored vessel sections)

Nature of the Clay Body

Examination of sherds from numerous net-impressed and horizontally-corded vessels has demonstrated significant differences in the clay body for the two types. This relates primarily to the degree of preparation of the clay used for making the vessels.

The vast majority (between 70 and 80 percent) of the net-impressed vessels examined had a clay body consisting of a sandy paste with no added grit temper. While there is no way to determine if the sand was intentionally added, it should be noted that naturally occurring clays in the glacial till of much of north central Minnesota, where net-impressed ceramics appear to have originated, contain similar proportions of sand to that found in net-impressed

sherds. The common occurrence of irregular pebbles up to approximately a centimeter in diameter in many of these vessels suggests that clay was used with little preparation after it was collected. Experimental replication by Goltz of these kinds of vessels has demonstrated that it is a simple task to remove pebbles that are too large to be contained in the vessel wall during construction as the vessel is being formed and thinned.

The remaining 20 to 30 percent of the net-impressed vessels examined have the same sandy paste, but with the addition of small amounts of crushed grit temper, mostly less than two or three millimeters in diameter. In most cases this appears to be crushed white quartz rather than the feldspar/quartz mix derived from crushed granitic rocks that is more common in later Woodland vessels.

With but one or two exceptions, all of the cord-impressed vessels examined contained crushed grit temper. This tended to be primarily crushed quartz, but generally occurred in larger amounts and in sizes up to about 5 millimeters in diameter. Some vessels had grit consisting of primarily crushed pink feldspar. Almost no irregular pebbles were found in the cord-impressed sherds examined.

This seems to indicate that considerably more effort was expended to clean and process the clay for these vessels compared to that used in the net-impressed vessels.

Because of these basic differences, we propose separating these two types into two wares. We propose that the net-impressed ceramics continue to be designated as Brainerd Ware.

While there are several existing defined wares that are similar to the horizontally cord-impressed ceramics (for example, Avery Corded in Manitoba and Ethridge Cord-Roughened in the Canadian Plains and Montana), none of them fit precisely with the ceramics found in north-central Minnesota. We first observed what we are identifying as the defining characteristics of these ceramics on a restorable vessel recovered from the LaSalle Creek Site (21-HB-26). Therefore, we are suggesting the name LaSalle Creek Ware for these cord-impressed vessels.

A third ceramic type that has been recovered in association with Brainerd and/or LaSalle Creek Ware on a few sites in Minnesota is a “horizontally fluted” or “parallel grooved” type. At least five such vessels have been recovered from four sites in Cass, Douglas, and Ottertail counties. A sixth vessel with a parallel grooved upper body and a net-impressed base was recovered from a site in Cass County. Because this ceramic type occurs in a limited extent in Minnesota and similar ceramics occur associated with net-impressed and horizontally-corded ceramics on the Canadian Plains, we propose that the Minnesota ceramics should be included under the name used in that area, Truman Parallel-Grooved.

The differences among these three wares are not merely technicalities. If we are to understand the cultural trajectories of ceramics, lumping ceramics that have major differences in manufacturing will only serve to obscure their development and spread and will, therefore, prevent the formulation of meaningful hypotheses relating to their origins and development.

WARE DEFINITIONS

The following definitions should be considered an update to the Handbook of Minnesota Prehistoric Ceramics.

Brainerd Net-Impressed Ware

Sample Size. During the course of this study, we personally examined rims from 250 net-impressed vessels from 18 sites. Additional collections likely contain at least another 150 to 200 vessels, bringing the total to an excess of 400 vessels.

Clay Body. A distinctive feature of Brainerd ceramics is the nature of the clay body. It can be described as somewhat porous and frequently sandy in appearance, and often has a weathered surface. The majority of vessels appear to have no intentionally added aplastic materials (temper). The significant amounts of fine to coarse sand, along with pebbles up to 1cm in size appear to be natural inclusions in the clay. Approximately 25 percent of vessels have small amounts of grit temper, 2 to 3mm in diameter and typically consisting of crushed quartz.

Thickness. Vessel wall thickness is usually quite variable within an individual vessel, typically increasing irregularly from rim to base. The rim area is typically 4.5 to 6.5mm thick with a range from 3.5 to 8.0mm. The body of most vessels is typically 6 to 8mm thick with a range from 5 to 9mm. Vessel bases are sometimes in excess of 10mm thick. There is some indication that later vessels tend to average somewhat thinner than early vessels.

Surface Treatment. The exterior surface of the vessel body has impressions produced by a fine mesh net. These impressions occasionally are also on the lip surfaces. They may range from a clear single net impression, where the knot pattern and connecting web strands are very distinct, to a complex impression where the net was applied and subsequently lifted and shifted, or was applied in a somewhat crumpled manner. Even where the net pattern is complex, however, the overall regular knot pattern is frequently discernable over large sherds or restored vessel segments. The surface may be left with distinct impressions or smoothed over to varying degrees, sometimes to the point of being almost smooth with only the faint impressions of the deeper knot marks (Figure 11).

Figure 11: Examples of variation in net impressions

The distinguishing characteristic is the presence of impressions of the knots. There are instances of sherds with a pattern of intersecting cord-like impressions that form a net-like arrangement (Figure 12). Unless there is a deeper knot impression at the intersection of the cords, this is not a net impression.

Figure 12: Intersecting cord-like impressions sometimes confused with net

The character of the net falls within a very narrow range. Mesh size is typically between 5.0 and 6.5mm (measured on the side of a mesh, knot-to-knot) with a range of 3.5 to 7.5mm. Cordage is usually Z-twist and typically ranges between 0.5 and 0.8mm in diameter. The cordage appears to be composed of well processed fine fibers, possibly from wood nettle or dogbane ("Indian hemp") or a similar plant. Knot size typically ranges between 1.75 and 3.0mm in diameter.

Method of Manufacture. Close examination shows at least some indication of construction joints similar to "coil breaks". These often are exhibited as a series of roughly horizontally oriented breaks, spaced approximately 3 to 5cm apart. This evidence suggests that initial forming of the vessel was accomplished by some type of coil construction. Observations of the net impressions on several restored vessels or on large vessel sections clearly shows a continuous net pattern that could not have been accomplished with a net-wrapped paddle or other object.

The overall pattern of the net impressions suggests that the roughly formed vessel was enclosed in a net bag for support during final thinning and shaping. Lifting and repositioning of the net bag during manipulation of the vessel would cause the effect of a complex net impression. This appears more common in the upper part of a vessel, rather than near the base.

Vessel Form and Size. Most Brainerd Ware vessels exhibit an overall conoidal to subconoidal body form with the maximum vessel diameter occurring down from the rim at about one-third of the vessel height. Rim section profiles typically are slightly insloping and may sometimes have a slight flare near the vessel lip. On a few vessels the rim section may be vertical. One almost completely restored vessel has a slight shoulder with a taller and

slightly constricted rim section. Below this, however, the vessel shape is identical to most other documented Brainerd Ware vessels.

Vessel bases are usually rounded to subconoidal, but more pointed bases have been observed on a few vessels. One vessel has an obviously rounded bowl shape, but it is not clear whether this is just an idiosyncratically shaped vessel or is actually a later vessel that for some reason has a net-impressed surface finish.

Vessel lips range from flat to gently rounded. Flattened lips may have a slight to moderate outslope, but insloping flattened lips have not been observed. A slightly to moderately folded over edge that projects somewhat to the exterior is sometimes present.

Brainerd Ware vessels have a distinctive profile that probably results from the manner in which they were formed and thinned. After enclosure within the net bag, most shaping and thinning was accomplished from the interior of the vessel by use of some spatulate shaped tool, possibly simply a mussel shell. Scraping and wiping striations are clearly visible on the interior of many sherds. This type of action naturally creates a vessel profile that is convex throughout. This convex profile is typically gently curved near the rim, assumes the greatest curvature at the maximum vessel diameter, and gradually diminishes in curvature approaching the vessel base. The curve at the base then increases rapidly to form either a subconoidal or rounded point shape. Overall, this vessel shape is similar to that of an egg with the large end removed. Geometrically, this shape can be described as a segment of the base of a parabola, rotated 90 degrees to its axis .

Brainerd Ware vessels tend to be quite large with typical rim diameters ranging between 26 and 32cm. Maximum vessel diameters are generally between 1.5 and 3cm larger than the rim. Vessels with rim diameters between 15 and 26cm are considerably less common. Vessel volumes for the larger vessels are typically between 12 and 20 liters.

Decoration. Decorative motifs were examined for 199 vessels from 18 sites and from the literature for an additional 22 vessels from other sites. In total, 221 vessels are included here. Of these, 123 (55.7%) are undecorated on the exterior. Thirty-four (15.4%) are decorated with some form of cord-wrapped-object stamp, 31 (14.0%) with vertical to slightly obliquely oriented angled stamps or shallow punctuates, 21 (9.5%) with oblique to vertical incised lines, and 5 (2.3%) with circular "hollow reed" or bone stamps. Seven vessels (3.2%) had some other decoration, often some combination of the above decorations. Vessel interiors were typically plain, but a few had oblique cwo stamps or incised lines. Except for occasional net markings, most vessel lips were plain, with a few having regular spaced "nicks" across them.

LaSalle Creek Ware (formerly Brainerd Horizontally Corded)

These ceramics have several basic characteristics that differentiate them from Brainerd Net-Impressed ceramics and should be placed within a separate ware category.

Sample Size. During the course of this study, we personally examined rims representing 120 cord-impressed vessels from 14 sites. Additional collections likely contain at least that many more vessels, bringing the total close to 300 vessels. Since sherds from these vessels are not as distinctive as net-impressed ceramics, the identified sample likely underestimates the real total.

Clay Body. As in Brainerd Ware, the clay body is distinctive in that it has a porous nature and a somewhat sandy appearance. The paste, however, tends to be finer and lacks the larger pebbles and coarser sand. With few exceptions, the clay body has at least a moderate amount of intentionally added grit temper consisting of crushed quartz or a mixture of quartz and feldspar, ranging from 2 to 5mm in diameter. Because of this the clay exhibits a more refined degree of processing than that commonly used in Brainerd Ware.

Thickness. Vessel wall thickness is usually quite variable within an individual vessel, increasing irregularly from rim to base. The rim area is typically 4.0 to 6.0mm thick with a range from 3.0 to 8.0mm. The body of most vessels is typically 5 to 8mm thick with vessel bases somewhat thicker.

Surface Treatment. The exterior surface of the vessel has cord impressions that are most commonly oriented horizontally or nearly so, often sloping 5 to 15 degrees to the right. A left sloping orientation is less common. Some vessels have a steeper slope to the cord orientation and, on a few vessels, the cord marks are vertical. Varying degrees of smoothing of the cord impressions were noted, but most impressions are still fairly distinct (Figure 13). Often cord marks near the rim area are more distinct from those further down on the vessel body.

Figure 13: Examples of horizontally cord-impressed surface treatment

Examination of restored vessel segments shows that the cord impressions were likely applied by rolling a cord wrapped, dowel shaped object over the surface of the vessel after it had been thinned and smoothed. Spacing of the cord wraps is typically 2.5 to 5.0mm. Closer apparent spacing sometimes occurs from multiple impressions. Most typically the cord is Z-twist, but S-twist cord marks are found on some vessels. Cord diameters as small as 0.5mm and as large as 1.75mm have been observed, and are often variable on a single vessel.

Method of Manufacture. The initial forming of the vessel appears to be by coiling. Final shaping and thinning of the vessel, however, appears to have been accomplished without the vessel being contained in a fabric structure, as is the case with Brainerd Ware. Once the final form and thickness was attained and the vessel surface smoothed, the cord-wrapped-object was applied to the exterior. Impressions suggest a simple back-and-forth rolling with the cwo moved from place to place as the impressing proceeded. The overlaps of the individual rollings are evident, particularly near the base where they tend to intersect at slight angles due to the tapering of the vessel body.

Vessel Form and Size. Most LaSalle Creek Ware vessels exhibit an overall conoidal to subconoidal form with the maximum vessel diameter occurring down from the rim at about a third of the vessel height. Rim section profiles are typically insloping and generally lack any flare near the vessel lip. LaSalle Creek Ware vessels commonly have a narrower diameter to height ratio than Brainerd Ware vessels, likely caused by the vessel walls being pushed in during the application of the cwo rolling. This action also affects the vessel profile,

which tends to be flattened from a continuous convex curve, both above and below the point of maximum diameter. Consequently, the complete vertical profile shows the maximum curve at the point of greatest diameter and has a much straighter segment between this point and the rim. The lower part of the profile is also straighter until it reaches the curve of the base.

Vessel bases, while subconoidal, tend to have a somewhat more rounded shape than the Brainerd Ware vessels. Vessel lips can be flat to rounded, and may have a protruding folded over exterior.

LaSalle Creek Ware vessels typically have rim diameters between 26 and 30cm, with a few smaller vessels.

Decoration. Decorative motifs were examined for 106 vessels from 14 sites and from the literature for an additional 6 vessels from 1 site, totaling 112 vessels. Of these 49 (43.8%) were undecorated on the exterior. Thirty-one (27.7%) were decorated with some form of cord-wrapped-object stamp, 22 (19.6%) with vertical to slightly obliquely oriented angled stamps or shallow punctuates, 5 (4.5%) with oblique to vertical incised lines, and 4 (3.3%) with "hollow reed" or bone stamps. One vessel (0.9%) had some other decoration. Vessel interiors, particularly on cwo stamped vessels, often had oblique cwo stamps.

Truman Parallel-Grooved Ware

While this ware is common on Avonlea sites in the western plains, only a few vessels have been recorded within Minnesota. The following description is necessarily brief, due to lack of data. Other descriptions of Truman Parallel-Grooved are found in Meyer and Walde (2009).

Sample Size. During the course of this study we personally examined rims from 4 parallel grooved vessels from 3 sites. This ceramic type has been recorded from one additional site within Minnesota and a vessel with a parallel-grooved rim area and a net-impressed lower body has been recovered from another Minnesota site. This latter vessel is not considered within this ware description. Thus, there are a minimum of 5 known vessels plus additional sherds that may represent an unknown number of additional vessels. There may be other vessels in extant collections, probably within what have been identified as "simple stamped" sherds. The number of identified vessels on the western plains is unknown, but is considerably higher than known from Minnesota.

Clay Body. The clay body from Minnesota vessels examined definitely has a finer paste and is more compact than that from either Brainerd or LaSalle Creek Wares. Grit temper in the form of moderate amounts of crushed quartz and/or feldspar is present in all vessels.

Thickness. Vessel wall thickness is less than either Brainerd or LaSalle Creek Wares. The rim area is typically 3.5 to 5.5mm thick and is only 2.5mm thick on one vessel examined. Body thickness ranges from 4.5 to 6.5mm on the vessels examined.

Surface Treatment. The exterior surface of the vessel body has horizontally oriented alternating "ridge and grooves" or "flutes". These tend to be of nearly equal width and range between 3 and 5mm in width. Some areas are smoothed over to the point of almost obliterating the impressions.

Method of Manufacture. Although the method of manufacture is unknown, it is presumed that these vessels were made similarly to LaSalle Creek Ware, with possibly a "thong-wrapped" dowel substituted for the cwo.

Vessel Form and Size. The lack of partially reconstructed vessels limits a determination of vessel form. Based on sherds recovered, these seem to have a less conoidal base than Brainerd or LaSalle Creek, but likely still have an overall subconoidal shape. Rims on at least two of the vessels have a flared lip, one substantially so.

Limited measurements suggest that the known vessels from Minnesota are smaller than most Brainerd or LaSalle Creek Ware vessels.

Decoration. Of the 4 vessels from Minnesota examined, 2 lack exterior decoration and 2 have vertically oriented angled stamps, one with at least 2 and possibly 3 widely separated rows.

DISTRIBUTION OF BRAINERD WARE CERAMICS

Our 1995 review located 130 sites coded as having Brainerd Ware. These would include sites with either net-impressed or horizontally-corded Brainerd ceramics, or both. This list was compiled through combining information collected by the investigators with a query of the Minnesota State Historic Preservation Office database. At that time, problems with the coding of information in the SHPO database were discussed, as only 73 percent of the known Brainerd sites appeared coded as Brainerd in that database.

For this update we utilized the SHPO database again, but also added information obtained from our own research and by direct inquiry to our colleagues. We also attempted to directly consult the site reports for all sites that had received Phase II or Phase III treatment, as these would be the sites most likely to have larger collections of the ware.

Database problems continued to abound. We digress here to include a brief discussion of these problems, as they severely compromise the usefulness of the database for testing any archaeological hypotheses.

There are two ways to locate a particular ceramic type using the SHPO database: a query under ceramics or a query under context. Since Elk Lake (the cultural complex encompassing Brainerd Ware) has not been used as a code in the database, the query would be for Brainerd (under ceramics) and Brainerd (under context). Unfortunately, there are sites with identified Brainerd Ware that are coded "aboriginal" under ceramics, and "Woodland" under context, thus making them invisible. Other problems include a total lack of coding under one or other of the relevant data fields, miscoding, and coding that is contradictory between ceramics and context. Frequently, sites with Brainerd Ware can be identified by the coding for context, but not for ceramics, and vice versa.

Most of the sites identified as having Brainerd ceramics in the 1995 study, but that were not coded as such in the SHPO database, remain miscoded in the current database over fifteen years later.

If the site database is to be used for any broad-scale studies of site distribution and characteristics, corrections need to be made before the database gets so large that it is virtually uncorrectable and unusable for research.

Our 1995 examination of the distribution of Brainerd Ware expanded the distribution from the original known concentration, which was centered around a nexus of sites in the Headwaters Reservoir Lakes area (Hohman-Caine and Goltz 1995).

In the course of the current examination we located 246 sites that had Brainerd Ware. Although the core concentration of these sites looks similar to what it did in 1995, there is an extension of known sites both southward and westward (Figure 14).

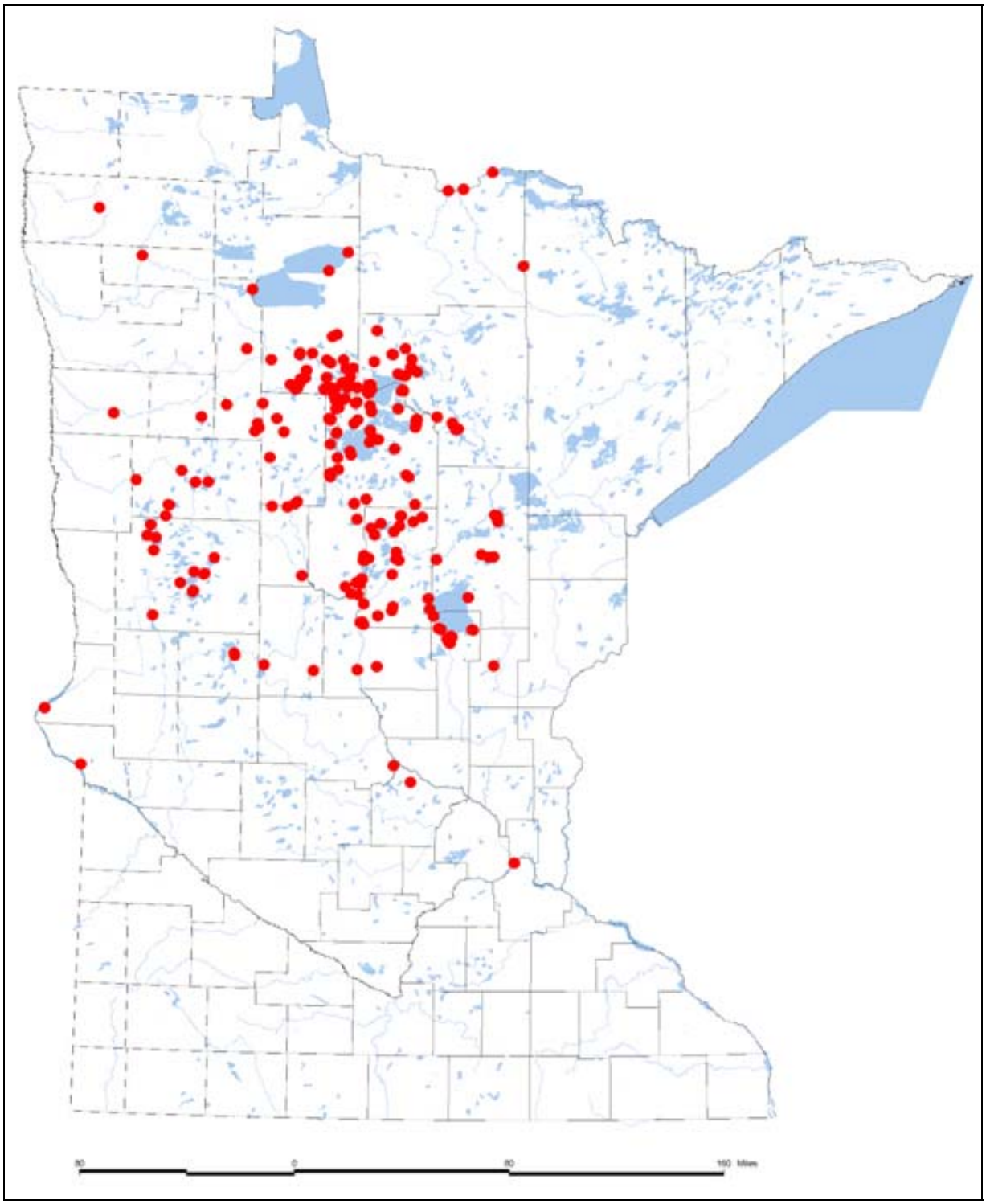

Figure 14: Locations of "Brainerd" sites in Minnesota

(Note: some symbols are overlapping and represent more than one site)

The major known concentration of sites remains in north-central Minnesota, however. If the number of Brainerd sites is viewed as a percentage of all numbered sites in a county, four

counties stand out where more than 10% of the numbered sites have Brainerd Ware. These counties are Beltrami, Clearwater, Cass, and Wadena. Counties with approximately 4-10% Brainerd sites include the surrounding counties of Koochiching, Itasca, Aitkin, Mille Lacs, Crow Wing, Todd, Otter Tail, Becker, Mahnomen, and Pennington. At the southern edge, Morrison, Kanabec, Wright, Dakota, and Stearns counties also have small numbers of Brainerd sites, as do the western edge counties of Douglas, Traverse, Big Stone, Norman, and Marshall. It is striking that Brainerd Ware sites do not occur to the northeast or east and, except for one site in Dakota County, do not occur in the south.

At the Canadian border, ceramic terminology for net-impressed ware changes. In Manitoba this same ware is known as Rock Lake Net-impressed. And, in Canada, the distribution extends westward through Saskatchewan into Alberta. There appears to be no reason to distinguish between net-impressed ceramics that have been termed Rock Lake Net-impressed and those that have been called Brainerd Ware Net-impressed type. The implications of this will be discussed further in the following chapters.

APPROACH TO DATING BRAINERD CERAMICS

Prior to the late 1980s the ability to date materials from archaeological contexts by radiometric methods was confined to rather large samples. The advent of AMS dating made possible the dating of extremely small samples, such as encrusted carbonized food residues on ceramic sherds. This is of particular value in situations where other dateable material is absent or scarce, or where such materials lack good association with objects of chronological interest.

During the 1990s a significant body of radiometric data from materials attributed to Brainerd ceramics had accumulated. Most of these dates were from burned food residues on ceramic sherds. Hohman-Caine and Goltz (1995) summarized these data along with other aspects of the material culture and environmental variables to define the Elk Lake Complex. A total of 18 dates, 16 of them from residues, were used to suggest a chronology.

Since that time several additional dates, 5 from wood charcoal and 9 from residues, have been obtained by various researchers. Although the cultural context of the residues could not be questioned, skepticism grew regarding the age of these dates. The present study was designed to answer the questions regarding those seemingly old dates.

The accumulated body of data suggested a long span of time, with dates ranging from approximately 4400 to 1300 B.P. While some of these dates obviously had to be in error, there was no information that allowed for the acceptance or dismissal with any degree of certainty for any individual date. In the few cases where paired dates consisting of a combination of residue dates and dates from other materials existed from the same depositional context, a span of several hundred years separated the dates.

The questions regarding dating for Brainerd ceramics can be summarized as follows:

A. Are existing AMS dates on burned food residues representative of actual dates for the ceramics?
B. Is the long time span shown by existing dates real or has it been artificially expanded due to varying errors in those dates (i.e. are some dates too early or late)?
C. Are the dates from burned food residues skewed because of incorporation of old carbon (sometimes referred to as the freshwater reservoir effect)?
    1. If so, is this skewing relatively uniform or are some dates affected more or less than others?
    2. If there is a freshwater reservoir effect, what factor(s) are involved (food source, geological setting, surface/groundwater chemistry, etc.)?

To provide data for answering these questions, 40 additional radiometric dating samples were submitted to two separate labs. Emphasis was placed on obtaining dates from other materials associated with existing or new dates from ceramic residues. In addition an additional dating method, Optically Stimulated Luminescence (OSL) dating was used to directly date some ceramic sherds.

RADIOMETRIC DATING SAMPLES

We originally planned to submit 24 to 30 samples from 6 to 8 sites for radiometric dating. We were eventually able to locate 15 sites from across north-central Minnesota that had good potential samples. Notes and data from these sites were searched to identify potential samples suitable for radiometric dating for this project.

Concurrently, a list of previous dates and results were compiled. This process identified the body of existing and potential radiometric data that were reasonably available for this project. It also identified data gaps where we needed to spend extra effort in order to find potential samples. Since this project was scheduled to be done during the time when no field work was possible due to frozen ground, the opportunity for collecting additional field data was extremely limited.

Materials from existing collections were searched to identify potential samples that could be submitted. For several sites, dates had already been obtained for residue samples on Brainerd sherds. In these cases we looked for suitable samples of other materials associated with the Brainerd occupation, primarily charcoal and burned bone that might provide comparative dates. In other cases we looked for additional residue samples from sites where no dates had been run, and comparative samples from other materials. Sample selection was done by Goltz with review by Caine and Syms.

The initial submission of samples consisted of 7 burned ceramic residue samples, 13 charcoal samples, and 7 bone/burned bone samples, and were sent to Beta Analytic, Inc. (Table 1). All samples were submitted for AMS dates. (Note: two of the samples were not dateable and were eliminated.)

Table 1 Initial AMS samples submitted to Beta Analytic, Inc.

SAMPLE NO.	SITE #	TYPE	PROVENIENCE	COMMENTS
GGTL-1	21-CA-738	Residue	ST-14	From H-Cord vessel
GGFL-1	21-OT-152	Residue	Unit 3, 5-10 SW	Par Grooved Vessel 1
GGFL-2	21-OT-152	Residue	Unit 7, 5-10 SE	Par Grooved Vessel 2
GGLV-1	21-CW-247	Residue	Unit 13, 5-10 NE	H-Corded, 212-11
GGRP-1	21-CA-067	Residue	Unit 10, 30+ feat.	Net-Impressed 203
GGRP-2	21-CA-067	Residue	Unit 11, 15-20 SE	Net impressed 218
GGRP-3	21-CA-067	Residue	Unit 17, 10-15 SW	Smoothed 334
GGTL-2	21-CA-	Charcoal	ST 14	w/ H-Cord vessel

	738			
GGLV-2	**21-CW-247**	**Charcoal**	**Unit 42, 5-10 NE**	**Bear paw feat, 713-286**
GGLV-3	**21-CW-247**	**Charcoal**	**Unit 43, 5-10 NW**	**Bear paw feat, 733-199**
GGLV-4	**21-CW-247**	**Charcoal**	**Unit 22, 10-15 NW**	**B. butternut, 436-80**
GGLV-5	**21-CW-247**	**Charcoal**	**Unit 19, 5-10 NW**	**w/H-Cord ves, 353-43**
GGLV-6	**21-CW-247**	**Charcoal**	**Unit 47, 15-20 SW**	**Burned shaft**
GGMX-1	**21-CA-109**	**Charcoal**	**Unit 3, 15-20 SE feat**	**216**
GGMX-2	**21-CA-109**	**Charcoal**	**Unit 15, 10-15 NE feat**	
GGMX-3	**21-CA-109**	**Charcoal**	**Unit 9, NW feat**	**103-10**
GGBR-1	**21-CA-737**	**Charcoal**	**Unit 2, 20+ feat bottom**	
GGRP-4	**21-CA-067**	**Charcoal**	**Unit 10, 30+ feat**	**203**
GGRP-5	**21-CA-067**	**Charcoal**	**Unit 16, 15-20 SE**	**325**
GGKE-1	**21-CA-226**	**Charcoal**	**Unit 21, 5-10-NE**	**w/H-Cord vessel**
GGLV-7	**21-CW-247**	**Bone**	**Unit 42, 5-10 NE**	**Lge. herbivore 713-91**
GGLV-8	**21-CW-247**	**Bn. bone**	**Unit 41, 5-10 SE**	**Bear 690-32&33**
GGLV-9	**21-CW-247**	**Bn. bone**	**Unit 19, 5-10 NW**	**w/H-Cord ves 353-20-42**
GGBT-1	**21-BK-099**	**Bn. bone**	**Unit G, 15-20**	**255,2-4; 256,1-3 elk?**
GGRP-6	**21-CA-067**	**Bn. bone**	**Unit 10, 30+ feat**	**203**
GGRP-7	**21-CA-067**	**Antler?**	**Unit 8, 15-20 SW**	**147 (not dateable)**
GGFL-3	**21-OT-152**	**Teeth**	**Unit 3, 5-10 SW**	**016 (not dateable)**

Ceramic residue samples submitted were from sites that had suitable samples, but where no dates had previously been run. In one case, a sample from an additional vessel was submitted (horizontally-corded) from a site where a vessel (net-impressed) had previously been dated. In addition to the AMS dating, 15N/14N isotope ratios were requested to better understand the nature of the residues.

The 13 charcoal samples were selected based on the following criteria: removed from a feature where a ceramic residue date had been or was being obtained (7 samples); where no suitable residue sample was available, but an optical luminescence date was being run on a ceramic sherd (8 samples); where Brainerd ceramics were recovered from a feature with charcoal but no other dating was available (2 samples); from midden deposits identified as associated with a Brainerd occupation (2 samples). (Note: numbers total to more than 13 because some samples fit more than one criterion.)

The 7 bone/burned bone samples were selected based on the following criteria: from a feature where a ceramic residue date had been or was being obtained (6 samples), from a feature where an optical luminescence date was being run (5 samples); or from a feature where a charcoal date was being run (4 samples). (Numbers total to more than 7 because some samples fit more than one criterion).

Ceramic residue samples were limited to those that were thick enough to allow removal with no actual scraping on the sherd. These samples could be flaked off. All of the charcoal samples consisted of material from a single fragment of charcoal rather than from a mixed sample. Bone/burned bone samples were selected based on criteria provided by the radiocarbon laboratory.

Four duplicate ceramic residue samples were submitted to a second laboratory as split samples. Three of these were from archived subsamples of previously dated samples and one sample was a subsample of one of the samples discussed above (Table 2). These were submitted to Paleo Research Institute.

Table 2: Split AMS samples submitted to Paleo Research Institute

SAMPLE NO.	SITE #	TYPE	PROVENIENCE	COMMENTS
GGFE-01	21-CA-188	Residue	Split of Beta 92827	Net-Impressed
GGBT-02	21-BK-099	Residue	Split of Beta 187667	Net-Impressed
GGFL-04	21-OT-152	Residue	Split of Beta 296080	Par-Grooved
GGLAC-02	21-HB-026	Residue	Split of Beta 76189	Net-Impressed

The second submission consisted of 3 burned bone/bone samples submitted to Beta Analytic, Inc. (Table 3). Two of these were burned bone from a feature containing net-impressed ceramics and one was from midden deposits tentatively associated with a Brainerd occupation.

Table 3: Second group of AMS samples submitted to Beta Analytic, Inc.

SAMPLE NO.	SITE #	TYPE	PROVENIENCE	COMMENTS
GGSI-1	21-CA-028	Bn. bone	Unit 13, 30-35 NW feat	w/Net-Imp ceramics
GGSI-2	21-CA-028	Bn. bone	Unit 13, 35-40 NW feat	w/Net-Imp ceramics
GGLV-10	21-CW-247	Bone	Unit 21, 25-30 SW	Midden 420-12 bison

The next group of samples consisted of 4 ceramic residue samples, 2 burned bone samples, and 1 charcoal sample. Five of these dates were financed by additional funds from MHS and two by funds from our original contract. All were submitted to Beta Analytic, Inc. (Table 4).

Table 4: Third group of AMS samples submitted to Beta Analytic, Inc.

SAMPLE NO.	SITE #	TYPE	PROVENIENCE	COMMENTS
GGPM-1	21-BL-031	Residue	2009 west site area	Net-Imp
GGPM-2	21-BL-031	Residue	2010 Unit 1E	Net-Imp
GGPM-3	21-BL-031	Residue	2010 Unit 14E	H-Cord
GGPM-4	21-BL-031	Residue	2009 E/W 5-6M E	H-Cord
GGRP-8	21-CA-067	Bn. bone	Units 9 & 21	182, 402, 404, 406, 411, 414
GGTL-3	21-CA-738	Bn. bone	Unit 4, 15-20 NW	Feat w/H-Cord sherds
GGTL-4	21-CA-738	Charcoal	Unit 5, 15cm SE	Feat w/H-cord rims

The 4 ceramic residue samples were from a site where no dates had previously been run. One burned bone sample was selected to substitute for a previous sample that returned an unacceptable date. The final burned bone sample and the charcoal sample were from a feature containing an almost complete horizontally-corded vessel. This vessel had been recovered from a Phase I survey shovel test and we returned to the site in late April of this year to recover additional samples to pair with a ceramic residue sample submitted earlier in the project.

One final ceramic residue sample was submitted to Paleo Research Institute. We had originally felt that this sample was too small, but since Paleo Research had used only a small fraction of previously submitted samples, we had confidence that this sample could be run by them. This sample consisted of burned residue from a second Net-impressed vessel from site 21-CW-247

OPTICALLY STIMULATED LUMINESCENCE DATING SAMPLES

When preparing our proposal, we searched for alternative methods to supplement radiometric dating. One obvious method was Thermoluminescence dating of ceramic sherds. After numerous inquiries to laboratories and colleagues who had previously submitted Thermoluminescence samples we discovered that no laboratories were available that had a turn-around time of less than a year. Obviously, this would not fit the project schedule.

A colleague in Winnipeg suggested that we try Optical Luminescence dating. He was working with a lab that offered a 3 to 4 month sample turn-around. We submitted 10 ceramic

sherds to the Luminescence Dating Research Laboratory at the Univeristy of Illinois, Chicago, within a week of the award of the contract to us.

Optical Luminescence depends on the fact that materials in the ground take on a charge since their last exposure to light. This technique is used primarily to date aeolian and alluvial sediments, but is applicable to ceramics. Since only a momentary exposure to light is needed to reset the sample to zero, the exposure during preparation of the clay should be adequate. Thus, this method should date the manufacture of the vessel. Although the surface of the sherd is exposed to light during recovery and subsequent activities, the exterior of the sherd can be removed and the interior can be dated.

Two conditions must be met. First, the sherd needs to be large enough and thick enough. Three cm in diameter is adequate and since Brainerd sherds tend to be fairly thick, this was not a problem (Ideally sherds should be 5 to 6mm thick, but we selected sherds between 7 and 9mm thick). The second requirement is a small soil sample, approximately 50 grams, from a location relatively close to where the sherd was recovered (ideally, within a half meter). This was the most limiting factor in our sample selection. We had soil samples from features that were adequate in several cases and in other cases we were able to collect enough soil (50 grams is only approximately a teaspoon or two) from bags of unwashed fire-cracked-rock from the same or adjacent quarter meter of the sherd location.

Seven of the samples were selected from vessels that had been previously dated or were to be dated by ceramic residues, and 3 samples were selected from features where associated charcoal could be dated (Table 5).

Table 5: Samples submitted for Optically Stimulated Luminescence dating

SITE NO.	SITE NAME	SAMPLE #	PROVENIENCE	COMMENTS
21-CW-247	Levesque	EP-688	Unit 41, 688	Large net-impressed
21-CW-247	Levesque	EP-712	Unit 42, 712	Smooth, thick
21-CA-226	Kelnhoffer	KH-23	Unit 23, 23-6-6	H-cord, flat bottom
21-CA-738	Thunder Lake	TL-14	ST 14	H-Cord
21-CA-109	Maxson	MX-066	Unit 7, 066.2	Par Grooved
21-CA-067	Rocky Point	RP-355	Unit 19, 355	Net-Impressed
21-BK-099	Buffalo Terrace	BT-181	Unit C, 181-3	Net-Impressed
21-CW-235	50 Lakes Bluff	FL-068	Unit , 068-1	H-Cord
21-HB-026	LaSalle Creek	LC-007	Unit 5, 007.1	Net-Impressed
21-HB-026	LaSalle Creek	LC-559	Unit 36, 559-9	H-Cord

RESULTS OF RADIOMETRIC DATING

The total number of radiometric dates available for this analysis is 72 dates from 24 archaeological sites. Of these, 41 are ceramic residue dates, 21 are from charcoal, and 10 are from bone or burned bone (Table 6).

Table 6: Summary of dated sites and samples

SITE #	SITE NAME	RESIDUE DATES	CHARCOAL DATES	BONE DATES	TOTAL
21-BK-099	Buffalo Terrace	2	0	1	3
21-BL-031	Pamida	4	0	0	4
21-BL-037	Midway	2	0	0	2
21-BL-071	Mikinako Sag	0	1	0	1
21-BL-273	Kitchie Bay	0	1	0	1
21-CA-028	Shingobee Island	0	2	2	4
21-CA-067	Rocky Point	3	2	2	7
21-CA-093	Maxson	0	3	0	3
21-CA-184	Roosevelt Narrows	5	0	0	5
21-CA-188	Felknor	2	0	0	2
21-CA-226	Kelnhoffer	0	1	0	1
21-CA-352	Cass Lake 1	2	0	0	2
21-CA-738	Thunder Lake West	1	2	1	4
21-CA-737	Moxness Beach	0	1	0	1
21-CW-235	50 Lakes Bluff	1	0	0	1
21-CW-247	Levesque	4	5	4	13
21-DL-002	Lake Carlos Beach	2	0	0	2
21-HB-026	Lasalle Creek	4	0	0	4
21-IC-012	Ogema Geshik	1	0	0	1
21-IC-176	Third R. Borrow Pit	1	3	0	4
21-MH-005	North Twin Lake	1	0	0	1
21-ML-002	Aquapaguetin Island	1	0	0	1
21-OT-152	West Point (Fish L.)	3	0	0	3
21-WD-006	Blueberry L. Village	2	0	0	2
TOTAL		**41**	**21**	**10**	**72**

Residue Dates

Sixteen (16) new residue dates were obtained, some from new vessels and some duplicates from previously dated vessels. The initial dates obtained on ceramic residues contained a preponderance of old dates. In fact, 9 of the 16 original dates used in our 1995 study were older than 2500 BP. In contrast, 19 of 25 dates obtained since that time are more recent than

2300 BP, with only 6 dates older than 2500 BP. Consequently, even with no adjustments, the increased sample size is shifting the average away from the older dates.

During discussions with staff from Beta Analytic, Inc., it was noted that a few dates seemed to have unusually depressed 13C/12C isotope ratios, many lower than -30. A further examination of the data revealed that all of the dates older than 2600 BP had 13C/12C isotope ratios lower than -30, with the two oldest dates from site 21-HB-026 having ratios in the -35 range. We are discussing this situation with both Beta Analytic and Paleo Research Institute as there is obviously a connection we need to understand. There is a strong case for significantly adjusting these dates (Beta 71671, 76189, 75658, 75659, 84684, 84685, 79570, 79571, 94859, 298247, 298248, 298249, 298250, and PRI-11-059-LAC-2)

Charcoal Dates

Fourteen (14) new charcoal dates were obtained. When combined with the 7 previous, there is a total of 21 charcoal dates available for this study. Ten (10) of these samples pair with residue dates and 11 are from features or other contexts that appear to be associated with Brainerd ceramics.

Bone/Burned Bone Dates

Ten (10) dates were obtained from bone or burned bone. No previous bone dates associated with Brainerd ceramics are available.

Results for samples submitted as a part of this project are shown in Tables 7 (Beta Analytic, Inc.) and table 8 (Paleo Research Institute).

Table 7: Results for samples submitted to Beta Analytic, Inc.

Site No.	Beta No.	Sample No.	Material	Measured age	13C/12C	15N14N	Conventional age	2 Sigma calibration
21-CA-738	298253	GGTL-4	Charcoal	1850 +/- 40 BP	-23.6		1870 +/- 40 BP	Cal AD 60 to 240 (Cal BP 1890 to 1710)
21-CA-738	298252	GGTL-3	Cremated bone carbonate	470 +/- 30 BP	-24.9		470 +/- 30 BP	Cal AD 1420 to 1450 (Cal BP 540 to 500)
21-CA-067	298251	GGRP-8	Cremated bone carbonate	2860 +/- 30 BP	-23.4		2890 +/- 30 BP	Cal BC 1190 to 1140 (Cal BP 3140 to 3090),Cal BC 1140 to 1000 (Cal BP 3090 to 2940)
21-BL-	298250	GGPM-	Potsherd	2720 +/-	-31.6	+10.6	2610 +/- 30	Cal BC

031		4	residue	30 BP			BP	810 to 780 (Cal BP 2760 to 2730)
21-BL-031	298249	GGPM-3	Potsherd residue	2740 +/- 30 BP	-29.2	+12.1	2670 +/- 30 BP	Cal BC 890 to 870 (Cal BP 2840 to 2820),Cal BC 850 to 800 (Cal BP 2800 to 2750)
21-BL-031	298248	GGPM-2	Potsherd residue	2410 +/- 30 BP	-32.0	+12.7	2300 +/- 30 BP	Cal BC 400 to 360 (Cal BP 2350 to 2310)
21-BL-031	298247	GGPM-1	Potsherd residue	2670 +/- 30 BP	-30.4	+12.3	2580 +/- 30 BP	Cal BC 800 to 760 (Cal BP 2750 to 2710)
21.CA-028	297531	GGSI-2	Cremated bone carbonate	4620 +/- 40 BP	-26.6		4590 +/- 40 BP	Cal BC 3500 to 3440 (Cal BP 5450 to 5390),Cal BC 3380 to 3330 (Cal BP 5330 to 5280),Cal BC 3210 to 3180 (Cal BP 5160 to 5130),Cal BC 3150 to 3130 (Cal BP 5100 to 5080)
21-CA-028	297530	GGSI-1	Cremated bone carbonate	4070 +/- 40 BP	-24.1		4080 +/- 40 BP	Cal BC 2860 to 2800 (Cal BP 4810 to 4760),Cal BC 2750 to 2710 (Cal BP 4700 to 4660),Cal

								BC 2710 to 2550 (Cal BP 4660 to 4500),Cal BC 2540 to 2490 (Cal BP 4490 to 4440)
21-CW-247	297529	GGLV-10	Bone collagen	5840 +/- 40 BP	-12.1	+7.6	6050 +/- 40 BP	Cal BC 5050 to 4840 (Cal BP 7000 to 6790)
21-CA-738	296104	GGTL-2	Charcoal	400 +/- 30 BP	-24.6		410 +/- 30 BP	Cal AD 1440 to 1500 (Cal BP 510 to 440),Cal AD 1600 to 1610 (Cal BP 350 to 340)
21-CA-738	296103	GGTL-1	Potsherd residue	2130 +/- 40 BP	-21.8	+6.4	2180 +/- 40 BP	Cal BC 370 to 150 (Cal BP 2320 to 2100),Cal BC 140 to 110 (Cal BP 2090 to 2060)
21-CA-067	296101	GGRP-6	Cremated bone carbonate	2660 +/- 30 BP	-24.6		2670 +/- 30 BP	Cal BC 890 to 870 (Cal BP 2840 to 2820),Cal BC 850 to 800 (Cal BP 2800 to 2750)
21-CA-067	296100	GGRP-5	Charcoal	890 +/- 30 BP	-25.2		890 +/- 30 BP	Cal AD 1040 to 1220 (Cal BP 910 to 730)
21-CA-067	296099	GGRP-4	Charcoal	610 +/- 30 BP	-23.9		630 +/- 30 BP	Cal AD 1290 to 1400 (Cal BP 660 to 550)
21-CA-	296098	GGRP-3	Potsherd residue	1390 +/- 30 BP	-22.9		1420 +/- 30 BP	Cal AD 590 to 660

067								(Cal BP 1360 to 1290)
21-CA-067	296097	GGRP-2	Potsherd residue	1700 +/- 40 BP	-23.1	+14.0	1730 +/- 40 BP	Cal AD 230 to 410 (Cal BP 1720 to 1540)
21-CA-067	296096	GGRP-1	Potsherd residue	1730 +/- 40 BP	-24.2 o/oo	+13.3	1740 +/- 40 BP	Cal AD 220 to 400 (Cal BP 1730 to 1550)
21-CA-109	296095	GGMX-3	charcoal	1440 +/- 30 BP	-26.2		1420 +/- 30 BP	Cal AD 590 to 660 (Cal BP 1360 to 1290)
21-CA-109	296094	GGMX-2	Charcoal	820 +/- 30 BP	-23.9		840 +/- 30 BP	Cal AD 1160 to 1260 (Cal BP 790 to 690)
21-CA-109	296093	GGMX-1	Charcoal	770 +/- 30 BP	-23.6		790 +/- 30 BP	Cal AD 1210 to 1280 (Cal BP 740 to 670)
21-CW-247	296092	GGLV-9	Cremated bone carbonate	2380 +/- 30 BP	-24.0		2400 +/- 30 BP	Cal BC 720 to 700 (Cal BP 2670 to 2650),Cal BC 540 to 400 (Cal BP 2490 to 2350)
21-CW-247	296091	GGLV-8	Bone collagen	60 +/- 30 BP	-22.1	+9.8	110 +/- 30 BP	Cal AD 1680 to 1770 (Cal BP 270 to 180),Cal AD 1800 to 1940 (Cal BP 150 to 10),Cal AD 1950 to 1960 (Cal BP 0 to 0)
21-CW-247	296090	GGLV-7	Bone collagen	4480 +/- 40 BP	-19.6	+3.9	4570 +/- 40 BP	Cal BC 3490 to 3460 (Cal BP 5440

								to 5420),Cal BC 3370 to 3320 (Cal BP 5320 to 5270),Cal BC 3230 to 3110 (Cal BP 5180 to 5060)
21-CW-247	296089	GGLV-6	Charcoal	5320 +/- 40 BP	-22.7		5360 +/- 40 BP	Cal BC 4330 to 4050 (Cal BP 6280 to 6000)
21-CW-247	296088	GGLV-5	Charcoal	100 +/- 30 BP	-24.1		110 +/- 30 BP	Cal AD 1680 to 1770 (Cal BP 270 to 180),Cal AD 1800 to 1940 (Cal BP 150 to 10),Cal AD 1950 to 1960 (Cal BP 0 to 0)
21-CW-247	296087	GGLV-4	Charcoal (Butternut shell)	280 +/- 40 BP	-26.2	+1.4	260 +/- 40 BP	Cal AD 1520 to 1590 (Cal BP 430 to 360),Cal AD 1620 to 1670 (Cal BP 330 to 280),Cal AD 1770 to 1800 (Cal BP 180 to 150),Cal AD 1940 to 1950 (Cal BP 10 to 0)
21-CW-247	296086	GGLV-3	Charcoal	1480 +/- 30 BP	-25.6		1470 +/- 30 BP	Cal AD 550 to 640 (Cal BP 1400 to 1300)

21-CW-247	296085	GGLV-2	Charcoal	1550 +/- 30 BP	-27.7		1510 +/- 30 BP	Cal AD 450 to 450 (Cal BP 1500 to 1500),Cal AD 460 to 480 (Cal BP 1490 to 1470),Cal AD 530 to 610 (Cal BP 1420 to 1340)
21-CW-247	296084	GGLV-1	Potsherd residue	1860 +/- 40 BP	-25.5		1850 +/- 40 BP	Cal AD 70 to 250 (Cal BP 1880 to 1700)
21-CA-226	296083	GGKE-1	Charcoal	10 +/- 30 BP	-23.6		30 +/- 30 BP	Cal AD 1890 to 1910 (Cal BP 60 to 40),Cal AD 1950 to beyond 1960 (Cal BP 0 to 0)
21-OT-152	296081	GGFL-2	Potsherd residue	1360 +/- 30 BP	-23.4	+10.2	1390 +/- 30 BP	Cal AD 610 to 670 (Cal BP 1340 to 1280)
21-OT-152	296080	GGFL-1	Potsherd residue	1780 +/- 40 BP	-23.4	+10.8	1810 +/- 40 BP	Cal AD 120 to 260 (Cal BP 1830 to 1680),Cal AD 280 to 330 (Cal BP 1670 to 1620)
21-BK-099	296079	GGBT-1	Cremated bone carbonate	5540 +/- 40 BP	-18.3		5650 +/- 40 BP	Cal BC 4550 to 4440 (Cal BP 6500 to 6380),Cal BC 4430 to 4370 (Cal BP 6380 to 6320)
21-CA-	296078	GGBR-1	Charcoal	1140 +/- 30 BP	-24.7 o/oo		1140 +/- 30 BP	Cal AD 810 to 980

737								(Cal BP 1140 to 970)

Table 8: Results for samples submitted to Paleo Research Institute

Site No.	PRI No.	Sample No.	Material	13C/12C	conventional age	2 Sigma callibration
21-BK-099	11-059-GGBT-2	GGBT-2	Charred ceramic residue	-21.3	1630 +/- 16	1570-1480; 1470-1410 BP AD 380-470 AD 480-540
21-OT-152	11-059-GGFL-4	GGFL-4	Charred ceramic residue	-25.9	1658 +/- 22	1595-1585; 1570-1525 BP AD 260-280 AD 330-430
21-CA-188	11-059-GGFE-01	GGFE-01	Charred ceramic residue	-26.0	1754 +/- 16	1720-1610 BP AD 230-340
21-HB-028	11-059-GGLAC-2	GGLAC-2	Charred ceramic residue	-28.7	3270 +/- 30	3580-3440; 3430-3400 BP 1630-1490 BC 1480-1450 BC
21-CW-247	11-081-MIACEP-1	GGEP-1	Charred ceramic residue	-23.9	2648+/-29	2850-2820; 2800-2730 BP 900-870; 850-780 BC

RESULTS OF OPTICALLY STIMULATED LUMINESCENCE (OSL) DATING

Ten samples were submitted to the Luminescence Dating Research Laboratory, Department of Earth and Environmental Sciences, at the University of Illinois, Chicago.

This process relies on the fact that geologic samples (samples from beneath the ground surface) accumulate a charge that is relative to the length of time since they were last exposed to light. This charge, or dose, can be measured and that time period determined.

Most types of samples must be carefully collected to avoid any exposure to light that could reset the dose to zero. For ceramic sherds, however, the measurements are taken at the interior after grinding away the surface. The age thus determined should relate to the time of manufacture of the vessel when the clay was mixed.

Sample criteria provided by the lab recommended a minimum sherd thickness of about 6mm and a sherd dimension of at least 3cm. In addition to a suitable sherd, a soil sample collected from within 0.5 meter of the sherd was requested. The requirements eliminated materials from some sites from consideration.

Our primary objective with the OSL dating was to select samples that would allow comparison with available radiometric dates, particularly those from ceramic residues. We attempted to select samples representing a broad distribution, both geographically and chronologically.

Since the OSL dating method is a destructive process, all submitted sherds were photographed on both interior and exterior surfaces, and molds and casts were made.

Of the ten samples submitted, one had insufficient quartz grains for analysis, so only nine results were obtained. The results are presented in Table 9.

Table 9: Results for OSL samples submitted to The University of Illinois, Chicago

Site No.	Sample Number	Lab Number	OSL Age	Comments
21-BK-099	BT-181	UIC 2939	1525+/-290	
21-CW-247	EP-712	UIC 2935	1150+/-160	Smooth Middle WL vessel
21-CW-247	EP-688	UIC 2936	1940+/-680	
21-CA-738	TL-14	UIC 2945	1810+/-200	Sample no. error corrected
21-CA-226	KH-23	UIC 2943	2350+/-190	
21-HB-026	LC-559	UIC 2946	815+/-60	
21-HB-026	LC-007	UIC 2947	2730+/-200	
21-CA-109	MX-006			Insufficient qtz for analysis
21-CW-235	FL-068	UIC 2937	2730+/-200	Sample no. error corrected
21-CA-067	RP-335	UIC 2944	1710+/-130	

SUMMARY AND ANALYSIS OF DATES

Following is a summary of each site with dated samples. This summary includes both previous and new dates.

21-BK-099, Buffalo Terrace. This appears to be a single component Elk Lake Complex site with Brainerd Net-impressed ceramics. A feature in one excavation block containing a large proportion of one undecorated vessel provided samples. Food residues from the interior of the vessel were dated at 1730 +/- 40 BP (Beta 187667). A split sample submitted to Paleo Research Institute was dated at 1630 +/- 30 BP (PRI-11-059-BT-2). Burned bone recovered from the feature returned a date of 5540 +/- 40 BP (Beta 296079).

The two residue dates overlap at the 2-sigma range. The burned bone date suggests a middle Archaic age. Although no materials diagnostically assignable to that context were recovered from the site, the possible presence of an unidentified Archaic component cannot be dismissed.

The OSL date obtained for this site is from a sherd of the same vessel dated by residue analysis. The date, 1525 +/- 290 BP, supports the residue dates.

21-BL-31, Pamida. This is a multi-component site that has been heavily impacted by urban commercial development. Nevertheless, significant undisturbed areas remain within the site. Salvage archaeology during 2009 and 2010 in conjunction with additional development recovered hundreds of sherds from net-impressed and horizontally-corded ceramics. Burned residue from two horizontally-corded and two net-impressed vessels were submitted for AMS dating. Dates from the horizontally-corded vessels were 2610 +/- 30 BP (Beta 298250) and 2670 +/- 30 BP (Beta 298249). Dates from the net-impressed vessels were 2300 +/- 30 BP (Beta 298248) and 2580 +/- 30 BP (Beta 298247). All of these dates have unusually low 13C/12C ratios, ranging between -29.2 and -32.0 that may suggest that they are too old. The 15N/14N isotope ratios for these dates, +10.6 to +12.7, correspond with typical values for fish.

21-BL-37, Midway. This is a multi-component site located near 21-BL-31. Two AMS dates from residue on Brainerd sherds were obtained from this site (Kluth 2002). The first (Beta 108831) dated to 2160 +/- 50 BP There was no indication whether this was from a net-impressed or horizontally-corded vessel. The second (Beta 148858) dated to 2030 +/- 40 BP and was from a net-impressed sherd. The first date has a 13C/12C ratio of -29.1, so may be suspect.

21-BL-71, Mikinako Sag. This site is described as a Middle Prehistoric (Brainerd) site. Phase II investigations totaling 7 square meters as scattered 1m x 1m units recovered two charcoal samples, one possibly associated with a feature. Both samples were submitted for AMS dating (Kluth 1995). The first, possibly associated with the feature, dated to 260 +/- 60 BP (Beta 84758), is obviously recent and is not included in the present analysis. The second, apparently not associated with any specific feature or artifact concentration, dated to 1320 +/- 50 BP (Beta 84759). The relatively late date on this sample, coupled with the lack of good

association with a specific context, partially due to the limited excavation block size, renders it of limited utility in the present analysis.

21-BL-273, Kitchie Bay. This is a small single component Elk Lake complex site located on a relict beach far removed from today's lakeshore. A small amount of horizontally-corded ceramics was recovered adjacent to a pit feature containing charcoal. The charcoal was dated to 2480 +/- 90 BP. This was the first radiocarbon date obtained associated with Brainerd ceramics in Minnesota. This date correlates well with the dated terminus of the open water period in what is now a cedar swamp in front of the site.

21-CA-28, Shingobee Island. This site was tested by the excavation of one block totaling 13 square meters (Hohman-Caine and Goltz 1999). Although there are sparse Late Woodland materials near the surface, the bulk of the artifacts recovered are associated with the Elk Lake Complex. More recent analysis of the site suggests the possibility of an Archaic component in the deeper levels. Two charcoal samples from deeper levels of a feature containing Brainerd ceramics were submitted for AMS dating. They returned dates of 4090 +/- 40 BP (Beta 116989) and 4400 +/- 40 BP (Beta 127963). These dates appear to be too old to reconcile with other existing Brainerd dates. Two burned bone samples from a different part of the feature and at a shallower depth were submitted for AMS dating as part of the present study. These were clearly associated with net-impressed ceramics. These returned dates similar to the previous charcoal samples, 4070 +/- 40 BP (Beta 297530) and 4590 +/- 40 BP (Beta 297531), and suggests mixing of older materials into the feature.

21-CA-67, Rocky Point. This is a multicomponent Woodland site. The Elk Lake component, however, is horizontally separated and on a different terrace from the later occupations. Excavations on this portion of the site, totaling 13.75 square meters, recovered net-impressed ceramics representing several vessels along with a complex of FCR filled pits, possibly representing a structure feature and an adjacent hearth. Burned food residues from three ceramic sherds along with two associated charcoal samples and two associated burned bone samples were submitted for AMS dating. Dates from two net-impressed sherds returned almost identical dates, 1740 +/- 40 BP (Beta 296096) and 1730 +/- 40 (Beta 296097). A third sherd, initially thought to be from a horizontally-corded vessel returned a date of 1420 +/- 30 BP (Beta 296098). Subsequent lab analysis identified additional larger rim sherds from the same vessel and we were able to determine that it was a smooth surface vessel with small horizontally oriented cwo stamps, suggesting a Late Middle Woodland context. The two burned bone samples returned dates similar to each other, 2670 +/- 30 BP (Beta 29610) and 2890 +/- 30 BP (Beta 298251), but approximately 1,000 years older than the residue dates. The two charcoal samples dated to 630 +/- 30 BP (Beta 296099) and 890 +/- 30 BP (Beta 296100). Both of these dates are obviously too recent.

The two dates from the net-impressed sherds are some of the youngest dates obtained so far for Brainerd ceramics. These samples had 13C/12C isotope ratios of -24.2 and -23.1 with 15N/14N ratios of +13.3 and 14.0. This compares closely to the typical isotope ratios of maple sap, -22.75 13C/12C and +14.99 15N/14N (Ens 1998). The elongated shape of the hearth feature is also similar to those ethnographically documented from maple sugaring camps.

The OSL date obtained for this site is from a sherd from the same net-impressed vessel dated by residue analysis. The date, 1710 +/- 130 BP, is almost identical to the two radiometric dates on the net-impressed sherd residues.

21-CA-109, Maxson. This site appears to be a single component Elk Lake complex site with net-impressed, horizontally-corded and parallel-grooved ceramics. Ceramics were recovered from three separate excavation blocks, but none had burned residues and no associated dateable faunal materials were recovered. Three charcoal samples were submitted for AMS dating. The first two were from a dense FCR feature containing rim and body sherds from an apparently horizontally-corded vessel. These returned dates of 790 +/- 30 BP (Beta 296093) and 840 +/- 30 BP (Beta 296094). These dates are statistically identical at the 95% level and have a pooled mean of 815 +/- 21 BP which calibrates to A.D. 1184 to 1265, obviously too late for Brainerd ceramics. However, the vessel from this particular excavation block has diagonally crisscrossed cord impressions rather than singly applied horizontal or oblique cord impressions typical for LaSalle Creek Ware (formerly Brainerd Horizontally-corded), and has an uncharacteristically high content of crushed feldspar temper. While the rim form shows similarity to Brainerd vessels, it does not fit well into either the LaSalle Creek Ware or Brainerd Ware definitions and may well be an as-yet undefined later ware with the dates acceptable for this vessel.

The third date is from a feature having charcoal and a concentration of FCR associated with a dense ceramic concentration containing at least five net-impressed vessels and one parallel-grooved vessel. This charcoal sample returned a date of 1420 +/- 30 BP (Beta 296095). This date is considerably later than any other date associated with net-impressed ceramics in this study, but may date the parallel-grooved vessel.

21-CA-184, Roosevelt Narrows. This is a multicomponent Late Archaic and Woodland site that is clearly dominated by a Elk Lake complex component. Five AMS dates were obtained from burned food residues from net-impressed sherds. It is not known if these sherds represent five separate vessels or if some could be from the same vessel. Two of the dates, 2610 +/- 60 BP (Beta 75658) and 2850 +/- 60 BP (Beta 75659) have unusually low 13C/12C isotope ratios of -31.7. The remaining three dates 2710 +/- 60 BP (Beta 76658), 2480 +/- 60 BP (Beta 76659), and 2090 +/- 60 BP (beta 76687) have more typical 13C/12C ratios of -24.6, -25.7 and 23.7 respectively.

21-CA-188, Felknor. This multicomponent Woodland site has most of the net-impressed ceramics either horizontally or vertically separated from other Woodland ceramic types. An AMS date of 1870 +/- 40 BP (Beta 92827) was initially obtained on burned food residues from a large net-impressed rim sherd. Vessel morphology suggested that this might fit rather late in the Brainerd chronology. As a part of the current study, an archived subsample of the residue was submitted to Paleo Research Institute. This returned a date of 1754 +/- 16 BP (PRI-11-059-FE-1). These two dates overlap at the 2-sigma level.

21-CA-226, Kelnhoffer. This site is a single component Elk Lake Complex site and was excavated in 1991 as part of a Hamline University field school. Most of the materials

recovered have not yet been processed so our analysis is confined to the part of the excavation where a partially restorable horizontally-corded vessel was recovered. Several charcoal samples were recovered associated with this vessel and one was selected for AMS dating. It returned a recent date (Beta 296083) which was eliminated from any further analyses.

The OSL date obtained for this site is from a sherd from the partially restored horizontally-corded vessel. Unfortunately, the charcoal sample submitted returned a recent date, so there is no date to compare with the OSL date. The OSL date of 2350 +/- 190 BP fits well with dates from several horizontally-corded vessels from other sites.

21-CA-352, Cass Lake 1. Two AMS dates were obtained on burned food residues from horizontally-corded ceramic sherds (Kluth and Thompson 1995). The dates are 2550 +/- 60 BP (Beta 84684) and 2600 +/- 60 BP (Beta 84685). It is not clear if these were from the same vessel. Again, these have very low 13C/12C ratios of -28.6 and -33.1.

21-CA-738, Thunder Lake West. This is a very large site with several horizontally separated Woodland components. During the Phase I survey one shovel test produced 450 horizontally-corded sherds, charcoal fragments, and FCR. All of the sherds were obviously from the same vessel and included rims, body sherds, and basal sherds. Several of the rim sherds had a thick interior residue of burned food. As a part of this research, it was proposed that limited additional field excavations be done to recover more samples for dating if early season field conditions permitted. A residue sample submitted for AMS dating returned a date of 2180 +/- 40 BP (Beta 296103). Stable isotope ratios for 13C/12C were -21.8 and for 15N/14N were +6.4. This did not suggest a strong aquatic resource component. A charcoal sample from the shovel test was also submitted, in case we were unable to return to the site. It returned a date of 410 +/- 30 BP (Beta 296104), obviously a bad sample. Near the end of April, 4.5 square meters of excavation recovered additional portions of the vessel along with associated charcoal and burned bone samples. After the additional field work a burned bone sample and a more securely associated charcoal sample were submitted for AMS dating. The burned bone returned a date of 470 +/- 30 BP (Beta 298252) and the charcoal 1870 +/- 40 BP (Beta 298253). The burned bone date is obviously too recent, but the charcoal date may define an error in the residue date.

The OSL date obtained for this site is from a sherd from the partially restored horizontally-corded vessel. The date, 1810 +/- 200 BP supports these dates.

21-CA- 737, Moxness Beach. This site had a small excavation block which yielded several horizontally-corded sherds, apparently from a single vessel, associated with a probable feature containing oxidized soil and significant quantities of charcoal. A sample of the charcoal was submitted for AMS dating. It returned a date of 1140 +/- 30 BP (Beta 296078) which appears to be too recent.

21-CW-235, 50 Lakes Bluff. This is a small single component Elk Lake Complex site. Excavations recovered a partially restorable horizontally-corded vessel that may have been in a house feature. A sample of burned food residue from the interior of this vessel returned an AMS date of 2580 +/- 40 BP (Beta 144014). The 13C/12C isotope ration of -27.0 is marginal to being unusually low.

The OSL date obtained for this site is from a sherd from the partially restored horizontally-corded vessel. The date, 2730 +/- 200 BP supports this date.

21-CW-247, Levesque. This is a dense multicomponent site with cultural components ranging from Late Paleoindian through Archaic, Elk Lake Complex, undefined Middle Woodland, Psinomani, and 19th century Ojibwe. The Psinomani component is horizontally separable and the remaining components appear to be reasonably stratified vertically, though some mixing likely exists. Four AMS dates were obtained on residues from ceramics sherds. Two of these are from an almost complete net-impressed vessel recovered from a feature containing burned bone and charcoal, and date to 2120 +/- 40 BP (Beta 163611) and 2240 +/- 40 BP (Beta 187668). These dates overlap at the 2-sigma level. The third date is on residues from a horizontally-corded vessel and dates to 1850 +/- 40 BP (Beta 296084). The fourth sample is from residues on another net-impressed vessel and dates to 2648 +/- 29 (PRI-11-081-MIACEP-1).

Five charcoal samples were submitted for AMS dating. The first two are from the feature containing the net-impressed vessel. These returned dates of 1510 +/- 30 BP (Beta 296085) and 1470 +/- 30 BP (Beta 296086). These dates are statistically identical at the 95% level with a pooled mean of 1490 +/- 21 which calibrates to A.D. 541-623. While the presence of two identical charcoal dates from adjacent excavation units lends credence to their validity, these results appear too recent to be associated with the net-impressed ceramics. However, numerous sherds from three restorable smooth-surfaced Middle Woodland vessels occurred in the same units. These dates may relate to those vessels.

Numerous fragments of burned butternut shell (*Juglans cinerea*) were recovered from mid-level strata of the site, the same levels that contained most of the Elk Lake Complex ceramics. One sample returned an AMS date of 260 +/- 40 BP (Beta 296087) with a 13C/12C isotope ratio of -26.2 and a 15N/14N isotope ratio of +1.4. This date calibrates to several intervals and is either associated with the Psinomani or Ojibwe occupations or relates to naturally burned nut shell from forest fires.

The fourth charcoal sample was recovered in association with the dated horizontally-corded sherd residue (Beta 296084). However, the date returned, 110 +/- 30 BP (Beta 296088) suggests it is intrusive from the Historic Ojibwe component.

The fifth charcoal sample is a fragment from a larger obviously worked charred wooden shaft, possibly a dart component. This was from the lower levels of what appeared to be an Elk Lake Complex midden. It returned an AMS date of 5360 +/-40 BP (Beta 296089) and obviously belongs to the sightly deeper Archaic component.

Four samples of bone/burned bone were submitted for AMS dating. The first was a sample of unburned large herbivore long bone recovered from the net-impressed vessel feature. It returned a date of 4570 +/- 40 BP (Beta 296090). Again, this probably belongs with the Archaic component. The 13C/12C ratio of -19.6 and the 15N/14N ratio of +3.9 suggests that it is likely elk.

The second sample is from two burned bear paw bones from the same feature as Beta 296090. This sample, however, yielded a date of 110 +/- 30 BP (Beta 296091) and is probably intrusive from the Historic Ojibwe component at the surface.

The third sample is from burned bone associated with the horizontally-corded vessel dated by sample Beta 296084. This sample returned a date of 2400 +/- 30 BP (Beta 296092). As was the case at 21-CA-067, this burned bone date is significantly older than the associated ceramic residue date, however, it may be associated with the occupation related to the second dated net-impressed vessel.

The fourth sample is from an unburned bison inner ear bone (petrous pyramid). This was recovered from shallower levels, containing some net-impressed sherds, than the deep, highly weathered bison bone feature on this site. It was also well preserved. It returned a date of 6050 +/- 40 BP (Beta 297529) and fits well into an Early Archaic component indicated by some of the projectile points recovered from the site. The 13C/12C isotope ratio of -12.1 indicates a C4 grass diet which also fits well with the Mid-Holocene date.

OSL dates for this site were obtained from sherds from two partially restored ceramic vessels.

The first is from a sherd from an undefined smooth surfaced Middle Woodland appearing vessel that was stratigraphically in the same levels as most of the Brainerd ceramics. The date, 1150 +/- 160 BP, confirms a Late Middle Woodland context for this vessel.

The second date is from a sherd from the first dated net-impressed vessel. This date, 1940 +/- 680 BP supports the two ceramic residue dates, but the large standard deviation is questionable.

21-DL-02, Lake Carlos Beach. This is a multicomponent site with Late Paleoindian and Elk Lake complex components horizontally separated from later Woodland components. Two AMS dates were obtained on burned food residues from ceramic sherds. The first sample was from a parallel-grooved vessel and returned a date of 1880 +/- 50 BP (Beta 104090). The second sample was from a horizontally-corded vessel and returned a date of 1980 +/- 50 BP (Beta 104091).

21-IC-12, Ogema Geshik. An AMS date of 1890 BP (standard deviation and lab number not available) was returned from burned food residues on a Brainerd ceramic sherd. No additional information is available, but this date is consistent with several dates from other sites.

21-HB-26, LaSalle Creek. This site is a single component Elk Lake Complex site. The numerous net-impressed and horizontally-corded vessels suggest multiple occupations. Some of the first dates on burned residues from ceramic sherds came from this site. A total of four AMS dates from residues on ceramics have been obtained, three of which appear to be from the same net-impressed vessel, with the fourth date from a horizontally-corded vessel.

The first residue sample from the net-impressed vessel returned a date of 3180 +/- 60 BP (Beta 71671) (Kluth & Kluth 1994). A year later a second sample was submitted which returned a date of 3000 +/- 60 BP (Beta 76189). It was suggested that these two dates likely dated the same vessel (Hohman-Caine and Goltz 1995). As part of the present study, an archived subsample from the 1995 sample was submitted to Paleo Research Institute. It returned a date of 3270 +/- 30 BP (PRI-11-059-LAC-2). Together, these three dates constitute the oldest dates from residues from net-impressed ceramics in Minnesota. The 1994 and 1995 dates also had the lowest 13C/12C isotope ratios thus far obtained, at -35.1 and -35.7. The sample analyzed by PRI also had an unusually low 13C/12C ratio of -28.7.

A fourth sample from this site is from the interior of a restorable horizontally-corded vessel. It returned a date of 2280 +/- 60 BP (Beta 76190) with a 13C/12C isotope ratio of -27.0.

OSL dates from this site were obtained from sherds of two different vessels.

The first date is from a sherd from the net-impressed vessel dated by the residue samples. The date, 2730 +/- 200 BP, supports our suspicion that the three ceramic residue dates are likely too old.

The second date is from a sherd from a partially restored horizontally-corded vessel. The date, 815 +/- 60 BP is obviously too recent and is rejected.

21-IC-176, Third River Borrow Pit. This is a small site with both Brainerd and Laurel ceramics. One AMS date of 2320 +/- 60 B.P. (Beta 94859), with a 13C/12C isotope ratio of -33.8, was obtained from burned food residues on a horizontally-corded vessel from a feature. An associated charcoal sample from the top of the feature was dated to 1700 +/- 70 BP (Beta 94420). Two additional, more secure, charcoal samples were submitted later. The first, from the base of the feature, dated to 1860 +/- 50 BP (Beta 101863). The second, a mixed aggregated sample from throughout the feature, dated to 1620 +/- 50 BP (Beta 101864). Based on information in the report, the 1860 +/- 50 BP date seems the most representative (Mulholland 1996). The low 13C/12C isotope ratio may indicate that the residue date is too old.

21-MH-05, North Twin Lake. One sample of burned food residues from the interior of a net-impressed vessel was submitted for AMS dating. It returned a date of 2455 +/- 50 BP (Beta 70373) (Navarre 1994).

21-ML-02, Aquapaguetin Island. One sample of burned food residues from the interior of a net-impressed sherd recovered during a surface collection was submitted for AMS dating. It returned a date of 1860 +/- 40 BP (Beta 280545).

21-OT-152, West Point Site. This is a single component, and probably single occupation Elk Lake Complex/Avonlea site. Formal excavation recovered net-impressed, horizontally-corded, and parallel-grooved ceramics. All of the artifacts recovered were from a single thin layer centered at a depth of approximately 8cm below the surface. Burned food residues on rim sherds from two parallel-grooved vessels were submitted for AMS dating. The sample from Vessel #1 was split and submitted to two different laboratories. This sample was from residues on the interior of the vessel. The sample submitted to Beta Analytic, Inc. returned a date of 1810 +/- 40 BP (Beta 296080). The sample submitted to Paleo Research Institute returned a date of 1650 +/- 22 BP (PRI-11-059-FL-4). These dates butt up to each other but do not overlap at the 2-sigma level, but would have a pooled mean of 1693 +/- 19 BP.

The sample from the second parallel-grooved vessel was from the exterior and was more of a thin carbon deposit than a burned food residue. It returned a date of 1390 +/- 30 BP (Beta 296081). Given the nature of the archaeological deposit, the time span suggested by this date seems unlikely.

21-WD-06, Blueberry Lake Village. Two dates were submitted on burned food residues from the interior of a horizontally-corded vessel (Bailey and Johnson, 1995). These returned dates of 2930 +/- 50 BP (Beta 79570) and 2940 +/- 80 BP (Beta 79571) with a pooled mean of 2933 +/- 47 BP These are the second oldest dates obtained on any Brainerd related ceramics, and the earliest of all dates on horizontally-corded ceramics by several hundred years. These samples have extremely low 13C/12C ratios of -31.3 and -31.1, which may indicate substantial problems with these results.

CHRONOLOGICAL DATA FROM OUTSIDE MINNESOTA

Net-impressed, horizontally-corded and parallel-grooved ceramics extend over a broad area to the north and west, into Manitoba and Saskatchewan in Canada and part of North Dakota and Montana in the United States. Most notably, they are associated with Avonlea sites on the western plains. Numerous radiocarbon dates have been obtained from these sites that demonstrate that these ceramics are more recent in the west and northwest. The Avonlea chronology has been summarized most notably for the region by Morlan as extending from A.D. 300 to 1100, with most dates concentrated in the period ca A.D. 600-1000 (Morlan 1988).

Further east, the chronology more closely matches that in Minnesota. At the Lockport site in Manitoba, net-impressed pottery occurs in the upper portion of Bed H (Flynn and Kogan 1991). This bed extends from 1.5 to 2m below surface (Buchner 1986), with a basal age of 3300 BP, a middle age of 2515 BP, and a termination age of 2315 BP (Buchner 1988). Thus, net-impressed pottery at this site, which appears to be identical to Brainerd Ware in Minnesota (Norris 2007), dates between ca 2500 and 2300 BP.

In North Dakota, horizontally-corded ceramics, similar to LaSalle Creek Ware, have been recovered from several sites. At the Horner-Kane site, 32-RY-077, these ceramics have been dated to 1910 +/- 50 BP (UCR-3200) (Toom 2000).

More recently similar ceramics have been recovered at the Irvin Nelson site, 32-BE-208, on Devil's Lake (Toom 2008). Rim sherds from four horizontally-corded vessels were recovered, and were designated vessels 08, 15, 16, and 18. Photographs of the sherds support this identification. No radiometric dates were associated with these ceramics. However, Toom assumes a date of A.D. 600-800. Several cord-marked body sherds were recovered which Toom assigns to a Middle Plains Woodland context, synonymous with the Sonota Complex, generally radiocarbon dated to ca A.D. 1-600. He states:

> Middle Plains Woodland ceramics are represented by body sherds only…, no rim sherds of this period were identified…. The lack of Middle Plains Woodland rims is perplexing because ***suspected*** [emphasis added] body sherds of this period are fairly numerous, as recognized by their typically greater thicknesses and heavily cord roughened exterior surfaces (Toom 2008).

Examination of photos of these sherds (Toom 2008, Fig. 11) clearly shows that they are most likely horizontally-corded sherds, at least some of which are probably from the same vessel as rim sherd "g" in Figure 10. A sample from carbon residue on one of these sherds returned an AMS date of 1750 +/- 50 BP (O5-21402), which is the same as several dates on similar ceramics from sites in Minnesota.

CURRENT RESEARCH ON THE FRESHWATER RESERVOIR EFFECT

THE FRESHWATER RESERVOIR EFFECT

The freshwater reservoir effect is the production of erroneously older radiocarbon dates on organic materials that have been influenced by the incorporation of dissolved inorganic carbon (DIC), primarily from aquatic sources. These older dates are caused by the inclusion of DIC, which is radiometrically "dead", within a sample of carbon derived from the atmospheric carbon reservoir. The apparent mechanism for this is through the incorporation of aquatic resources into the food chain. It is somewhat related to the marine reservoir effect in which marine materials are consistently older than contemporaneous terrestrial sources. See Southon and Fedje (2003), Stuiver, Pearson and Brazuinas (1993) and Molto et al. (1997) for recent summaries for this global phenomenon. Globally there is an average offset of about 400 years although the values vary through time and around the world and include ranges of 600-1000 years. There is now a global database for corrections at the CALIB website (Reimer and Reimer 2001). The implication for coastal researchers around the world is obvious. When they are now dating marine materials or populations with a marine diet, including inland populations with a salmon diet, they must correct for this reservoir effect.

The freshwater reservoir effect has been identified primarily in Europe. It has been studied extensively in the Netherlands but it is also being tested and found to be an important variable in the Ukraine, England, Ireland, Germany, Sweden, Norway and Denmark and Serbia (Lanting and van der Plicht 1996, 1998; Fisher and Heinemeier 2003; Cook et al 2001; Bocherens 2009; Lille et al. 2009). Lanting and van der Plicht have been working on bone samples from a variety of rivers in the Netherlands. When they corrected for the freshwater reservoir effect they were able to account for a number of dating anomalies, e.g., skeletons of the Dutch royal family were no longer 400 years too old. They also identified the pervasive nature of this effect and the efforts required to correct for it (Table 10).

Cook et al. (2001) were working with Serbian Mesolithic burials and village deposits and were able to coordinate contradictory data between skeletal materials and younger charcoal dates from the settlement occupations when they ran isotopic samples and corrected for the freshwater reservoir effect. They found that a reservoir effect on bones with a 100% aquatic diet changed the dates by about 425 +/- 55 14C years; however isotopic analyses indicated that diets were variable, but higher 15N/14N value indicated a higher fish resource use which in turn produced a higher freshwater reservoir effect.

Fisher and Heinemeier (2003) were addressing the issue of dates from ceramic encrustations from inland sites in Denmark. They dated modern fish, two different species of fish from two archaeological deposits, and pot encrustations from the two occupations. The modern freshwater fish were found to be about 300 years too old as a result of the reservoir effect. The archaeological specimens were also too old but the pike, whose diet would include some non-aquatic foods such as ducklings and frogs, showed less change (about half the date change) than the tench (a Eurasian member of the carp family) (Wikipedia 2010) which have a different trophic regime consisting solely of aquatic diet of larvae, bivalves, snails and

slugs. They found that ceramic encrustations produced reservoir effects in the range of 500 years. Like the Netherlands research, they emphasize the need to test both carbon and nitrogen isotopes; larger negative values for 13C/12C, but particularly higher positive values for 15N/14N, will indicate high rates of freshwater resources and larger reservoir impacts on the dates.

These few examples show that correcting for the freshwater reservoir effect is very complex. While there are undoubtedly impacts on the dates of the bones, pottery encrustations and other materials, there needs to testing of different water sources, different species with different trophic levels, and different diets with different ratios of aquatic versus terrestrial sources.

DISCOVERING THE LOCAL FRESHWATER RESERVOIR EFFECT

In Manitoba the local freshwater reservoir effect was discovered through the dating efforts of the Churchill River Diversion Archaeological Project (CRDAP) in the Boreal Forest of northern Manitoba and from a small sample of dated caches from the Woodland Region of southeastern Manitoba in the 1990s (Table 11) (Syms 2000, 2001). While these studies focus on dating chronologies for human bone, relative to diet, the principles apply to understanding supposed errors in dating of residues on ceramics.

Many of the dates came from isolated burials that had been found eroding from shore lines and were recovered to be returned to the First Nations communities to be reburied. Features were dated by two and sometimes three calibrated AMS dates. Dates were sometimes different, not even overlapping at one standard deviation, which should not be the case for single events

The Nagami Bay Woman

The recovery and analysis of the Nagami Bay woman on Southern Indian Lake provided a dating sample which represented a single isolated feature with an independent dating source, historical documentation (Brownlee and Syms 1999). This was an eroding burial of a woman from the Protocontact Period, the period when local Cree First Nations were starting to obtain European goods from the east through intermediary Native traders, but when European traders had not yet reached northern Manitoba. She was accompanied by a large cache of mainly traditional Precontact First Nation bone and stone items, such as stone whetstones, scrapers, bifaces, adze, worked flakes, a graphite paintstone, bone awls, a loon wing awl handle, a knife from a moose spinous process, and geochemically identified catlinite beads, plus 1,641 pin cherry seed beads. However, she was also accompanied by a small European sample of two blue glass beads, a copper and an iron knife blade in split rib handles, and an iron awl point in a wing bone handle (Brownlee and Syms 1999). These European materials would have come from the St. Lawrence River area. For the Churchill River System, the Protocontact Period was A.D. 1654-1682, starting with the opening of the upper Great Lakes to traders about A.D. 1654, after the cessation of the Iroquois wars that had closed western trade, and ending in A.D. 1682 when the construction of three local forts

on the Hudson Bay provided a surge of European goods (see Brownlee and Syms 1999 for discussion).

Efforts to date the individual initially produced anomalous results. A bone date that was sent to Isotrace came back at cal A.D. 1310-1355 (88%) and cal A.D. 1385-1400 (100%) at one sigma, impossibly early dates. Assuming that a laboratory error had taken place, a second sample was submitted, but this, too, came back with almost identical dates of cal A.D. 1310-1350 (62%) and A.D.1390-1420 (100%) at one sigma. When questioned about the impossibly early date, Isotrace staff responded by saying that there must have been mixing from other occupations, which could not have taken place because this was a single event. A sample was sent to Beta Analytic to test for laboratory variability but it came back with a similar date of cal A.D. 1435-1460 at one sigma. It had to be assumed that either there had been the unlikely influence from the last of the Vikings in Greenland or, more likely, that the dates were in error. At the suggestion of Kevin Brownlee, a terrestrial sample of pin cherry seed beads was submitted, and these produced a date that was about 250 years more recent and compatible with the historically derived date. Like most recent dates it produced multiple intercepts with the calibration curve, of which one, cal A.D.1650-1680 at one sigma and cal A.D. 1635-1700 at 2 sigma matched the historic date range. In the meantime, the trace element calibration of the blue glass beads also confirmed the historically documented date range.

Although there are only a few paired dates representing both terrestrial and aquatically influenced sources from single features in Manitoba (Table 12), with one exception, all of the dates from aquatic sources, e.g. loon and human populations consuming a fish diet, are approximately 220 to 370 years older, using age range intercepts, than the dates from terrestrial sources, e.g. moose and pin cherries, from the same archaeological features of events. These dates do not show any changing trend through time. As Brownlee has found, the values for 13C/12C and 15N/14N are also clustered very tightly throughout the full time period. These older dates are thought to be due to the freshwater reservoir effect introduced through a heavy fish diet, a diet that we know to have been important traditionally (Syms 2003a, 2003b, 2003c, 2004, 2008).

NEED FOR STABLE ISOTOPE ANALYSIS IN DEVELOPING CONSISTENT RADIOCARBON DATES

The freshwater reservoir effect and marine reservoir effect are also part of the larger issue of dating samples from different species that "contain inherent differences as a result of isotopic fractionation in the living plant and animal" (Morlan 1999:3). For example, C3 plants, as represented in most flowering plants and temperate zone grasses, yield different results than C4 plants such as corn. These differences in isotopic fractionation are further differentiated up the food chain between the ungulates who feed on the plants and the carnivores who feed on the ungulates. Within the aquatic setting there are food chains that include both aquatic and terrestrial food sources whether it is fish that consume some non-aquatic resources or birds such as loons that consume fish, molluscs, and other aquatic resources. As Morlan has so eloquently stated, "Unless we take into account the inherent differences in isotopic

fractionation among these dating samples and correct for them, we are not merely comparing apples and oranges…, we are building on a veritable fruit basket!" (Morlan1999:4).

In order to identify and correct for the freshwater reservoir effect, it is necessary to determine an isotopic fractionation baseline of local resources that include terrestrial and aquatic resources and animals with mixed terrestrial and aquatic diets. A detailed review of the complexities of isotopic analysis is beyond the scope of this study. Values have been commonly calculated for 13C/12C and 15N/14N. Increasing values for these isotopes reflect increasing trophic levels in the food chain from plants to herbivores to carnivores to humans. There have been recent developments in the use of stable hydrogen isotope, δD, which also shows increasing values in the trophic chain from herbivores to omnivores to humans to carivores, in patterns that are analogues to the 15N/14N developments (Reynard and Hedges 2007, 2008; Arnay-de-la-Rosa et al. 2010).

Developing a Freshwater Reservoir Calibration

When dealing with marine reservoir calibration there have been thousands of calibrations including controlled samples. As a result there is an established calibration curve (Reimer and Reimer 2001) and see Molto et al. (1997) for an application.

Quantification of the freshwater reservoir effect is in the developmental stage. Initial work in northern Manitoba used the simple technique of subtracting the calibrated dates of human remains from terrestrial dates based on pin cherry seeds and moose and assumed that the differences represented the impact of aquatic diet (Brownlee and Syms 1999; Syms 2004, 2008). As noted, a number of calculations using the same approach have been determined from international sites, but it cannot be assumed that these values will be universally consistent and, therefore, be transferable to local research.

Current Developments

The recognition of the importance of this effect is appearing sporadically around the world. As noted earlier the applications of this dating correction are developing rapidly in Europe. Elsewhere, its development appears to be sporadic and only recently is it starting to emerge as a brief review of some of the reports are indicating, e.g., effects on riverine shells in the Murray-Darling Basin in New South Wales, Australia (Gillespie et al 2004), and altered dating of 340+/_ 20 years on freshwater shells in the Elk Hills of California (Culleton 2006). The freshwater reservoir effect is being addressed or incorporated sporadically in the Americas (Culleton 2006; Zarrillo et al. 2008a, 2008b). Zarrillo et al. (2008a, 2008b) identified it as an issue in early Ecuadorian sites but argued that it was not an important issue there because the diet was largely plant-consuming terrestrial animals. This is clearly a worldwide, if somewhat sporadically developed phenomenon.

IMPLICATIONS ARISING FROM THE FRESH WATER RESERVOIR EFFECT

Since the fresh water reservoir effect exists as well as the marine reservoir effect, and since there is evidence that seems to confirm that, like Western Europe, the effect is present in North America, what are the ramifications?

1. In any area where there is the likelihood of fish, mollusc or other aquatic resource consumption (and that is in much of North America), it is necessary to take multiple dates and stable isotope measurements on terrestrial and aquatic resources and consumers of these resources to check for the freshwater reservoir effect and to establish the degree of that effect. In choosing the dating samples, it is important to have some knowledge of animal behavior. For example, some mammals and birds consume substantial quantities of fish. Migratory waterfowl may be affected by their southern environments, e.g. loons not only have a northern aquatic diet but also some marine diet in the south.

2. It is crucial to establish diet through 13C/12C values in collagen and bone apatite fractions and through 15N/14N to determine if fish or other aquatic species were part of the diet and caused the reservoir effect. δD values are also becoming important and may reduce the need for 13C/12C. It will be necessary to determine diet based on relating isotopic values and faunal resources (Katzenberg 2000; Katzenberg and Harrison 1997).

3. In addition to making the existing corrections to past, present, and future dating samples to produce consistent conventional dates and calibrated dates, it will now be necessary to correct for both marine and fresh water reservoir effects in many areas. All dates must be converted to conventional dates and all must be calibrated; this must also apply to related geomorphological and environmental dates.

Failure to identify, measure, and correct for the reservoir effects may not only continue to produce unexplainable anomalous dates, such as burials associated with villages yielding different dates than samples from the villages, but it will produce fallacious results that could lead to a great number of inevitable misinterpretations

IMPLICATIONS IN DATING CERAMIC RESIDUES

While many of the problems relating to the Freshwater Reservoir Effect have focused on dating of human remains, some studies relative to the dating of burned food residues on ceramic sherds have been done (Fischer and Heinenmeier 2003, Fischer et al. 2007, Hart and Lovis 2007a and 2007b, Boudin et al. 2010). Like studies of human remains, many of these studies emphasize the importance of 13C/12C and 15N/14N isotope ratios in understanding the problem. They differ markedly, however, in application of this data, and none provide a reliable method for resolution.

One of the most perplexing questions is the determination of the origin of the burned food residues. Attempts to determine what combinations of foods have been cooked in the vessel by analyzing isotope ratios has met with mixed success. One approach has been to attempt to use this information to separate residues into groups such as freshwater, marine, terrestrial, herbivore, etc. (Boudin et al. 2010, Fischer et al. 2007), with mixed results. Other

researchers have concluded that the problems are too great to produce reliable results (Hart et al. 2007).

Some researchers, however, question the validity of a freshwater effect. One study, covering the northeastern part of the United States, concluded that there was no significant reservoir effect offset for dates from ceramic residues (Hart and Lovis 2007b). These same researchers also dispute the conclusions of Fischer and Heinemeier's (2003) analysis (Hart and Lovis 2007)

Several researchers have analyzed modern and archaeological food specimens to determine 13C/12C and 15N/14N isotope ratios (Ens 1998, Fischer and Heinenmeier 2003, Katzenberg et al. 2009, Fischer et al. 2007). These data can form the beginnings of a data set to attempt further understanding of the nature of ceramic residues.

While the identification of the food origin of ceramic residues remains problematic the occurrence of very negative 13C/12C isotope ratios does appear to correlate with the most problematic dates. Almost no potential food sources have values low enough to account for these highly negative values, so there must be some complex interactions involved. Understanding this will be key to understanding the Freshwater Reservoir Effect as it relates to ceramic residue dates. As Fisher and Heinenmeier (2003) clearly stated:

> We have the impression that very negative 13C/12C ratios may be taken as a warning that the food residue in question may have a particularly high age effect.

Table 10: Some important insights on the freshwater reservoir effect in the Netherlands

(based on information from Lanting and Van der Plicht (1996))

1. There are fresh water reservoir effects on samples from both rivers and standing water such as lakes and canals.
2. There are differences in degree of the effect along rivers with lower effects occurring down river.
3. Any consumers of fish, including human populations and animals such as dogs, will exhibit the fresh water reservoir effect. Even sheep that were eating coastal fish were affected.
4. Changes in cultural patterns such as the medieval Catholic requirements of fish three times a week will increase the reservoir effect.
5. It is crucial to run stable isotopic analyses on bone samples to determine diet, particularly the likelihood of aquatic resources; in addition to measure of ^{13}C on collagen that is routinely run by dating laboratories, it is also necessary to run ^{13}C on the carbonate fraction of bone apatite and to run ^{15}N; without the ^{15}N it is almost impossible to estimate the reliability of age determination.

- ^{13}C collagen fraction provides evidence based only on the protein whereas the bone apatite fraction provides evidence based in the total diet.
- ^{15}N is far more positive for fish than for terrestrial foods; it can provide insights into trophic levels of various species in the food chain.
- When choosing bone elements for dating and isotopic analysis, it is best to use dense bones rather than porous bones.

Table 11: Comparative, multiple-dated samples from Manitoba CA

Site Name	Lab Number	Borden Number	Conventional Date, BP	Calibrated Age Range cal BP	Calibrated Age Range cal BC/AD	Material	Carbon $\delta^{13}C$ (‰)	Nitrogen $\delta^{15}N$ (‰)
Moose Rack	Beta - 163689	GjLp-7	5950 +/-40	6870 - 6670 BP	4920 - 4720 BC	Human Bone	-19.9	12.8
Moose Rack	Beta - 163690	GjLp-7	5590 +/-40	6440 - 6300 BP	4490 - 4350 BC	Moose Antler		
Island River Burial	Beta - 180718	HdLx-1	4100 +/- 40	4720 - 4510 BP	2770 - 2560 BC	Human Bone	-20.5	12.3
Victoria Day Feature 1	CAMS - 13187	GkLr-61	4370 +/- 60	5053 - 4831 BP	3104 - 2882 BC	Human Bone	-21.6	13.9
Victoria Day Feature 1	CAMS - 13187	GkLr-61	4050 +/- 70	4741 - 4405 BP	2792 - 2456 BC	Moose Bone	-22.1	
Victoria Day Feature 1	Stable Isotope (Molto)	GkLr-61				Beaver Tooth	-20.7	
Victoria Day Feature 2	TO-6031	GkLr-61	3700 +/- 60	4161 - 3868 BP	2212 - 1919 BC	Moose Antler		
Victoria Day Feature 2	TO-6032	GkL-61	3920 +/- 60	4018 - 3681 BP	2069 - 1732 BC	Loon Bone		
Victoria Day Feature 2	Stable Isotope (Molto)	GkLr-61				Human Bone	-24.1	15.48
Two Exes	Stable Isotope (SFU)	GlLt-3	Archaic?			Human Bone	-22.7	14.7
Too Hot Site	Stable Isotope (SFU)	GlLk-4	Archaic?			Human Bone	-22.4	14.3
Bone Knives Site	Beta - 130154	GkLs-20	1950 +/- 50	1930 - 1710 BP	AD 20 - 240	?	-21.3	
Bone Knives Site	Beta - 130155	GkLs-20	2020 +/- 70	2065 - 1725 BP	BC 115 - AD 225	?	-21.6	
The Pas Burial Site	CAMS - 13187	FkMh-5	1810 +/- 60	1873 - 1597 BP	AD 77 - 357	Moose Antler	-19.9	
The Pas Burial Site	CAMS - 13185	FkMh-5	1740 +/- 60	1744 - 1531 BP	AD 206 - 419	Moose Antler	-20.0	
The Pas Burial Site	CAMS - 13186	FkMh-5	1750 +/- 60	1817 - 1538 BP	AD 133 - 412	Antler	-20.3	
Wapisu Cairn Burial	CAMS - 13189	GkLt-20	1750 +/- 60	1817 - 1538 BP	AD 133 - 412	Antler	-21.3	
Wapisu Cairn Burial	CAMS - 13190	GkLt-20	1720 +/- 60	1744 - 1519 BP	AD 206 - 431	Human Bone	-20.0	12.9
Wapisu Cairn Burial	CAMS - 13191	GkLt-20	1700 +/- 70	1739 - 1476 BP	AD 211 - 474	Moose Tooth	-19.9	
Nagami Bay Burial	Beta - 106475	HgLt-1	220 +/- 50	315- 250 BP	AD 1635 - 1700	Pin cherry Seed	-25.3	
Nagami Bay Burial	Beta - 107745	HgLt-1	440 +/- 30	525 - 465 BP	AD 1425 - 1485	Human Bone	-23.3	
Nagami Bay Burial	TO-5228	HgLt-1	590 +/- 40	675 - 525 BP	AD 1300 -1440	Human Bone	-25.0	
Oto-Who-Win	Beta - 153570	GkLr-11	270 +/- 40	170-150 BP	AD 1780-1800	Human Bone		
Oto-Who-Win	Stable Isotope (Ens)						-20.4	12.4
Birch Bark Wrapped	Stable Isotope (Ens)	GkLr-5	Historic		AD 1850?	Human Bone	-20.0	12.7
Hydro Line Site	Stable Isotope (SFU)	GkLk-7	Historic		AD 1900?	Human Bone	-20.3	12.4

Table 12: Central date differences between terrestrial source dates vs aquatic sources and human population dates, northern Manitoba

Site	Conventional Radiocarbon Dates (BP) and Materials		Date Differences
Moose Rack GjLp-7	5950 +/-40 human bone	5590 +/-40 moose antler	360
Victoria Day GkLr-61 Feature 1	4370 +/-60 human bone	4050+/-70 moose bone	320
Victoria Day GkLr-61 Feature 2	3920 +/-60 loon bone	3700+/-60 moose antler	220
Nagami Bay HgLt-1	440 +/-30 human bone	220+/-50 pin cherry seeds	220
	590+/-40 human bone	220+/-50 pin cherry seeds	370

ENVIRONMENTAL FACTORS RELATING TO "OLD CARBON" IN DATES

The existence of the freshwater reservoir effect raises the underlying problem of how "old carbon" is incorporated into materials that are ultimately sampled from archaeological sites and used to determine cultural chronology. "Old carbon" can exist in the environment in several forms. Carbonates from bedrock, marl deposits, and other highly calcareous materials are some of the most likely sources. Most of this carbon is "radiometrically dead" and returns an infinite age. Other possible sources include ancient biological carbonaceous sediments. Such old carbons can become incorporated into samples dated by radiometric means either directly through geology, such as carbonaceous clays used as pottery making materials, or through biological processes involving solution in ground and surface waters and subsequent movement of this dissolved inorganic carbonate (DIC) into the aquatic food chain.

One question relating to the issue of old carbon in the environment is the potential for variation in carbonate content of geologic sediments over the geographic range of Brainerd ceramics. To gain some understanding of this potential, relative ages from residue dates from ceramics were plotted on a map to see if locations of older or younger dates corresponded with the distribution of differing glacial sediments.

Surficial glacial deposits in north-central Minnesota range from highly calcareous glacial drift transported from the northwest to non-calcareous glacial drift transported from the northeast. The most calcareous glacial deposits are located in the western edge of the study area in Mahnomen, Becker, Ottertail, and Douglas Counties. These deposits are associated with Late Wisconsin age DesMoines Lobe drift.

Most of the study area including Beltrami, Hubbard, Wadena, Cass, Itasca, and western Crow Wing Counties has glacial deposits associated with Rainy Lobe drift from the north-northeast. There is some admixture of northwestern drift along the northern border of this area. Glacial deposits are moderately calcareous, originating primarily from crystalline rocks with only minor localized inclusions of significant amounts of carbonate rocks.

The eastern edge of the study area, including Mille Lacs, Aiken, and eastern Crow Wing Counties, contain significant amounts of non-calcareous Superior Lobe drift, mixed with Rainy Lobe drift (Figure 15).

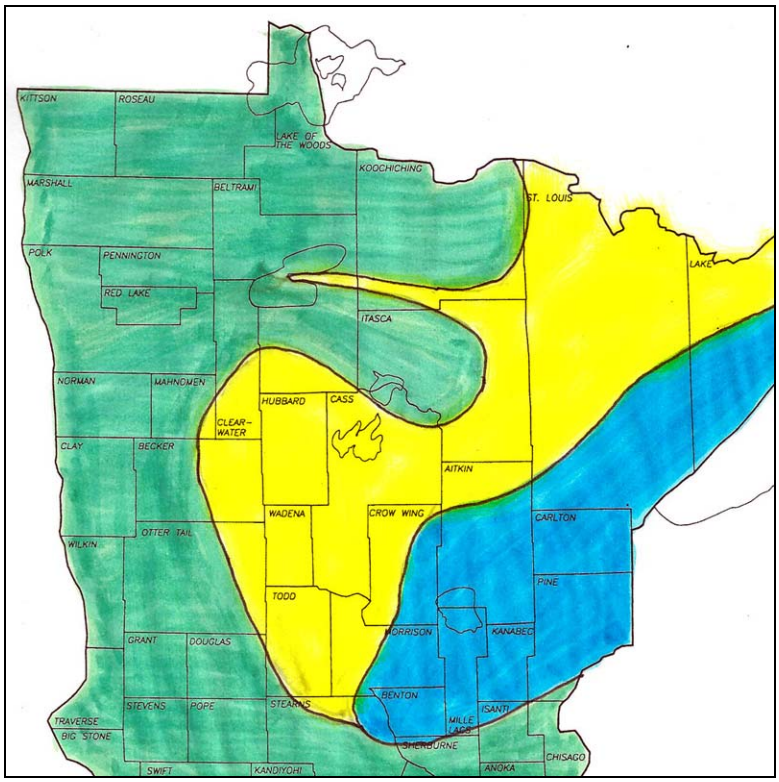

Figure 15: Generalized surficial glacial drift sources within the study area

(various sources)

Surface waters, in the form of lakes and streams, are generally supplied from shallow ground-water aquifers in the region, generally through short distance recharge/discharge or movement through permeable glacial drift. Shallow ground-water aquifers within the study area are characterized by a calcium magnesium bicarbonate type water containing greater than 200 mg per liter hardness as CaCO3. In spite of the variation in carbonate content from east to west in the glacial till, there is obviously sufficient carbonate in older, somewhat deeper, glacial drift to offset this difference. Thus the gradient of hardness in shallow ground-water is such that the western edge of the study area typically has up to 500 mg. per liter of hardness, grading to about 200 mg. per liter at the eastern edge of the study area (Adolphson, Ruhl, and Wolf 1981). Consequently, the water throughout the study area is above the threshold of DIC that could contribute to old carbon entering the aquatic food chain.

When residue dates are plotted relative to surficial glacial deposits, there is no evidence of a relationship. In fact, the most recent dates are concentrated in the east, south, and west edges of the study area, representing the entire range of carbonate content in the glacial sediments.

Regarding direct input of old carbon into the clay paste used in the ceramics, most clay sources that were most likely used would have been well weathered near-surface deposits relatively depleted in carbonates. Any other forms of naturally occurring carbon in clays would usually have been burned out during the pot firing process. These factors, combined with thick residue crust samples that would be subjected to a full alkali/acid/alkali pre-

treatment, effectively eliminates the potential for geologically derived carbon from the clay paste of the vessel to be present in the final AMS sample.

Another issue relative to the DIC levels in shallow groundwater (and, thus, surface waters) is the use of such waters when boiling or otherwise cooking in ceramic vessels. This could result in the deposition of such DIC as evaporates in pot encrustations. Again, full pretreatment of dated samples eliminates any such carbonates.

This full pretreatment also precludes depositional "older" carbon being present in the dated food residue. This treatment would have effectively removed any carbonates (from surface/ground waters or contact with surrounding pedogenic carbonates in soils) and humic acids from either more recent or older sources. (Ron Hatfield, Beta Analytic, personal communication).

PROJECTILE POINT STYLES ASSOCIATED WITH BRAINERD CERAMICS

A summary of projectile points associated with Brainerd ceramics was presented for eight sites in our 1995 paper (Hohman-Caine and Goltz 1995). Since that time we have recovered points associated with Brainerd ceramics from five additional sites: Buffalo Terrace (21-BK-99), Rocky Point (21-CA-67), Maxson (21-CA-109), 50 Lakes Bluff (21-CW-235), and Levesque (21-CW-247).

Five projectile points were recovered from Buffalo Terrace. Three of these resemble some form of Oxbow Point. One resembles a Besant Point, and one is a medium sized, straight-based side-notched point. All of these points are too large to be arrow points and were probably used on darts.

Three projectile points were recovered from Rocky Point. One resembles a Hanna or Lockport Stemmed Point, one is a medium sized corner-notched point with a concave base, and one has the base snapped off, but is too large to be an arrow point.

One projectile point was recovered from the Maxson Site. It is a well made, rather large side-notched point with a straight base.

One projectile point was recovered from the 50 Lakes Bluff Site. It is a medium sized side-notched point.

Fourteen points tentatively associated with the Brainerd ceramics component were recovered from the Levesque Site. Seven of these could be classified as Besant Points. Three are Oxbow-like, one is a straight based side notched point, and three are corner notched. While this site has both older and more recent components, these points seem well associated with the net-impressed and horizontally-corded ceramics.

One of the major problems in identifying associated projectile points is the lack of an established point typology and chronology for Minnesota. Consequently, we are forced to use data from adjacent regions that may or may not directly relate to what we are dealing with in Minnesota. And, since many of the points recovered from Minnesota sites do not readily match known types, most identifications are tenuous, at best.

In light of these observations, however, one fact remains clear and is very meaningful. In examining points apparently associated with net-impressed and horizontally-corded ceramics from 13 sites in Minnesota, there was essentially a complete absence of smaller points that could be identified as arrow points. All of the points are of a size that would function on darts. This is a striking contrast to points associated with similar ceramics on the western plains. The ceramics in those areas typically date to between A.D. 400 and 1000. Associated projectile points are almost exclusively smaller Timber Ridge Side Notched arrow points, the hallmark of Avonlea.

Further east in Canada net-impressed ceramics are also associated with medium sized dart points. At the Lockport Site in Manitoba, associated points were identified as Anderson

Corner-Notched and Lockport Stemmed. Dates for the strata containing these points and net-impressed pottery are between 2500 and 2300 B.P.

At the Cemetery Point site in Manitoba, net-impressed ceramics were recovered associated with Laurel Ware and McKean Lanceolate and Nutimik concave dart points.

At the United Church Site, the net-impressed and horizontally-corded ceramics were found with Late Archaic/Early Woodland points, such as McKean Lanceolate, Hanna, and Anderson Corner-notched. Although there are no radiometric dates, the pottery was found in association with Laurel Ware, much like the situation at Cemetery Point.

PALEOENVIRONMENTAL SETTING AND RELATIONSHIP TO AGE

North central Minnesota is located in a unique environmental setting at the juncture of three major biomes: the prairie on the west, mixed hardwood forests on the southeast, and mixed conifer/hardwood forest on the northeast. The boundaries between these three biomes have moved considerably during the Holocene in response to changing temperature and precipitation over time. During the same time period these same factors of changing temperatures and precipitation coupled with the effect of erosion and deposition along lakeshores, shifting patterns of drainage networks, and erosion and downcutting of lake outlets have caused major changes in the environmental landscape of the present study area.

As in many regions within the forested portions of North America, one of the key elements determining the locations of pre-contact habitation sites is proximity to water. As changes in the environmental landscape have shifted the positions of shorelines of lakes and banks of streams, the focus of human habitation has shifted in concert. Consequently, we frequently find archaeological sites located on what are now relict beaches. This may involve entire sites being located on landforms that are presently a considerable distance from an existing water feature, or sites with cultural components of varying ages distributed across a series of shoreline features that were active at different periods in the evolution of a landscape.

Careful interpretation of the chronology of this landscape evolution, coupled with the identification of archaeological components associated with specific shoreline features, can provide valuable insights for interpreting the chronological position of these components. Several archaeological sites with Brainerd ceramics, located within the present study area lend themselves to these kinds of interpretations.

<u>Kitchie Bay Site: 21-BL-273</u>
The Kitchie Bay Site is located on a terrace overlooking a cedar swamp, almost a mile northeast of the present shore of Kitchie Lake in Beltrami County. One projectile point, a low density of lithic debitage, and a few small horizontally corded body sherds were recovered from 12 square meters of formal excavation. Charcoal from an associated pit feature returned a conventional date of 2480+/-80 B.P. (Beta 43516).

The environmental setting of the site, on an upland terrace above a relict beach with the adjacent former lake basin occupied by a cedar swamp, provided an ideal situation to determine a possible site chronology based on past environmental conditions.

Two peat cores were collected and sampled for pollen. Samples for radiocarbon dating were submitted from the base of the core and at the interface of the lake phase/swamp forest phase for each core. Core CNF-9601 was collected 75m from the upland margin and core CNF-9602 was collected 30m closer to the relict shoreline (Janssens 1997). The radiometric dates were adjusted based on analyses of the pollen spectra relative to previously defined regional chronologies and a sedimentation curve drawn considering paleoenvironmental conditions during the depositional history of the peat deposit.

Interpretation of the data from these cores suggest that open water existed until approximately 2,500 B.P. near the relict beach and until approximately 1,600 B.P. at 75m offshore. After that date, the basin likely drained rapidly to its present condition (Hohman-Caine and Goltz 1999). This interpretation supports the radiocarbon dating for the site as being occupied before the end of the period of open water.

Island View Lodge Site: 21-CA-157

This site is located on Gull Lake. The site is situated on a series of lower beach ridges and a higher terrace. Cultural components include almost the entire range of regional Woodland components. Late Woodland Blackduck and Sandy Lake ceramics are confined to the lower beach ridges. Brainerd ceramics are found on the highest beach ridge and upper terrace, which is at some distance from the present lakeshore (Harrison 1986).

Cass Lake Campground/Norway Beach: 21-CA-229/281

These two sites are located on the southeast shore of Cass Lake within the Chippewa National Forest. The environmental setting consists of the modern beach ridge with a series of successively elevated beach ridges behind. Phase I and II surveys recovered a variety of Woodland ceramics, but no Sandy Lake ceramics were found. Almost no artifacts were recovered from the lowest beach ridge. Blackduck ceramics were found primarily on the mid-level beaches. Brainerd ceramics were confined largely to the upper level beaches. This patterning was particularly evident on site 21-CA-229 where the upper beach ridges were at a higher elevation than on site 21-CA-281 (Goltz 1993a, 1993b).

Lake Carlos State Park Beach Site: 21-DL-2

This site is located in Lake Carlos State Park on a series of beach ridges extending back a considerable distance from the present shoreline. The upper beach marks an older shoreline of Lake Carlos and contains a Brainerd Ware occupation overlying a Late PaleoIndian occupation. Lower beach ridges closer to the lake contained components with Blackduck, Sandy Lake, Plains Village Big Stone Phase, and Extended Middle Missouri variant ceramics (Gonsior 2003).

These are a few of many examples of the frequent association of sites having Brainerd ceramics with older landforms.

DISCUSSION

The ideal goal of this study was to obtain comparable dates from a number of archaeological "events" representing individual Brainerd ceramic vessels. These comparable dates would consist of a date derived from another material or by another method that could be paired with a date derived from charred residue on a ceramic vessel. In an attempt to accomplish this goal, additional radiometric dates were obtained on charcoal, bone, and ceramic residues to bring the total of radiometric dates, including existing dates, to seventy-two (72). Forty-one (41) of these are on ceramic residues, twenty-one (21) are on charcoal, and ten (10) are on bone. Nine (9) additional dates were obtained directly from ceramic sherds by the process of Optically Stimulated Luminescence (OSL), bringing the total of available dates for consideration to eighty-one (81).

As with any such study, a percentage of these dates were not useable for several reasons. Some obviously related to cultural components other than the focus of this study. Given the shallow nature of archaeological deposits in this region, where more than one cultural component is present on a site some degree of mixing is inevitable. Other samples were obviously simply contaminated by older, or in most cases, younger, materials.

Of the initial eighty-one available dates, fifty-one (51) were determined to be valid and applicable to this study (Table 13). These included thirty-nine (39) of the forty-one (41) ceramic residue dates. One date was determined to be from a more recent vessel and one simply could not be reconciled with the other data. Seven (7) of the nine (9) OSL dates were determined to be valid and applicable to this study. One (1) non-Brainerd sample was intentionally submitted to attempt to determine its relationship to Brainerd ceramics and one date was considered to be in error.

Only four (4) of the twenty-one (21) charcoal dates were determined to be applicable to this study. Many of the rejected dates did fit well with other cultural contexts present on a site, indicating that there was mixing of components that was not detectable during excavation. Other samples were either contaminated by more recent charcoal or may simply have been non-cultural.

Only one (1) of the ten (10) bone sample dates was determined to be applicable to this study. In most cases, dates from burned bone appeared to be too old. In a few cases the bone dates could clearly be assigned to other identified components on a site but were either intruded into Brainerd features from more recent components or mixed into Brainerd features from older components. In a few cases the burned bone dates seemed to be indicative of older cultural components that might have been suspected on a site, but were not indicated by clearly identifiable diagnostic artifacts.

Table 13: Dates used in the final analysis

Site Number	Lab Number	Material Dated	Conventional Date	13C/12C	15N/14N
21-BK-099	B 187667	Residue	1730+/-40	-23.7	

	PRI-11-059-BT-2	Residue	1630+/-13	-21.3	
	UIC 2939	OSL	1525+/-290		
21-BL-31	B 298248	Residue	2300+/-30	-32.0	+12.7
	B 298247	Residue	2580+/-30	-30.4	+12.3
	B 298250	Residue	2610+/-30	-31.6	+10.6
	B 298249	Residue	2670+/-30	-29.2	+12.1
21-BL-37	B 108831	Residue	2160+/-50	-29.1	
	B 148858	Residue	2030+/-40	-26.9	
21-BL-273	B 43516	Charcoal	2480+/-90		
21-CA-67	B 296096	Residue	1740+/-40	-24.2	+13.3
	B 296097	Residue	1730+/-40	-23.1	+14.0
	UIC 2944	OSL	1710+/-130		
21-CA-109	B 296095	Charcoal	1420+/-30		
21-CA-184	B 75658	Residue	2610+/-60	-31.7	
	B 75659	Residue	2850+/-60	-31.7	
	B 76658	Residue	2710+/-60	-24.6	
	B 76659	Residue	2480+/-60	-25.7	
	B 76687	Residue	2090+/-60	-23.7	
21-CA-188	B 92827	Residue	1870+/-40	-25.7	
	PRI-11-059-FE-1	Residue	1754+/-16	-26.0	
21-CA-226	UIC 2943	OSL	2350+/-190		
21-CA-352	B 84684	Residue	2550+/-60	-28.6	
	B 84685	Residue	2600+/-60	-33.1	
21-CA-738	B 296103	Residue	2180+/-40	-21.8	+6.4
	B 298253	Charcoal	1870+/-40		
	UIC 2945	OSL	1810+/-200		
21-CW-235	B 144014	Residue	2580+/-40	-27.0	
	UIC 2937	OSL	2730+/-200		
21-CW-247	B 163611	Residue	2120+/-40	-29.9	
	B 187668	Residue	2240+/-40	-24.5	
	UIC 2936	OSL	1940+/-680		
	B 296084	Residue	1850+/-40	-25.5	
	PRI-11-081-MIACEP-1	Residue	2648+/-29	-23.9	
	B 296092	B. Bone	2400+/-30	-24.0	
21-DL-02	B 104090	Residue	1880+/-50	-21.9	
	B 104091	Residue	1980+/-50	-24.8	
21-HB-26	B 71671	Residue	3180+/-60	-35.1	
	B 76189	Residue	3000+/-60	-35.7	
	PRI-11-059-LAC-2	Residue	3270+/-30	-28.7	
	UIC 2947	OSL	2730+/-200		
	B 76190	Residue	2280+/-60	-27.0	
21-IC-012	N.A.	Residue	1890+/-?		
21-IC-176	B 94859	Residue	2320+/-60	-33.8	
	B 101863	Charcoal	1860+/-50		

21-MH-05	**B 70373**	**Residue**	**2455+/-50**		
21-ML-02	**B 280545**	**Residue**	**1860+/-40**	**-25.9**	
21-OT-152	**B 296080**	**Residue**	**1810+/-40**	**-23.4**	**+10.8**
	PRI-11-059-FL-4	**Residue**	**1650+/-22**	**-25.9**	
21-WD-06	**B 79570**	**Residue**	**2930+/-50**	**-31.3**	
	B 79571	**Residue**	**2940+/-80**	**-31.1**	

The fifty-one (51) useable dates selected for the final analysis are from twenty-one (21) individual archaeological sites that are distributed across the known geographical range of Brainerd ceramics in Minnesota (Table 13). They represent thirty-three (33) individual events (vessels): sixteen (16) net-impressed (Brainerd Ware), twelve (12) horizontally-corded (LaSalle Creek Ware), three (3) parallel-grooved (Truman Ware), and two (2) undertermined.

Of the thirty-three (33) individual events, eight (8) have results from more than one dating method/material, two (2) have duplicate dates from more than one laboratory, and two (2) have duplicate dates from the same laboratory. Twenty-one (21) of the events have singular dates, eighteen (18) from ceramic residue, two (2) from charcoal, and one (1) from OSL (Table 14).

Table 14: Archaeological events (vessels) used in this analysis

Site Number	Event	Residue Date	Charcoal Date	Bone Date	OSL Date
21-BK-099	**Net Vessel**	**2**			**1**
21-BL-31	**Net Vessel 1**	**1**			
	Net Vessel 2	**1**			
	H-Cord Vessel 1	**1**			
	H-Cord Vessel 2	**1**			
21-BL-37	**Unid. Vessel**	**1**			
	Net Vessel	**1**			
21-BL-273	**H-Cord Vessel**		**1**		
21-CA-67	**Net Vessel**	**2**			**1**
21-CA-109	**P. Groove Vessel**		**1**		
21-CA-184	**Net Vessel 1**	**1**			
	Net Vessel 2	**1**			
	Net Vessel 3	**1**			
	Net Vessel 4	**1**			
	Net Vessel 5	**1**			
21-CA-188	**Net Vessel**	**2**			
21-CA-226	**H-Cord Vessel**				**1**
21-CA-352	**H-Cord Vessel**	**2**			
21-CA-738	**H-Cord Vessel**	**1**	**1**		**1**
21-CW-235	**H-Cord Vessel**	**1**			**1**

21-CW-247	**Net Vessel 1**	**2**			**1**
	H-Cord Vessel	**1**			
	Net Vessel 2	**1**		**1**	
21-DL-02	**P. Groove Vessel**	**1**			
	H-Cord Vessel	**1**			
21-HB-026	**Net Vessel**	**3**			**1**
	H-Cord Vessel	**1**			
21-IC-12	**Unid. Vessel**	**1**			
21-IC-176	**H-Cord Vessel**	**1**	**1**		
21-MH-05	**Net Vessel**	**1**			
21-ML-02	**Net Vessel**	**1**			
21-OT-152	**P. Groove Vessel**	**2**			
21-WD-06	**H-Cord Vessel**	**2**			

EVENTS WITH MORE THAN ONE DATING METHOD

21-BK-099, net-impressed vessel. Two (2) residue dates from separate laboratories (Beta 187667, PRI-11-059-BT-2) and one (1) OSL date (UIC 2939) are available for this vessel. The residue dates of 1730 +/- 40 BP and 1630 +/- 13 BP calibrate to 1720-1540 and 1570-1480 BP at the 2 sigma level and thus overlap. The 13C/12C isotope ratios of -23.7 and -21.3 suggest no problem with these dates. The OSL date of 1525 +/-290 supports the residue dates.

21-CA-67, net-impressed vessel. Two (2) residue dates (Beta 296096, Beta 296097) and one (1) OSL date UIC 2944) are available for this vessel. The residue dates of 1740 +/- 40 BP and 1730 +/- 30 BP are almost identical and calibrate to 1720-1540 BP and 1730-1550 BP at the 2 sigma level. The 13C/12C isotope ratios of -24.2 and -23.1 and the N15/N14 isotope ratios of +13.3 and +14.0 suggest no problems with these dates. The OSL date of 1710 +/- 130 BPP supports the residue dates.

21-CA-738, horizontally-corded vessel. One (1) residue date (Beta 296103), one charcoal date (Beta 298253) and one OSL date (UIC 2945) are available for this vessel. The residue date of 2180 +/- 40 BP calibrates to 2320-2100 and 2090-2060 BP at the 2 sigma level. The 13C/12C isotope ratio of -21.8 and the 15N/14N isotope ratio of +6.4 suggests no problems with this date. The charcoal date of 1870 +/- 40 BP calibrates to 1890-1710 BP at the 2 sigma level. The OSL date of 1810 +/- 200 BP supports the charcoal date. While the residue date is slightly older than the other dates, it is not unreasonably old considering other dates obtained for horizontally-corded ceramics.

21-CW-235, horizontally-corded vessel. One (1) residue date (Beta 144014) and one (1) OSL date (UIC 2937) are available for this vessel. The residue date of 2580 +/- 40 BP calibrates to 2765 to 2715 BP at the 2 sigma level. The 13C/12C isotope ration of -27.0 is marginal in suggesting that this date may be too old, but the OSL date of 2730 +/- 200 BP centers exactly on this range.

21-CW-247, net-impressed vessel #1. Two (2) residue dates (Beta 163611, Beta 187668) and one (1) OSL date (UIC 2936) are available for this vessel. The residue dates of 2120 +/- 40 BP and 2240 +/- 40 BP calibrate to 2160-1990 and 230-2140 at the 2 sigma level, overlapping somewhat. The 13C/12C isotope ratios of -29.9 and -24.5 suggest that one date may be slightly too old. The OSL date of 1940 +/- 680 BP is similar, but the large standard deviation does not help refine the residue dates. A date range of 2200-2000 BP is probably reasonable for the age of this vessel and is well within an acceptable range.

21-CW-247, net-impressed vessel #2. One (1) residue date (PRI-11-081-MIACEP-1) and one (1) burned bone date (Beta 296092) are available for this vessel. The residue date of 2648 +/- 29 calibrates to 2850-2820 and 2800-2730 BP at the 2 sigma level. The 13C/12C isotope ration of -23.9 suggests no problems with this date. The burned bone date of 2400 +/- 30 calibrates to 2670-2650 and 2490-2350 BP at the 2 sigma level. This seems to indicate a residue date that is slightly too old. A reasonable correction for the age of this vessel may be more in the 2700 BP range.

21-HB-026, net-impressed vessel. Three (3) residue dates (Beta 71671, Beta 76189, PRI-11-059-LAC-2) and one (1) OSL date (UIC 2947) are available for this vessel. The residue dates of 3180 +/- 60, 3000 +/- 60, and 3270 +/- 30 BP calibrate to 3646-3417, 3449-3150, and 3580-3440 BP at the 2 sigma levels. The 13C/12C isotope ratios of -35.1, - 35.7, and -28.7 strongly suggest that these dates are too old. The OSL date of 2730 +/- 200 is likely reasonable, suggesting a reservoir effect offset of approximately 600-700 years.

21-IC-176, horizontally-corded vessel. One (1) residue date (Beta 94859) and one (1) charcoal date (Beta 101863 are available for this vessel. The residue date of 2320 +/- 60 calibrates to 2455-2155 BP at the 2 sigma level. The 13C/12C isotope ratio of -33.8 strongly suggests that this date is too old. The charcoal date of 1860 +/- 50 BP calibrates to 1890-1700 BP at the 2 sigma level. This would suggest a reservoir effect offset of approximately 400-500 years.

EVENTS WITH DUPLICATE DATES FROM MORE THAN ONE LABORATORY (SPLIT SAMPLES)

21-CA-188, net-impressed vessel. Two (2) residue dates from separate laboratories (Beta 92827, PRI-11-059-FE-1) are available for this vessel. These dates of 1870 +/- 40 and 1754 +/- 16 BP calibrate to 1880-1705 and 1720-1610 BP at the 2 sigma level. This overlap and the 13C/12C isotope ratios of -25.7 and 26 suggest that these dates accurately represent the age of this vessel.

21-OT-152, parallel-grooved vessel. Two (2) residue dates from separate laboratories (Beta 296080, BRI-11-059-FL-4) are available for this vessel. These dates of 1810 +/- 40 and 1650 +/- 22 BP calibrate to 1830-1680, 1670-1620 BP (first date), and 1620-1520 BP (second date) at the 2 sigma level. The 13C/12C isotope ratios of -23.4 and -25.9 and the 15N/14N isotope ratio of +10.8 for the first date suggest no problems with these dates.

While these dates do not overlap, the do abutt at the 2 sigma level and an age of approximately 1600-11650 BP is probably reasonable for this vessel.

EVENTS WITH DUPLICATE DATES FROM ONE LABORATORY (SPLIT SAMPLES)

21-CA-352, horizontally-corded vessel. Two (2) residue dates from the same laboratory (Beta 85684, Beta 84685) are available for this vessel. The dates of 2550 +/- 60 and 2600 +/- 60 BP calibrate to 2765-2355 and 2785-2705 BP at the 2 sigma level. The 13C/12C isotope ratios of -28.6 and -33.1, however, suggest that these dates are substantially too old.

21-WD-06, horizontally-corded vessel. Two (2) residue dates from the same laboratory (Beta 79570, Beta 79571) are available for this vessel. The dates of 2930 +/- 50 and 2940 +/- 80 BP calibrate to 3316-2931 and 3371-2871 BP at the 2 sigma level. The 13C/12C isotope ratios of -31.3 and -31.1, however, suggest that these dates are substantially too old.

SINGULARLY DATED VESSELS

21-BL-37. Two (2) vessels from this site have single residue dates. The first is an undetermined vessel dated to 2160 +/- 50 BP (Beta 108831) which calibrates to 2110-1890 BP at the 2 sigma level. The 13C/12C isotope ratio of -29..1 may suggest that this date is slightly too old.

The second vessel is a net-impressed vessel dated to 2030 +/- 40 (Beta 148858) which calibrates to 2320-1995 BP at the 2 sigma level. The 13C/12C isotope ratio of -26.7 suggests no problems with this date.

21-BL-31. Two (2) net-impressed vessels and two (2) horizontally-corded vessels from this site are dated by single residue dates.

The first net-impressed vessel is dated to 2300 +/- 30 BP (Beta 298248) which calibrates to 2350-2310 BP at the 2-sigma level. The second net-impressed vessel is dated to 2580 +/- 30 BP (Beta 298247) which calibrates to 2750-2710 BP at the 2 sigma level. These vessels have 13C/12C isotope ratios of -32.0 and -30.4 which suggests that these dates are likely significantly too old. The 15N/14N isotope ratios are +12.7 and +12.3.

The first horizontally-corded vessel is dated to 2610 +/- 30 BP (Beta 298250) which calibrates to 2760-2730 BP at the 2 sigma level. The second horizontally-corded vessel is dated to 2670 +/- 30 BP (Beta 298249) which calibrates to 2840-2820 and 2800-2750 BP at the 2 sigma level. Again, the 13C/12C isotope ratios of -31.6 and -29.2 suggest that these dates are significantly to old. The 15N/14N isotope ratios are +10.6 and +12.1.

21-BL-273. A single horizontally-corded vessel from this site is dated from a charcoal sample removed from an associated feature. This date (Beta 43516) of 2480 +/- 90 BP calibrates to 2770-2330 BP at the 2 sigma level. This charcoal date should be acceptable.

21-CA-109. A parallel-grooved vessel from this site is dated from a charcoal sample recovered from an associated feature. This date (Beta 296095) of 1420 +/- 30 BP calibrates to 1360-1290 BP at the 2 sigma level. Although this date seems somewhat too recent, it may define an Avonlea-related event of some kind. A sherd from this vessel was submitted for OSL dating. It could not be dated due to the low content of quartz grains. This might suggest that it was not made from local clays.

21-CA-184. Five (5) net-impressed vessels from this site are dated from single residue dates. These dates of 2610 +/- 60 (Beta 75658), 2850 +/- 60 (Beta 75659), 2710 +/- 60 (Beta 76658), 2480 +/- 60 (Beta 76659), and 2090 +/- 60 BP (Beta 76687) calibrate to 2856-2676, 3262-2842, 2930-2745, 2745-2350, and 2160-1805 BP at the 2 sigma level. The first two dates have a 13C/12C isotope ratio of -31.7, suggesting that these dates are substantially too old. The remaining three dates have 13C/12C isotope ratios of -24.6, -25.7, and -23.7 which should indicate no problems with these dates.

21-CA-226. A horizontally-corded vessel from this site is dated by an OSL date of 2350 +/- 190 BP (UIC 2943). Based on the demonstrated reliability of OSL dates from other samples in this study, this date seem acceptable as is.

21-CW-247. A horizontally-corded vessel from this site is dated by a residue date of 1850 +/- 40 BP (Beta 296084) which calibrates to 1880-1700 BP at the 2 sigma level. The 13C/12C isotope ratio of -25.5 suggests that there are no problems with this date.

21-DL-02. Two (2) vessels from this site have single residue dates. The first is a parallel-grooved vessel dated to 1880 +/- 50 BP (Beta 104090) which calibrates to 1905-1705 BP at the 2 sigma level. The 13C/12C isotope ratio suggests no problems with this date.

The second is a horizontally-corded vessel dated to 1980 +/- 50 BP (Beta 104091) which calibrates to 2010-1820 BP at the 2 sigma level. The 13C/12C isotope ratio of -24.8 suggests no problems with this date.

21-HB-26. A horizontally-corded vessel from this site is dated by a single residue date of 2280 +/- 60 BP (Beta 76190) which calibrates to 2332-2126 BP at the 2 sigma level. The 13C/12C isotope ratio of -27.0 may indicate that this date is slightly too old.

21-IC-12. A vessel from this site, identified only as Brainerd, is dated by a single residue date of 1890 BP (no laboratory number of standard deviation is given). This date appears to fall within an acceptable range.

21-MH-05. A net-impressed vessel from this site is dated by a single residue date of 2455 +/- 50 BP (Beta 70373) which calibrates to 2730-2350 BP at the 2 sigma level. No 13C/12C isotope ratio is given. This date is in an acceptable range.

21-ML-02. A net-impressed vessel from this site is dated by a single residue date of 1860 +/- 40 BP (Beta 280545) which calibrates to 1880-1710 BP at the 2 sigma level. The 13C/12C isotope ratio of -25.9 suggests no problems with this date.

CONCLUSIONS AND RECOMMENDATIONS

These conclusions are referenced to the research questions (Appendix A).

1. Dates of Brainerd Ceramics

A. The results of this study show that the Freshwater Reservoir Effect offset has affected some of the ceramic residue dates that have been obtained for Brainerd and related ceramics. Of the thirty-nine (39) usable existing residue dates, fourteen (14) appear to be substantially too old. Twenty-two (22) of the dates, however, appear to be reliable. Three (3) of the dates may be slightly (<200 yr) too old.

   Obtaining good comparable radiometric dates on other site materials (charcoal and faunal materials) was a particular problem in this study. The shallow stratigraphy of archaeological sites in the research area and the pervasive mixing of cultural components is a major obstacle. Other limitations were imposed by the inability to collect additional samples in the field (with one minor exception). Access to collections, however, from a number of small to moderate sized excavations, many from private development projects, provided samples that were adequate.

   Perhaps the most valuable information came from the ability to submit samples of ceramics to a new method of dating, Optically Stimulated Luminescence. Eight (8) of the nine (9) samples analyzed by this method returned dates that either verified existing dates that were felt to be correct, or provided a basis to adjust dates that were felt to be in error.

B. The time span indicated by previously existing dates spanned a period of over 1.500 years, possibly almost 2,000 years depending on which dates one was willing to include. The results of this study show that the dates on the more recent end of this span appear to be valid. The problem appears to be primarily with the oldest of the existing dates. It seems obvious from the results of the present study that residue dates calibrating to older than about 2750 BP are erroneous. Thus, the actual age range of Brainerd and related ceramics begins at approximately 2750 BP and ends at approximately 1700 BP, for a span of about 1,000 years. Regardless, these do represent the earliest ceramics in the region and confirm that Minnesota does, indeed, have an Early Woodland.

C. It is obvious that several of the existing and newly acquired dates from burned food residues are skewed because of some sort of Freshwater Reservoir Effect. The exact causal agents in this skewing, however, are not definable at the present state of our understanding.

   1. The skewing of the residue dates is not uniform. Twenty-two (22) of the available dates appear to be reasonably acceptable. Three (3) dates appear to have errors of less than 200 years. Fourteen (14) of the dates are probably as much as 400 to 600 years too old.

2. The exact factors involved are poorly understood. A few factors, however, can be eliminated. The geological setting and surface/groundwater chemistry do not appear to be a factor. Carbonate levels above the threshold for contributing a significant dissolved inorganic carbonate (DIC) load to cooked foods are present throughout the region. Any such carbonates that might enter the burned residues by way of the ceramic paste or evaporates from cooking water, or through humic acids or other substances within the soil matrix are effectively eliminated by the standard sample pretreatment procedures. Consequently, we are left with the nature of the foods cooked as the smoking gun. It would appear that the "what" that was cooked, whether a single food or some combination, is not the only factor involved. Isotope fractionation during the cooking process is likely also involved and understanding the complex reactions between proteins, fats, and carbohydrates over time and under varying temperatures and cooking methods is likely far too complex to readily relate to ceramic residues.

   One measure that does appear to be a "red flag" is the 13C/12C isotope ratio of the dated sample. As demonstrated during the present study, there appears to be a direct relationship between samples with a ratio more negative than -26.0 and residue dates that are too old. This relationship was suggested by several researchers (most noteably Fischer and Heinenmeier 2003). All of the dates used in this study that were older than 2800 BP had highly negative 13C/12C ratios, some as low as -35.1. Where comparable dates were available all of these dates proved to be too old. At this point there is no explanation for this phenomenon. No naturally occurring food sources within the region have a ratio in this low range except some freshwater bivalves (low tropic state filter feeders) at around -28.0 to -29.0 and chenopodium (a terrestrial plant) in the -31.0 to 32.5 range.

3. Rather than procedures to minimize or eliminate these effects for future dating of ceramic residues, a program to better define and understand these effects seems to be in order. Residue dates provide an almost perfect assurance of context, particularly given the nature of the sites we deal with in this region. We need to keep running residue dates. The 13C/12C isotope ratios are standard with AMS dates. We need to spend the small extra cost to also run 15N/14N isotope ratios on samples where this can be done. This would include all residue dates and any collagen dates. It is probably not important to run on wood charcoal, but other charred food related materials such as nut shells or seeds should have this done.

   Our experience with OSL dating of ceramic sherds was very positive. This provided the most useable comparative data for the present study. Finding a laboratory to do this dating can be difficult. We used the laboratory at the University of Illinois at Chicago. Expect a long turn-around time. We were told three to four months, but results actually took a year---but it was worth the wait. Sherd samples need to be as thick as possible, at least 6 to 7mm and

about 3cm or larger in diameter. A small soil sample collected within 50cm of the sherd is also required. Fifty grams is sufficient. Plan ahead in your field work.

There may well be other helpful analyses. Anything that characterizes or identifies the residue will likely be helpful. We need to start developing the database. The answers will come slowly.

2. The Nature and Definition of Brainerd Ware

A. We have subdivided what has been called Brainerd Ware into three separate wares. The explanation for this subdivision is covered in the body of this report.

Brainerd Ware: includes all net-impressed vessels

LaSalle Creek Ware: includes what was previously called Brainerd horizontally-corded

Truman Ware: The few parallel grooved vessels found in Minnesota. This is the name used for these ceramics on Avonlea sites to the west.

B. We could find no consistent geographic or temporal relationships to any vessel attributes other than the small amount of Truman Ware present, which is confined to about the western half of the study area.

C. All of the newly defined wares relate to ceramics further to the west and northwest. Net-impressed pottery identical to Brainerd Ware in all attributes and chronology is found in Manitoba and very similar ceramics occur on Avonlea sites further to the west. These sites are more recent. In Canada, the ceramics have been called Rock Lake Ware (Norris 2007). Horizontally-corded ceramics similar to, but not identical to, LaSalle Creek Ware also occur on these sites to the north and west. These ceramics are more recent on Avonlea and related sites. The parallel-grooved Truman Ware is a hallmark ceramic of Avonlea sites to the west. Its presence on a few sites in Minnesota is limited.

The overall implications appear to be that these ceramics originated early in what is now Minnesota, but over time the people migrated to the west and the ceramics went with them. This is a fruitful area for future research.

3. Associated Lines of Evidence

A. Due to the shallow nature of archaeological sites in Minnesota, directly associating any projectile points with a specific cultural context can be problematic. This is further complicated by the fact that there is no well established projectile point typology or chronology for the state.

Field research to date seems to indicate a wide variety of projectile points on Brainerd and related sites. Whether this represents fact or not is difficult to reconcile. Quite likely some of these points represent a Late Archaic use of a site that is otherwise invisible or undiscovered.

Regardless, what can be telling is the absence of later small arrow points on Brainerd and related sites that lack a visible Later Woodland component (based on ceramics present). Almost all points found on these sites would fall into the category of small to medium sized dart points. While this does not define a chronology, it certainly gives a general indication of relative age.

B. Where landforms and paleoclimatic/hydrologic features can be defined, there are some sites which lend support to the chronology presented in this study. Some of these are described in the body of this report. These show that where hydrologic features have changed over time, Brainerd and related sites tend to be located on past landforms.

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APPENDICES

APPENDIX A: RESEARCH QUESTIONS FROM "PROPOSAL FOR 'THE AGE OF BRAINERD CERAMICS' RFP, PREPARED BY SOILS CONSULTING

RESEARCH QUESTIONS

1. Dates of Brainerd Ceramics

A. Are existing AMS dates on burned food residues representative of actual dates for the ceramics?

B. Is the long time span shown by existing dates real or has it been artificially expanded due to varying errors in those dates (i.e. are some dates too early/late?)

C. Are dates from burned food residues skewed because of incorporation of old carbon (freshwater reservoir effect)?

1. If so, is this skewing relatively uniform or are some dates skewed more than others?

2. If there is a freshwater reservoir effect, what factor(s) are involved? (food source, geological setting, surface/groundwater chemistry, etc.)

3. What procedures (such as sample selection, dating methods, etc.) can be used to minimize or eliminate these effects for future research?

2. The Nature and Definition of Brainerd Ware

A. Is the current concept of Brainerd ceramics as a single ware valid, or should it be subdivided?

B. Do the differences in vessel attributes, such as surface treatment, decorative motifs, vessel morphology and others, have geographic or temporal implications?

C. What is the relationship of Brainerd ceramics to similar ceramics from elsewhere in the Midwest and Canada?

3. Associated Lines of Evidence

A. Can other artifact types (such as projectile points) be directly associated with Brainerd ceramics and used as an indicator of chronology?

B. Can paleoenvironmental data on site locations suggest a relative chronology for sites containing Brainerd Ware?

APPENDIX B: LIST OF BRAINERD SITES

BRAINERD SITES

AK-07	Russ/Ind Pt
AK-14	
AK-24	
AK-25	
AK-55	Headquarters Ridge
AK-58	Cedar Creek
AK-105	Rice River Bridge
AK-111	Fisher's Resort I
AK-113	Twin Lakes Trail
BK-01	Mitchell Dam
BK-33	Lake Sallie Access
BK-72	Tamarack Natl Wildlife Ref. I
BK-92	Becker 092
BK-90	Buffalo Bluff II
BK-99	Buffalo Point
BK-102	Mill Lake
BL-01	Shocker
BL-02	Waskish
BL-04	Knutson Dam
BL-05	Pug Hole

BL-07	
BL-08	Episcopal Mission
BL-11	Fisher's Point
BL-12	Fisher's Post
BL-13	Fisher's Bend
BL-18	River Lake Resort
BL-26	Preece
BL-22/31	Pamida (also called Lake Boulevard on SHPO)
BL-35	Lake Bemidji
BL-37	Midway
BL-62	Hiltz
BL-64	Pug Hole Lake
BL-65	Moose Lake II
BL-70	Mikinako-zibi
BL-71	Mikinako-sag
BL-87	Pine Tree Park
BL-88	Pimush Boat Access
BL-141	NW Burned Out Bridge
BL-148	Cass Lk Beach Ridge
BL-165	
BL-169	Jacobson
BL-170	Diamond Pt Park
BL-172	Carr Lake

BL-180	Lk Bemidji Outlet
BL-193	Turtle River Village
BL-194	Turtle River Flowage
BL-198	West Big Lake #2
BL-213	The Canoe Camp
BL-222	Schoolcraft Crossing
BL-223	North Marquette
BL-235	Lk Bemidji Shelter Bldg
BL-246	Sherman
BL-249	Benchmark
BL-272	Mick Finn Lot
BL-273	Kitchie Bay (also on SHPO database as BLeg)
BL-281	
BL-289	Three Island
BL (RL-LR-012)	Sandy River Bridge (no state #; RL site)
BLz	needs site form
BL-RL	Ponemah Waterline (no state #; RL site)
BL-	North Star Island Narrows ???
BS-32	Kanne Bros Farm
CA-01	Scott
CA-02	Mud Lake
CA-06	Ebert
CA-10	Sugar Point

CA-13	Mud Lake Dam
CA-27	Steamboat Lake
CA-28	Shingobee Island
CA-29	Kabekona Narrows
CA-36	
CA-37	Gull Lake Dam
CA-38	South Pike Bay
CA-47	Blackduck Point
CA-48	Bear River
CA-52	Portage Creek Bridge
CA-55	Chippewa Agency
CA-58	Langer
CA-59	Dam Bay
CA-62	Lego
CA-63	Uram Bay
CA-69	
CA-88	
CA-91	
CA-116	
CA-117	
CA-118	
CA-135	Warren Huffman
CA-136	Brockway Culvert

CA-146	Spider Ridge
CA-148	Fawn Point
CA-157	Island View
CA-169	Nushka Lake
CA-174	Cass Lake Channel
CA -181	Pillager Ridge
CA-182	Pillager Hills
CA-184	Roosevelt Lk Narrows
CA-188	Felknor
CA-191	Hanson/Hime
CA-201	Horseshoe Bay
CA-216	Grife
CA-218	Shady Point
CA-226	Kelnhoffer
CA-229	Cass Lake Campground
CA -281	Norway Beach Campground
CA-284	The Lake Mud Parking Lot
CA-287	St. Marks/Pike Bay SE
CA-368	Portage Lk Boat Access East
CA-352	
CA-482	
CA-486	Gull Lk Dam Tender
CA-539	The Winnie Cottages

CA-543	The Upper Sucker Lk Channel
CA-551	The Oak Point Ceramic
CA-555	The Whitefeather #1
CA-557	The Whitefeather #3
CA-559	The Whitefeather #5
CA-569	Northeast Pike Bay
CA-571	Upper Sucker Lake
CA-573	North Bay
CA-579	Lake Ada Access
CA-586	Boy Lake Boat Landing
CA-587	The NE Steamboat Lake
CA-600	
CA-627	Ten Mile Portage
CA-631	Angel View
CA-632	Angel Bay
CA-635	Winter Eagle
CA-636	Singing Bay
CA-642	Wetland Point
CA-649	Laura Lake Access
CA-676	Bug-e-zo-we-ning
CA-695	Stand 635
CA-705	Maxson
CA-737	Moxness Beach

CA-738	Thunder Lake West
CE-05	Lower Rice Lake
CE-15	Lake Itasca Headwaters
CE-23	Chambers Creek East
CE-27	Bear Paw Campground
CE-28	Herberg
CE-38	Ruffy Brook
CW-09	Ray Scott
CW-02	King Mound
CW-11	
CW-15	Crow Wing State Park
CW-33	Pine River Egg Take
CW-48	Round Lake Outlet
CW-53	Sebre Lk/ Nokasippi
CW-59	
CW-65	Hummingbird Mds
CW-68	Busbey Hill
CW-90	Conway
CW-96	Black Bear
CW-97	Dr. Camp
CW-108	Green's Point
CW-136	Marcho Mds/Hab
CW-210	Arrowhead P&Q

CW-217	
CW-230	
CW-235	Eagle Lake
CW-236	Fifty Lakes
CW-247	Levesque
CW-272	Dahler Lake
CW-285	Duck Lake
CW-287	
DK-31	Sibley House
DL-02	Lake Carlos St. Pk Beach I
DL-126	Lake Carlos #3
HB-06	Shell River
HB-12	Bosell
HB-19	Palmer Pines
HB-21	Lake Hattie Access
HB-26	LaSalle Creek
HB-56	Island Lake-Md Creek
IC-01	White Oak Point
IC-02	Osufsen
IC-04	Lake Winnie Dam
IC-12	Ogema Geshik
IC-15	Round Lake
IC-16	Inger

IC-22	Seelye Point
IC-23	Williams Narrows
IC-24	Little Cutfoot Sioux
IC-27	Plug Hat Point
IC-28	Sugar Lake
IC-32	Mississippi Inlet
IC-33	
IC-44	
IC-60	
IC-77	
IC-87	Inger Bridge
IC-108	Long Lake Access
IC-123	Old CutFoot Sious Ranger Sta
IC-176	Third River Borrow Pit
IC-279	Sugar Lake 5
IC-221	Bird's Eye Lake
IC-313	WS-26
IC-330	Big Tree
IC-349	North Shallow Pond Lk W
IC-354	East Sugar Lake Ridge
IC-365	Bowstring
IC-o	Sugar Island (no info)
KA-68	

KC-01	Nett Lake
KC-02	McKinstry
KC-03	Grand Mound
KC-37	Railroad Point
MA-63	Middle River Gravel
MH-05	North Twin Lake
ML-02	Aquapaguetin Island
ML-15	Fa Hennepin St. Pk I
ML-28	Fa Hennepin St Pk II
ML-48	Mille Lacs Health
ML-55	Upper South Harbor
ML-81	
ML-84	
ML-88	
ML-102	
ML-120	
ML-125	Sutton
MO-11	Rice Lk. Peninsula II
MO-114	Kruger
NR-01	Slininger
OT-36	Maplewood St. Pk
OT-41	Rosengren
OT-51	Dead River I

OT-73	Deer Lake
OT-109	Lake Lida
OT-112	Glendalough St. Pk IV
OT-113	Glendalough St Pk V
OT-117	Pelican Bay NE
OT-118	Pelican Bay SE
OT-132	Glendalough
OT-152	West Point
OT-169	Tumuli
OT-175	Rush Lake
PE-02	Squaw Point
SN -85	
T0-22	Listberger
TO-26	North Bass
TR-38	Lake Traverse Co Pk
WD-06	Blueberry Lk Vill
WD-09	Shell City
WD-19	Old Wadena
WR-75	Lake Maria St Pk I

APPENDIX C: RADIOMETRIC AND OSL DATA SHEETS

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.7:lab. mult=1)

Laboratory number: **Beta-296078**

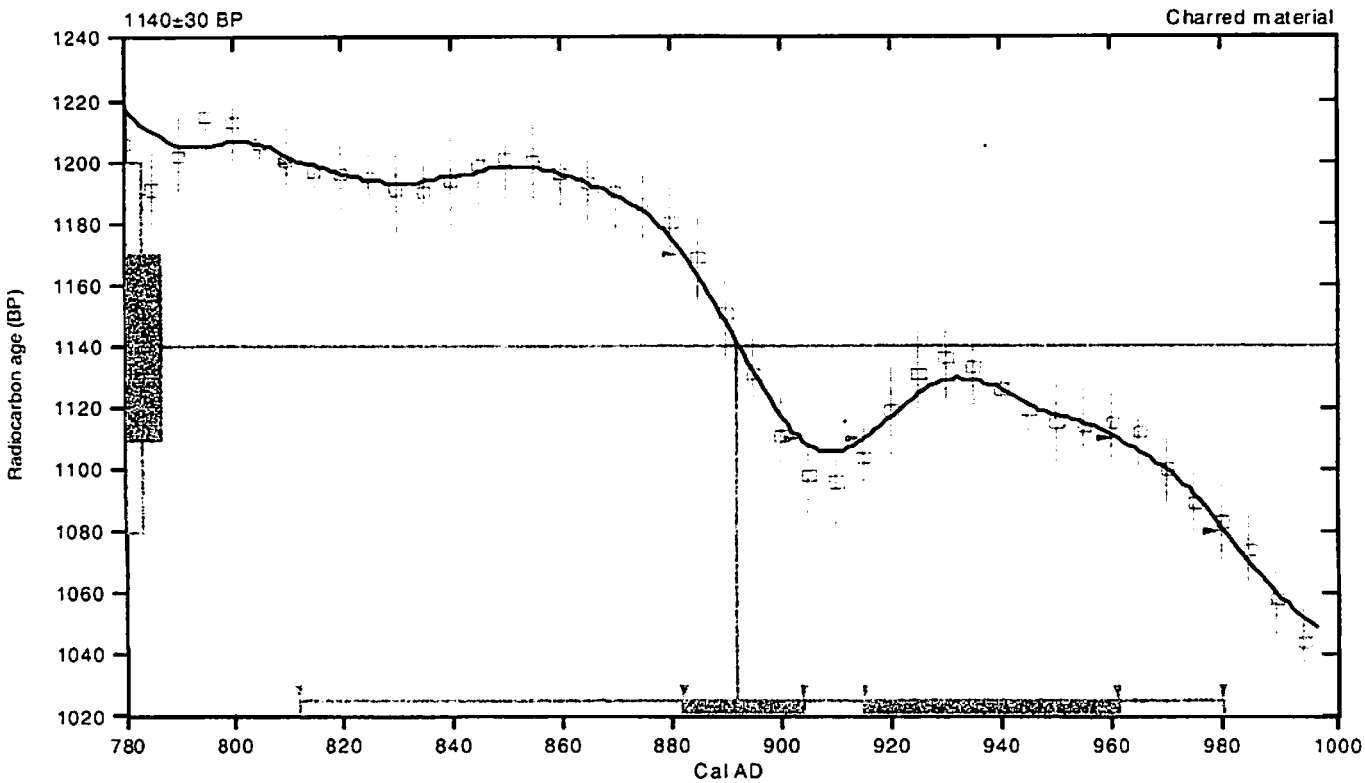
Conventional radiocarbon age: **1140±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 810 to 980 (Cal BP 1140 to 970)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 890 (Cal BP 1060)

1 Sigma calibrated results: (68% probability) Cal AD 880 to 900 (Cal BP 1070 to 1050) and Cal AD 920 to 960 (Cal BP 1040 to 990)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18.3:lab. mult=1)

Laboratory number: **Beta-296079**

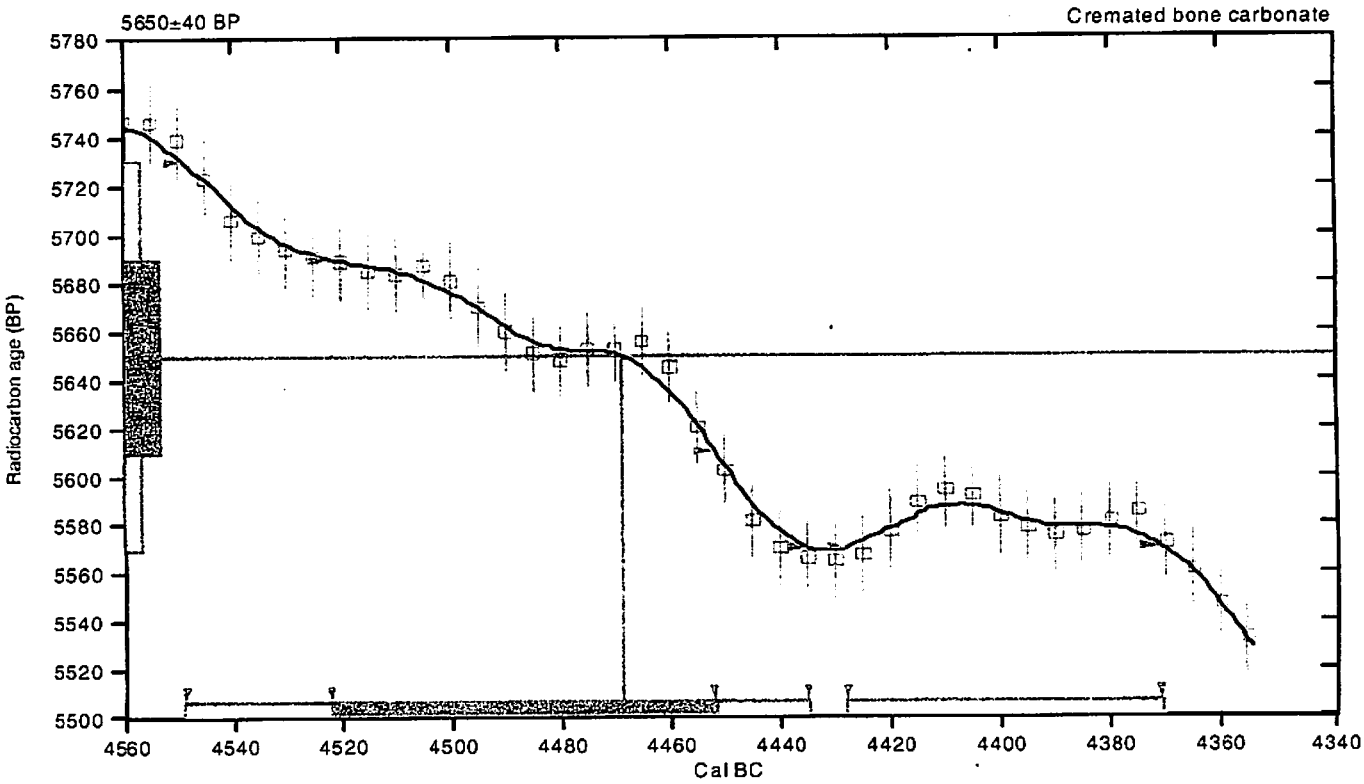
Conventional radiocarbon age: **5650±40 BP**

2 Sigma calibrated results: **Cal BC 4550 to 4440 (Cal BP 6500 to 6380) and**
(95% probability) **Cal BC 4430 to 4370 (Cal BP 6380 to 6320)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 4470 (Cal BP 6420)

1 Sigma calibrated result: Cal BC 4520 to 4450 (Cal BP 6470 to 6400)
(68% probability)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number: **Beta-296080**

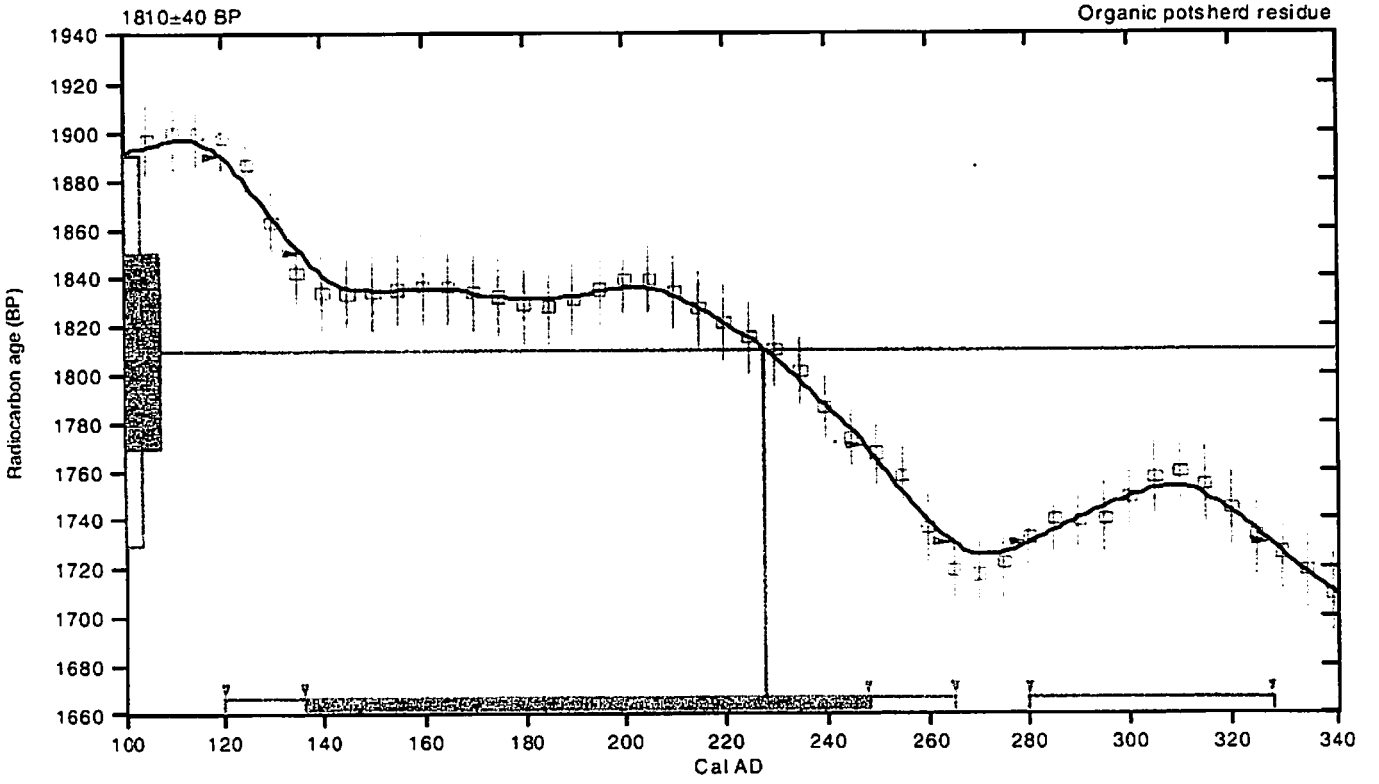
Conventional radiocarbon age: **1810±40 BP**

2 Sigma calibrated results: **Cal AD 120 to 260 (Cal BP 1830 to 1680) and**
(95% probability) **Cal AD 280 to 330 (Cal BP 1670 to 1620)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 230 (Cal BP 1720)

1 Sigma calibrated result: Cal AD 140 to 250 (Cal BP 1810 to 1700)
(68% probability)



References:

Database used
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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number: **Beta-296081**

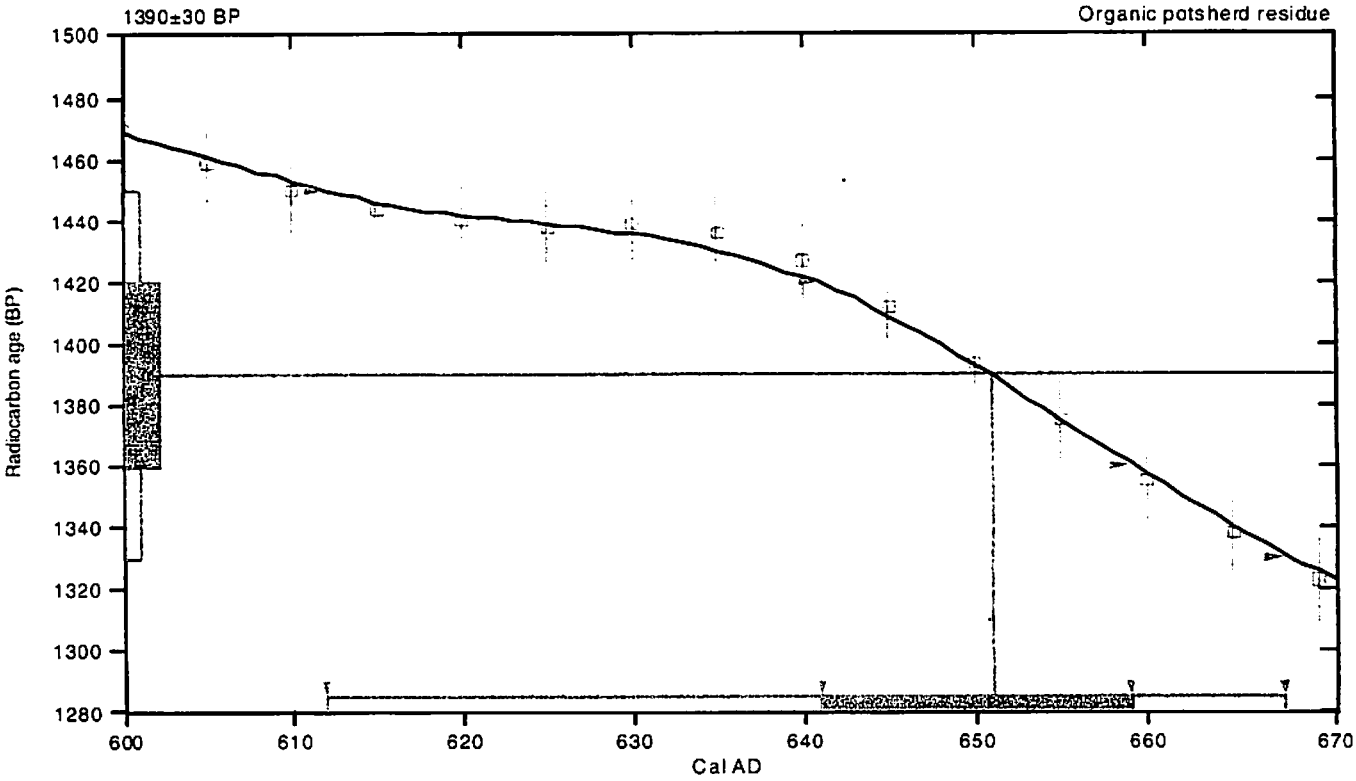
Conventional radiocarbon age: **1390±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 610 to 670 (Cal BP 1340 to 1280)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 650 (Cal BP 1300)

1 Sigma calibrated result: (68% probability) Cal AD 640 to 660 (Cal BP 1310 to 1290)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.6:lab. mult=1)

Laboratory number: **Beta-296083**

Conventional radiocarbon age: **30±30 BP**

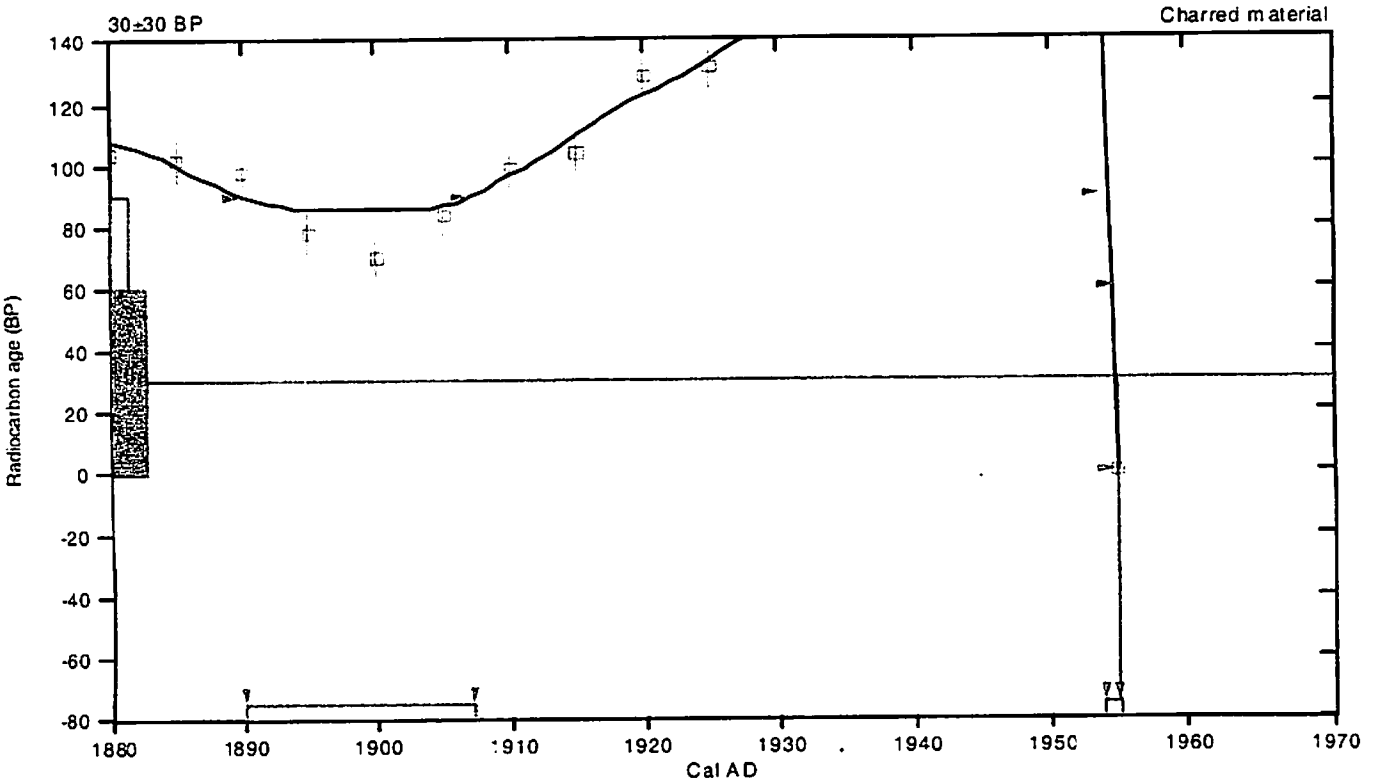
2 Sigma calibrated results[2]: **Cal AD 1890 to 1910 (Cal BP 60 to 40) and**
(95% probability) **Cal AD 1950 to beyond 1960 (Cal BP 0 to 0)**

[2] *2 Sigma range being quoted is the maximum antiquity based on the minus 2 Sigma range*

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1960 (Cal BP 0)

1 Sigma calibrated result: (68% probability) Cal AD 1960 to 1960 (Cal BP 0 to 0)



References:

Database used

INTCAL04

Calibration Database

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.5:lab. mult=1)

Laboratory number: **Beta-296084**

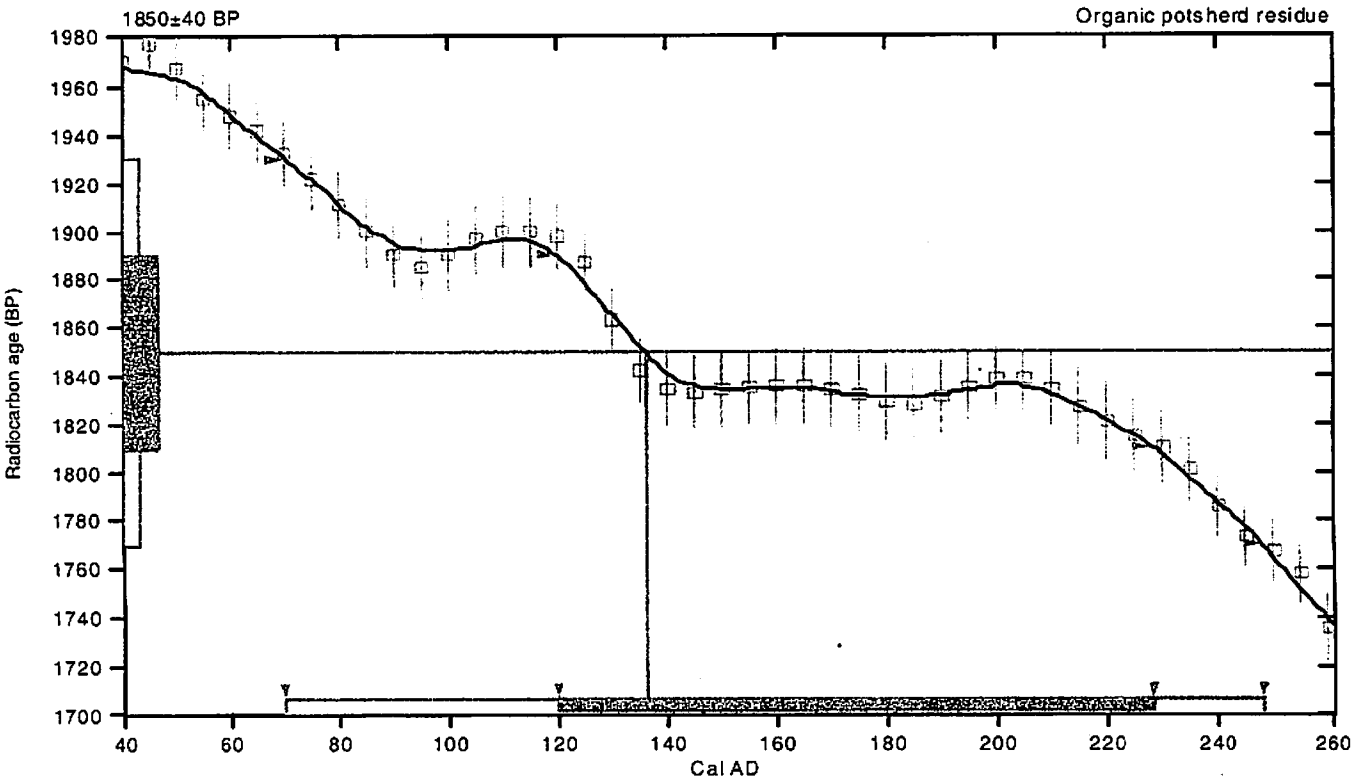
Conventional radiocarbon age: **1850±40 BP**

2 Sigma calibrated result: **Cal AD 70 to 250 (Cal BP 1880 to 1700)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 140 (Cal BP 1810)

1 Sigma calibrated result: Cal AD 120 to 230 (Cal BP 1830 to 1720)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.7:lab. mult=1)

Laboratory number: **Beta-296085**

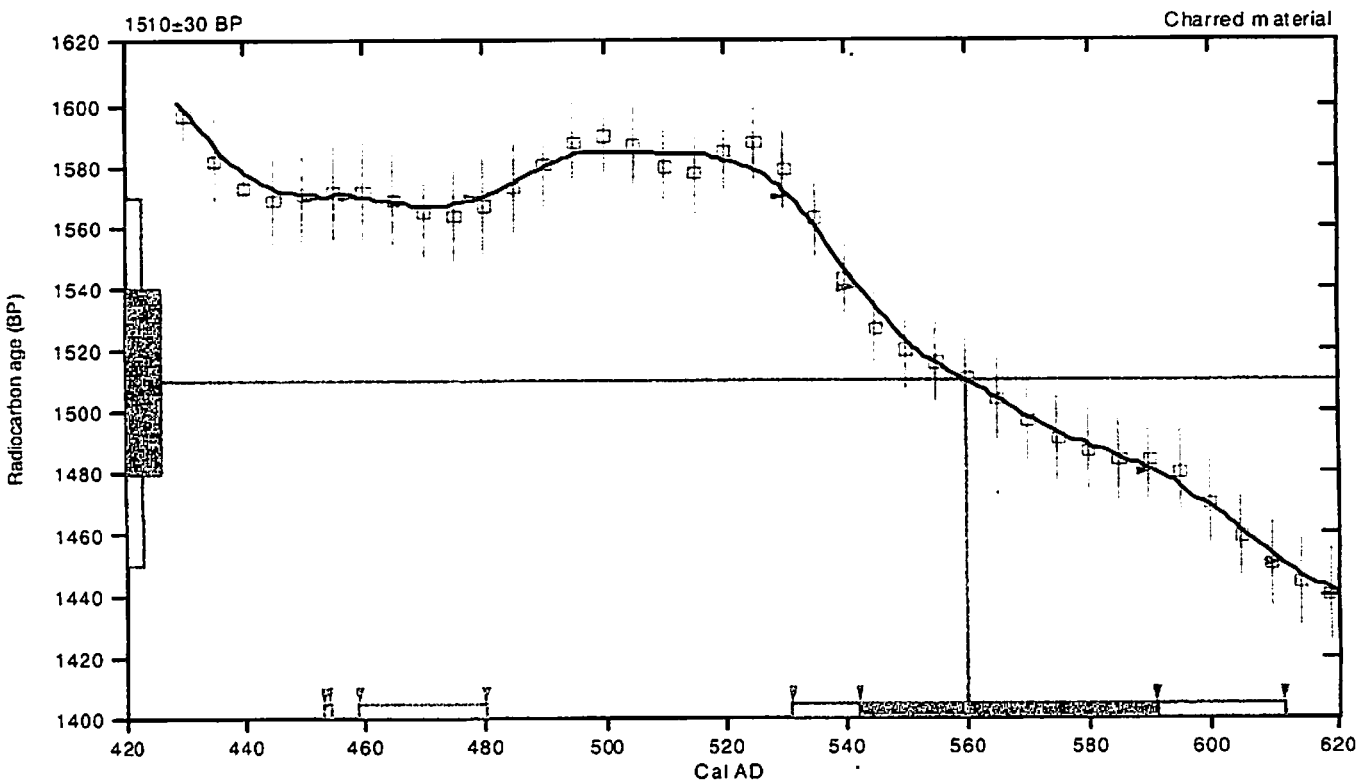
Conventional radiocarbon age: **1510±30 BP**

2 Sigma calibrated results: **Cal AD 450 to 450 (Cal BP 1500 to 1500) and**
(95% probability) **Cal AD 460 to 480 (Cal BP 1490 to 1470) and**
Cal AD 530 to 610 (Cal BP 1420 to 1340)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 560 (Cal BP 1390)

1 Sigma calibrated result: Cal AD 540 to 590 (Cal BP 1410 to 1360)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.6:lab. mult=1)

Laboratory number: **Beta-296086**

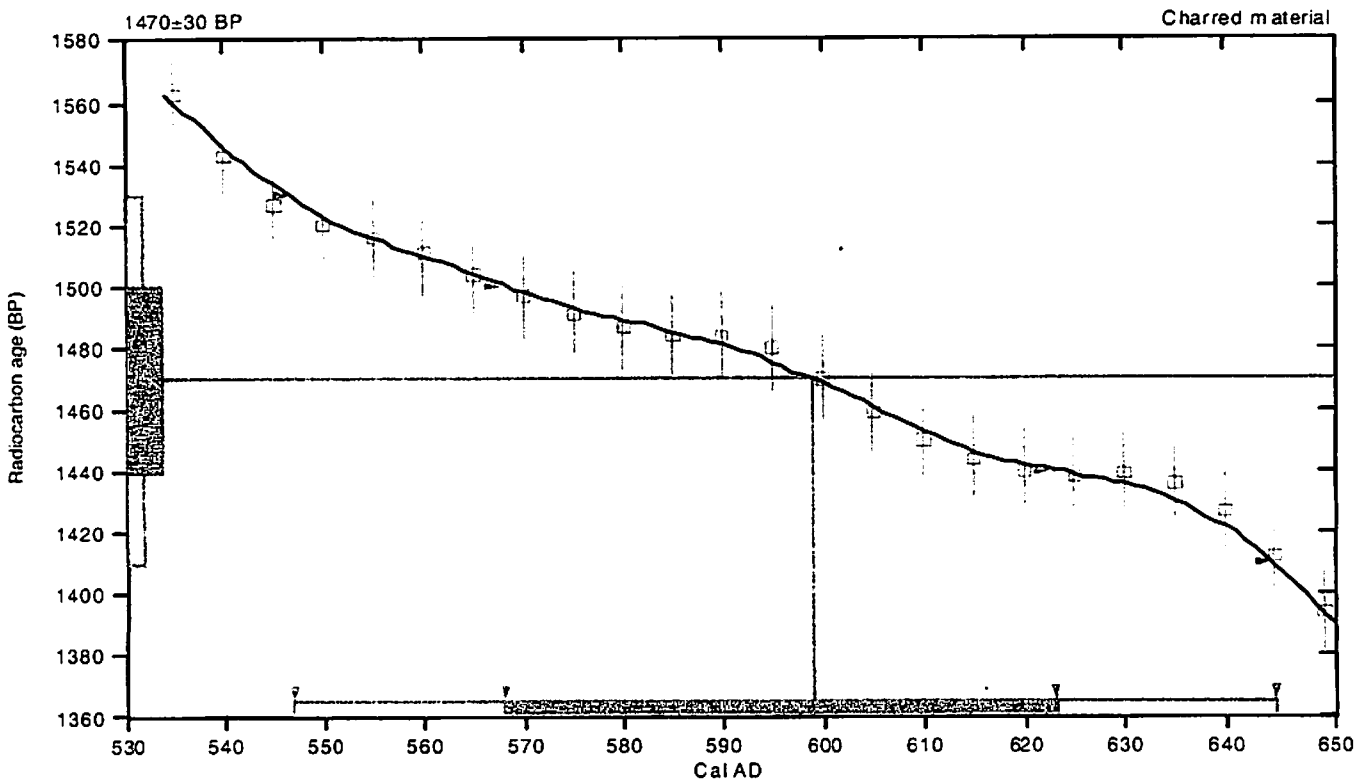
Conventional radiocarbon age: **1470±30 BP**

2 Sigma calibrated result: **Cal AD 550 to 640 (Cal BP 1400 to 1300)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 600 (Cal BP 1350)

1 Sigma calibrated result: Cal AD 570 to 620 (Cal BP 1380 to 1330)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.2:lab. mult=1)

Laboratory number: **Beta-296087**

Conventional radiocarbon age: **260±40 BP**

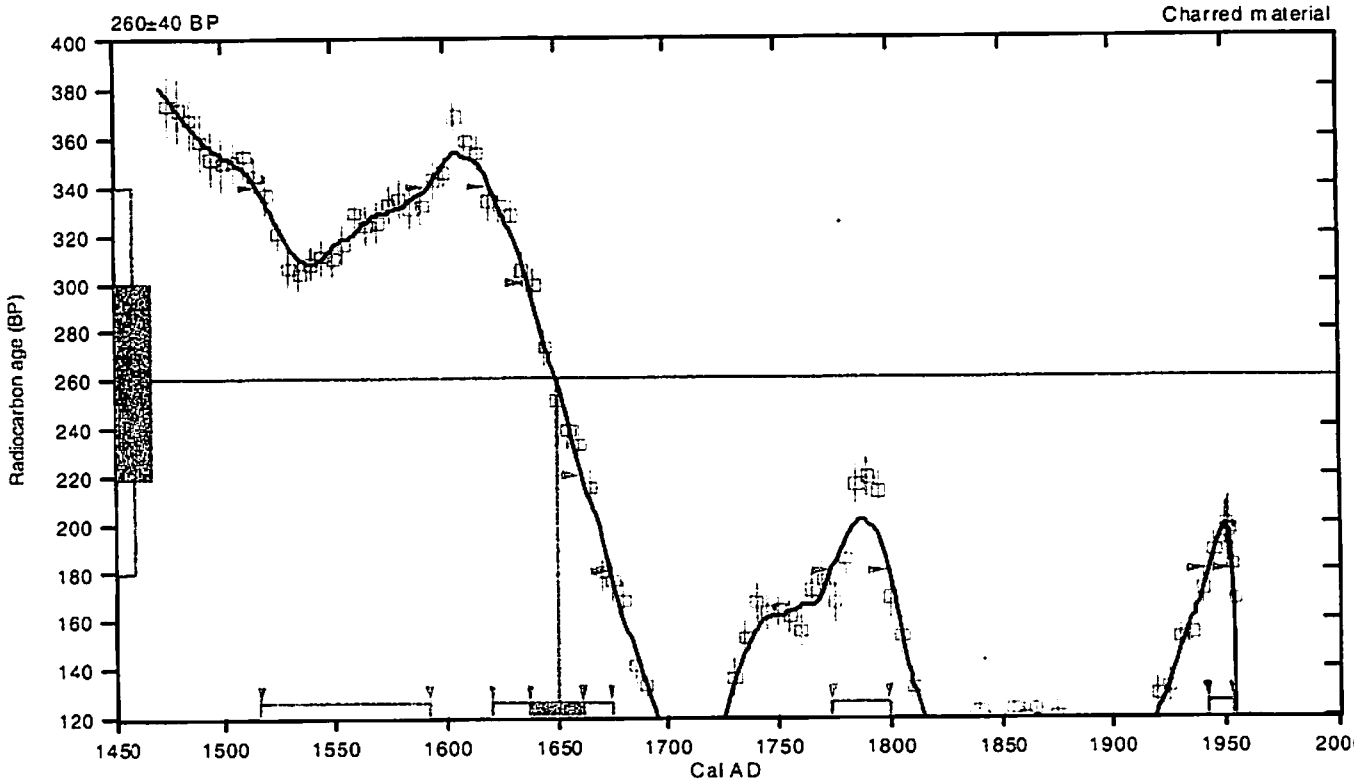
2 Sigma calibrated results: **(95% probability)**

Cal AD 1520 to 1590 (Cal BP 430 to 360) and
Cal AD 1620 to 1670 (Cal BP 330 to 280) and
Cal AD 1770 to 1800 (Cal BP 180 to 150) and
Cal AD 1940 to 1950 (Cal BP 10 to 0)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1650 (Cal BP 300)

1 Sigma calibrated result: (68% probability) Cal AD 1640 to 1660 (Cal BP 310 to 290)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.1:lab. mult=1)

Laboratory number: **Beta-296088**

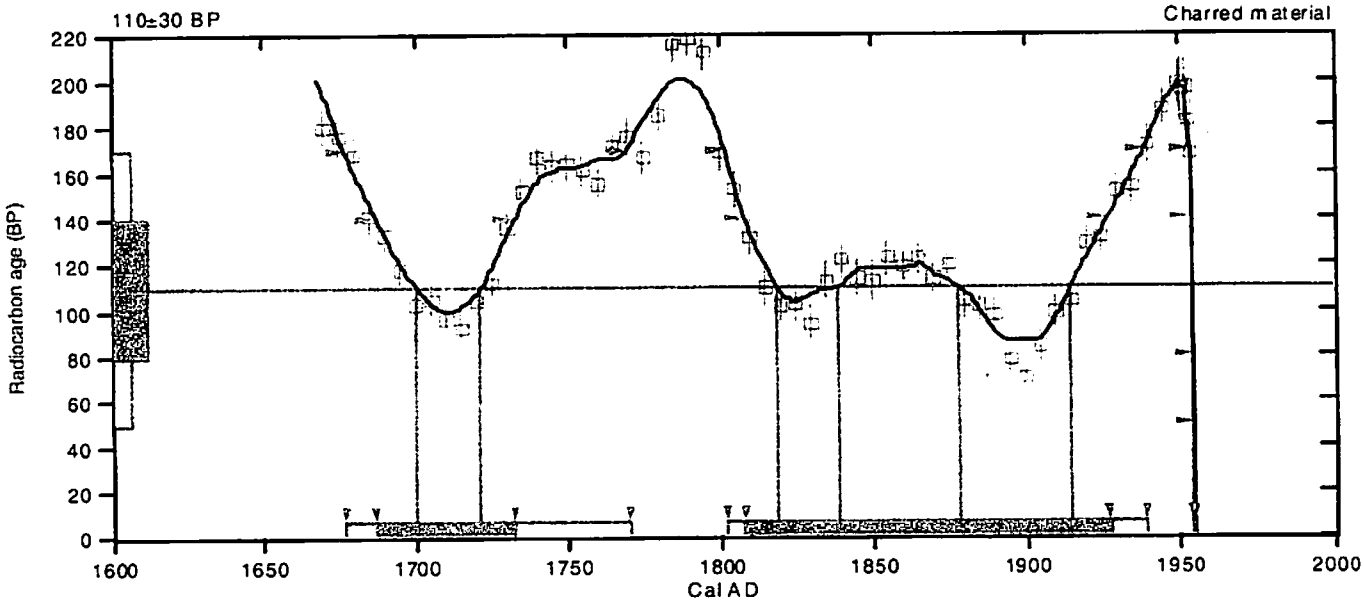
Conventional radiocarbon age: **110±30 BP**

2 Sigma calibrated results: **Cal AD 1680 to 1770 (Cal BP 270 to 180) and**
(95% probability) **Cal AD 1800 to 1940 (Cal BP 150 to 10) and**
Cal AD 1950 to 1960 (Cal BP 0 to 0)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1700 (Cal BP 250) and
Cal AD 1720 (Cal BP 230) and
Cal AD 1820 (Cal BP 130) and
Cal AD 1840 (Cal BP 110) and
Cal AD 1880 (Cal BP 70) and
Cal AD 1920 (Cal BP 40) and
Cal AD 1950 (Cal BP 0)

1 Sigma calibrated results: Cal AD 1690 to 1730 (Cal BP 260 to 220) and
(68% probability) Cal AD 1810 to 1930 (Cal BP 140 to 20) and
Cal AD 1950 to 1960 (Cal BP 0 to 0)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.7:lab. mult=1)

Laboratory number: **Beta-296089**

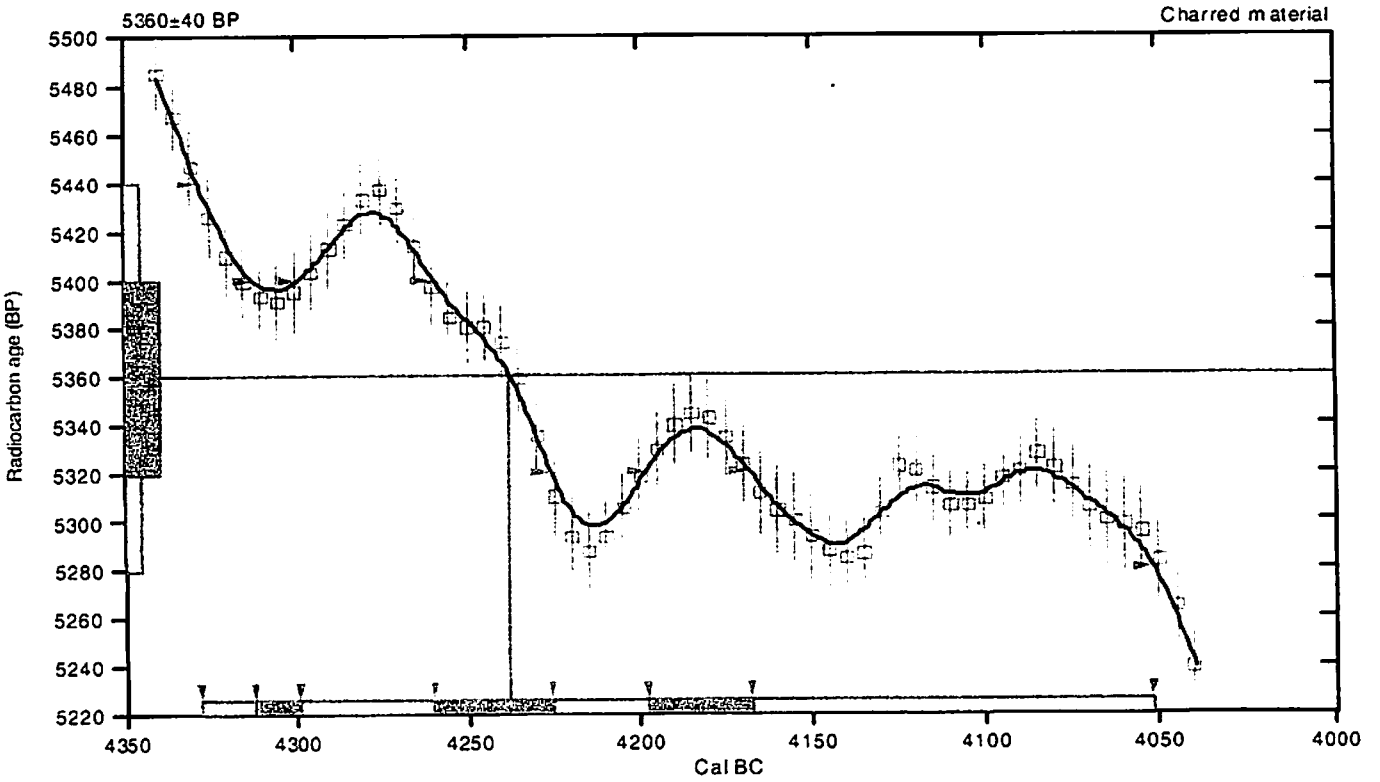
Conventional radiocarbon age: **5360±40 BP**

2 Sigma calibrated result: **Cal BC 4330 to 4050 (Cal BP 6280 to 6000)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 4240 (Cal BP 6190)

1 Sigma calibrated results: (68% probability)
Cal BC 4310 to 4300 (Cal BP 6260 to 6250) and
Cal BC 4260 to 4230 (Cal BP 6210 to 6180) and
Cal BC 4200 to 4170 (Cal BP 6150 to 6120)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-19.6:lab. mult=1)

Laboratory number: **Beta-296090**

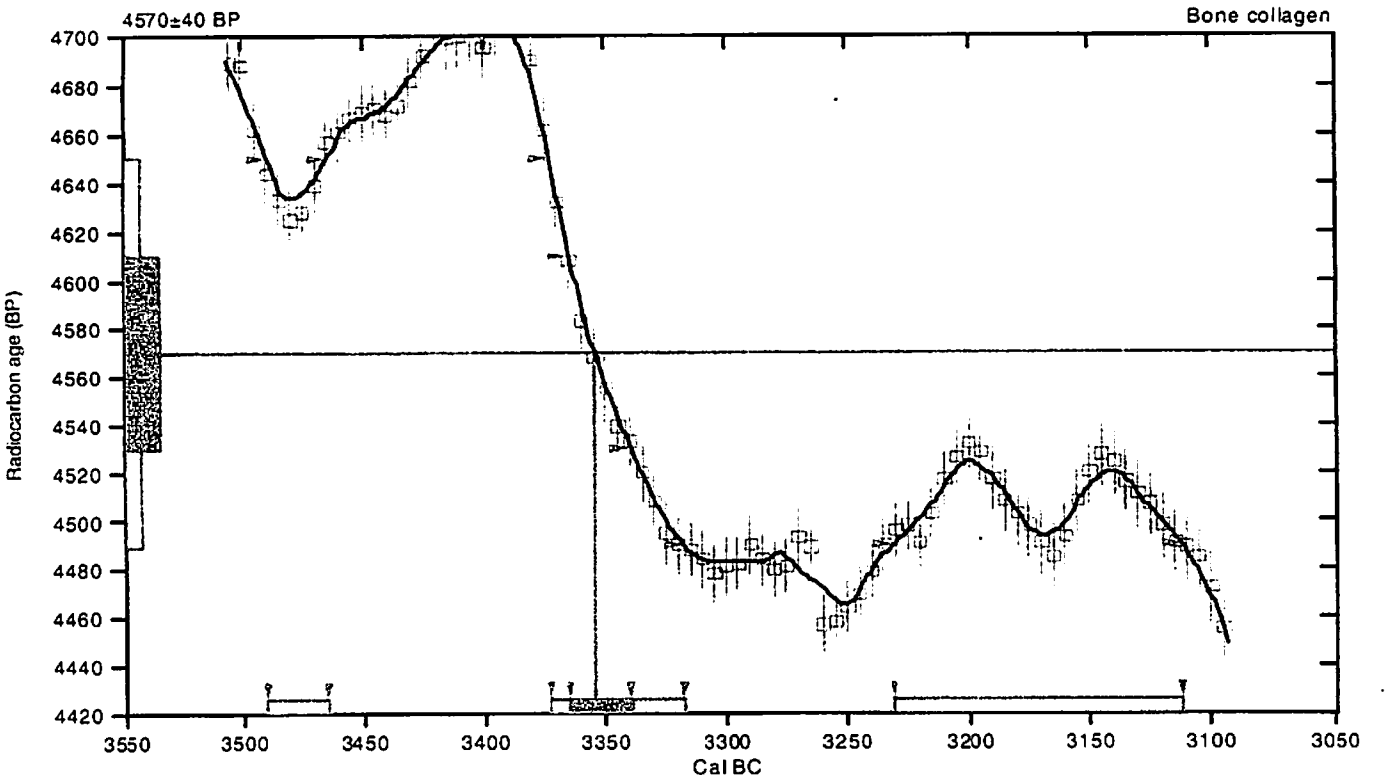
Conventional radiocarbon age: **4570±40 BP**

2 Sigma calibrated results: **Cal BC 3490 to 3460 (Cal BP 5440 to 5420) and**
(95% probability) **Cal BC 3370 to 3320 (Cal BP 5320 to 5270) and**
Cal BC 3230 to 3110 (Cal BP 5180 to 5060)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 3360 (Cal BP 5300)

1 Sigma calibrated result: Cal BC 3360 to 3340 (Cal BP 5320 to 5290)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.1:lab. mult=1)

Laboratory number: **Beta-296091**

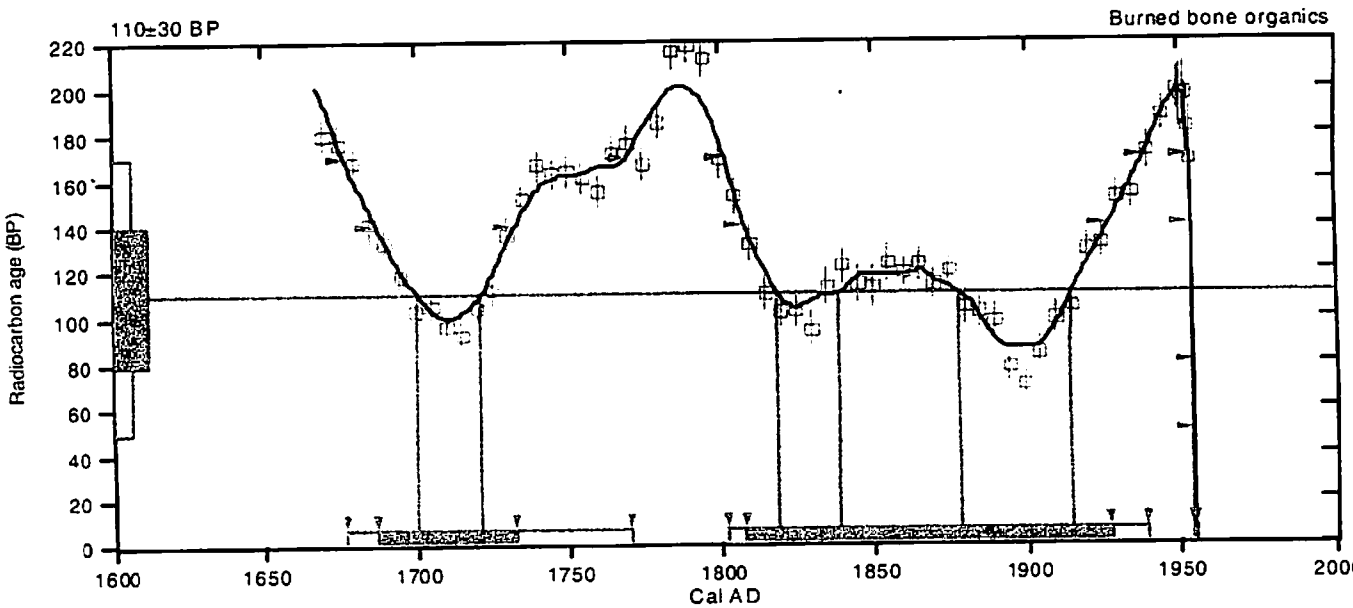
Conventional radiocarbon age: **110±30 BP**

2 Sigma calibrated results: **Cal AD 1680 to 1770 (Cal BP 270 to 180) and**
(95% probability) **Cal AD 1800 to 1940 (Cal BP 150 to 10) and**
Cal AD 1950 to 1960 (Cal BP 0 to 0)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1700 (Cal BP 250) and
Cal AD 1720 (Cal BP 230) and
Cal AD 1820 (Cal BP 130) and
Cal AD 1840 (Cal BP 110) and
Cal AD 1880 (Cal BP 70) and
Cal AD 1920 (Cal BP 40) and
Cal AD 1950 (Cal BP 0)

1 Sigma calibrated results: Cal AD 1690 to 1730 (Cal BP 260 to 220) and
(68% probability) Cal AD 1810 to 1930 (Cal BP 140 to 20) and
Cal AD 1950 to 1960 (Cal BP 0 to 0)



References:

Database used
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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24:lab. mult=1)

Laboratory number: **Beta-296092**

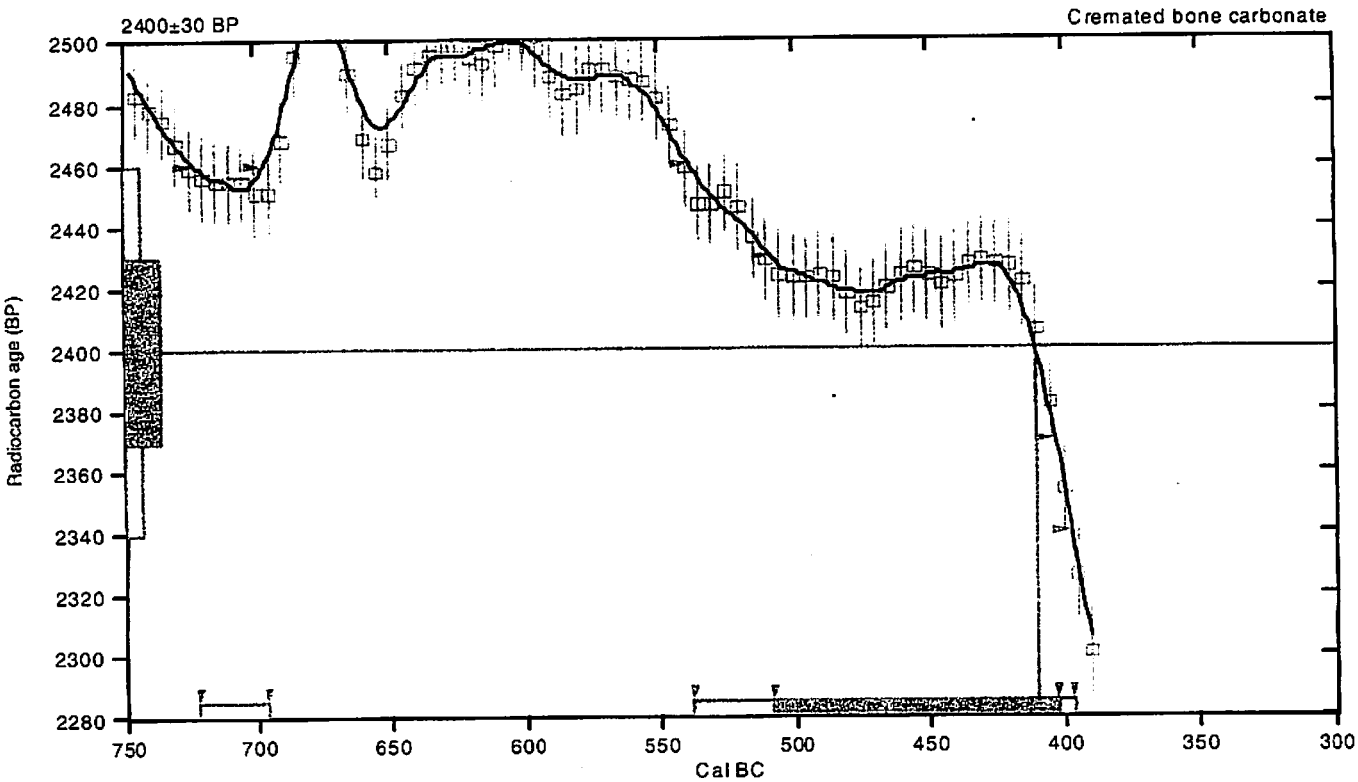
Conventional radiocarbon age: **2400±30 BP**

2 Sigma calibrated results: **Cal BC 720 to 700 (Cal BP 2670 to 2650) and**
(95% probability) **Cal BC 540 to 400 (Cal BP 2490 to 2350)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 410 (Cal BP 2360)

1 Sigma calibrated result: Cal BC 510 to 400 (Cal BP 2460 to 2350)
(68% probability)



References:

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Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.6:lab. mult=1)

Laboratory number: **Beta-296093**

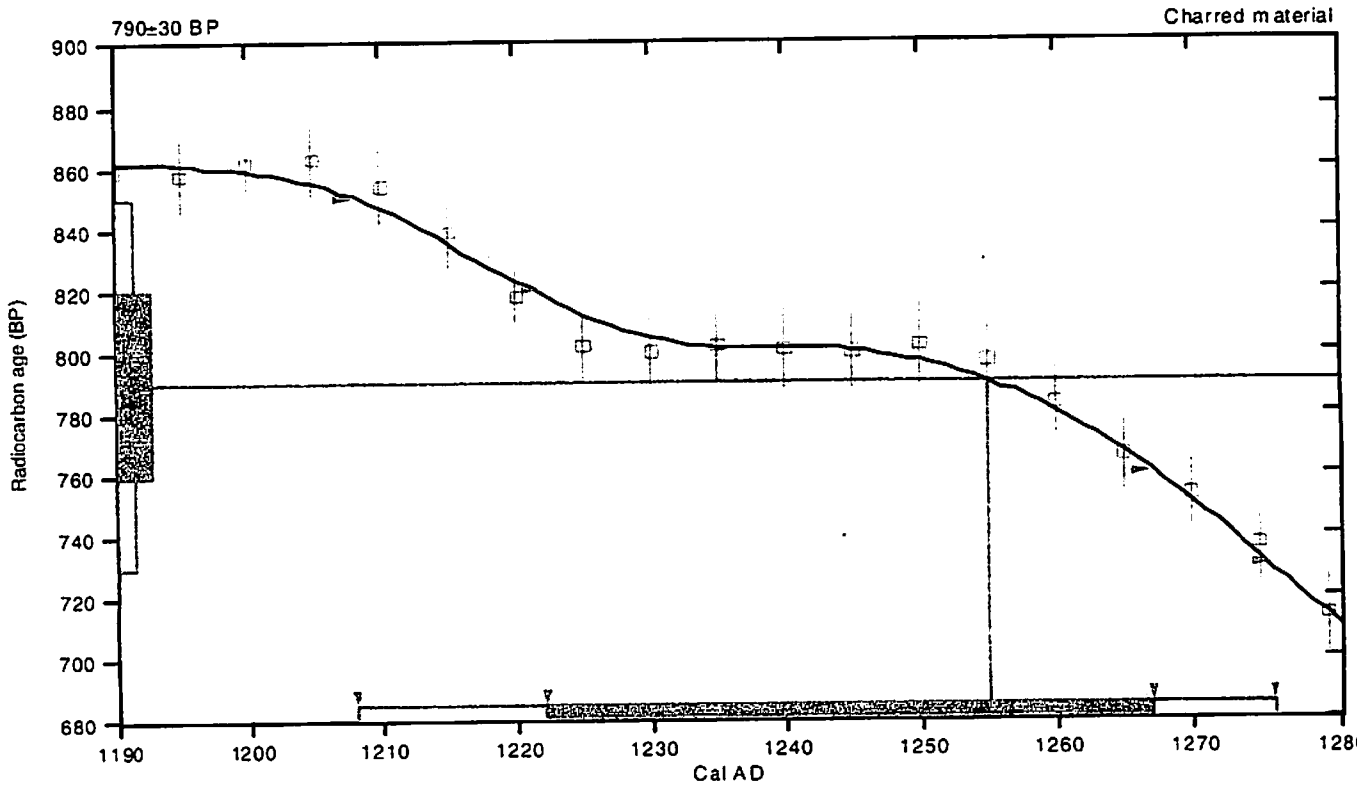
Conventional radiocarbon age: **790±30 BP**

2 Sigma calibrated result: **Cal AD 1210 to 1280 (Cal BP 740 to 670)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1260 (Cal BP 700)

1 Sigma calibrated result: Cal AD 1220 to 1270 (Cal BP 730 to 680)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.9:lab. mult=1)

Laboratory number: **Beta-296094**

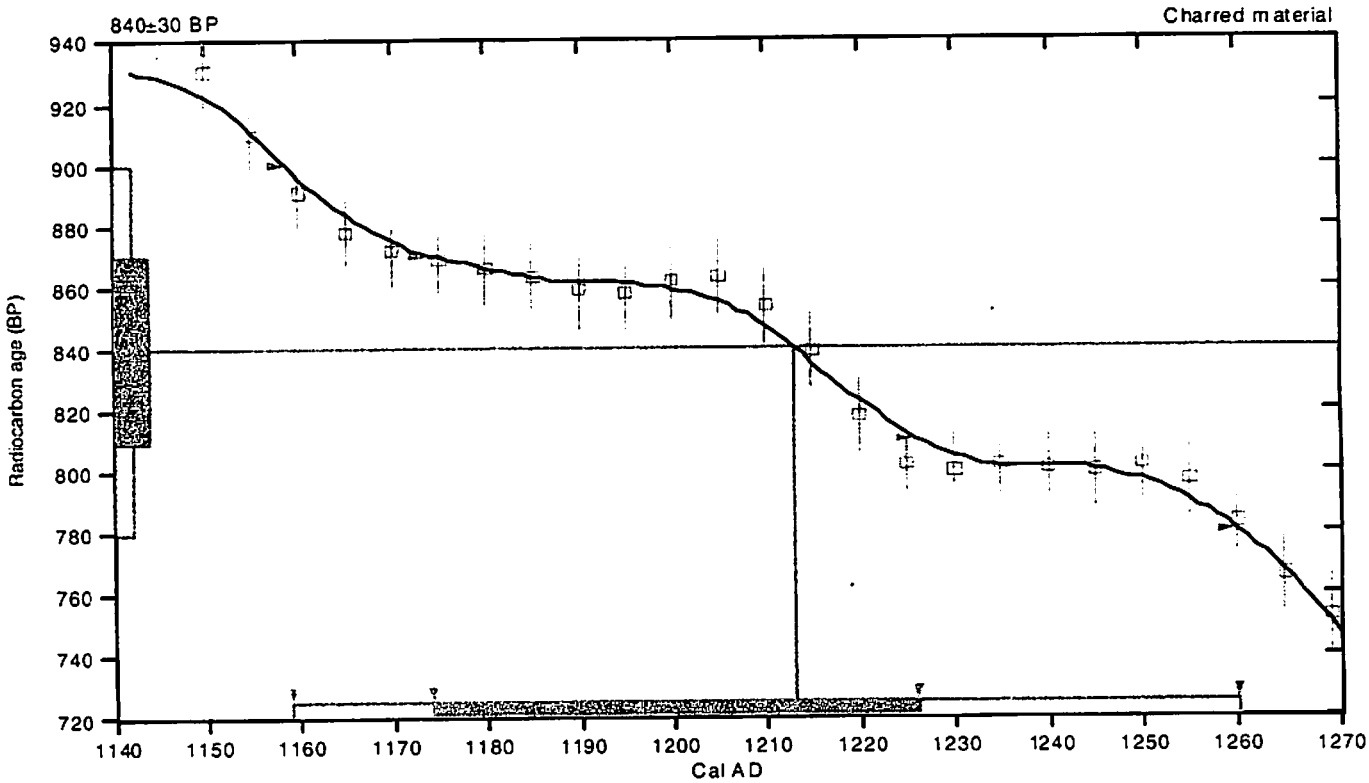
Conventional radiocarbon age: **840±30 BP**

2 Sigma calibrated result: **Cal AD 1160 to 1260 (Cal BP 790 to 690)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1210 (Cal BP 740)

1 Sigma calibrated result: Cal AD 1170 to 1230 (Cal BP 780 to 720)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.2:lab. mult=1)

Laboratory number: **Beta-296095**

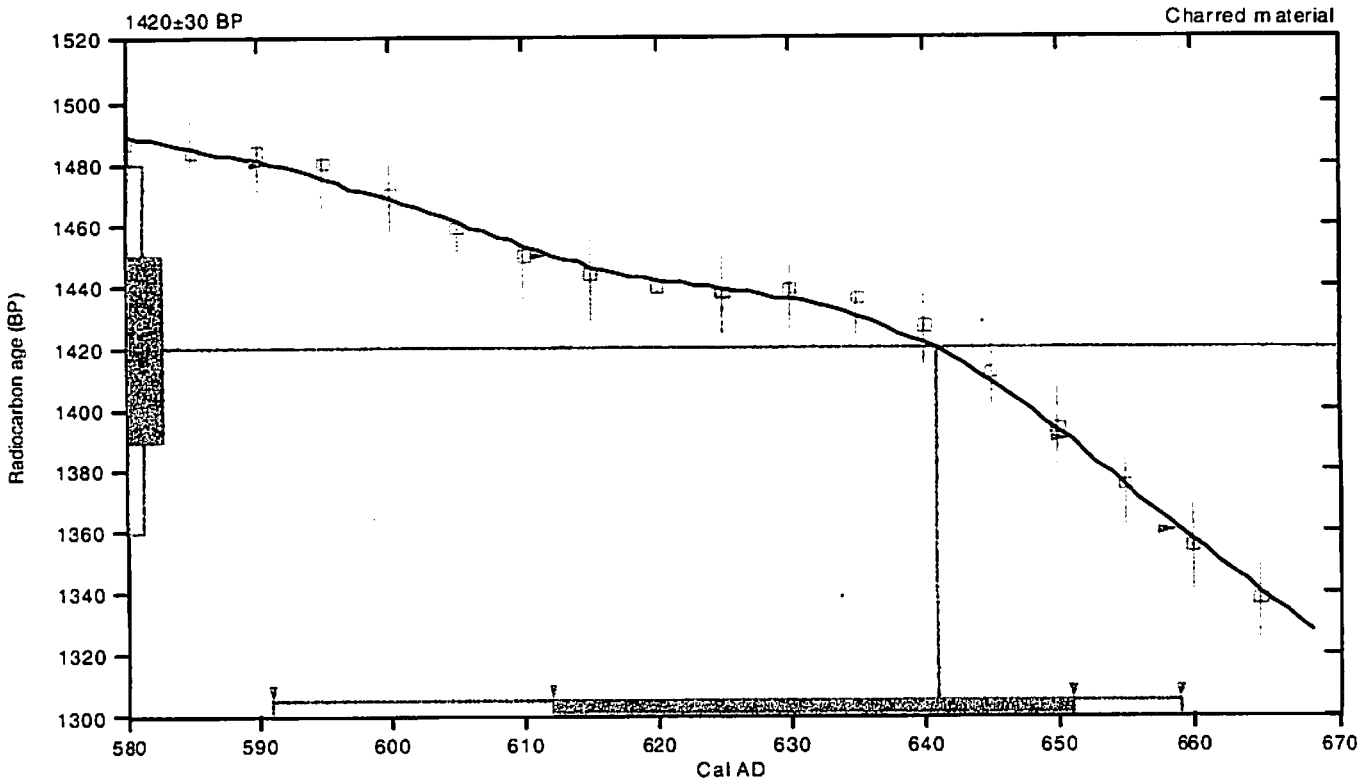
Conventional radiocarbon age: **1420±30 BP**

2 Sigma calibrated result: **Cal AD 590 to 660 (Cal BP 1360 to 1290)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 640 (Cal BP 1310)

1 Sigma calibrated result: Cal AD 610 to 650 (Cal BP 1340 to 1300)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.2:lab. mult=1)

Laboratory number: **Beta-296096**

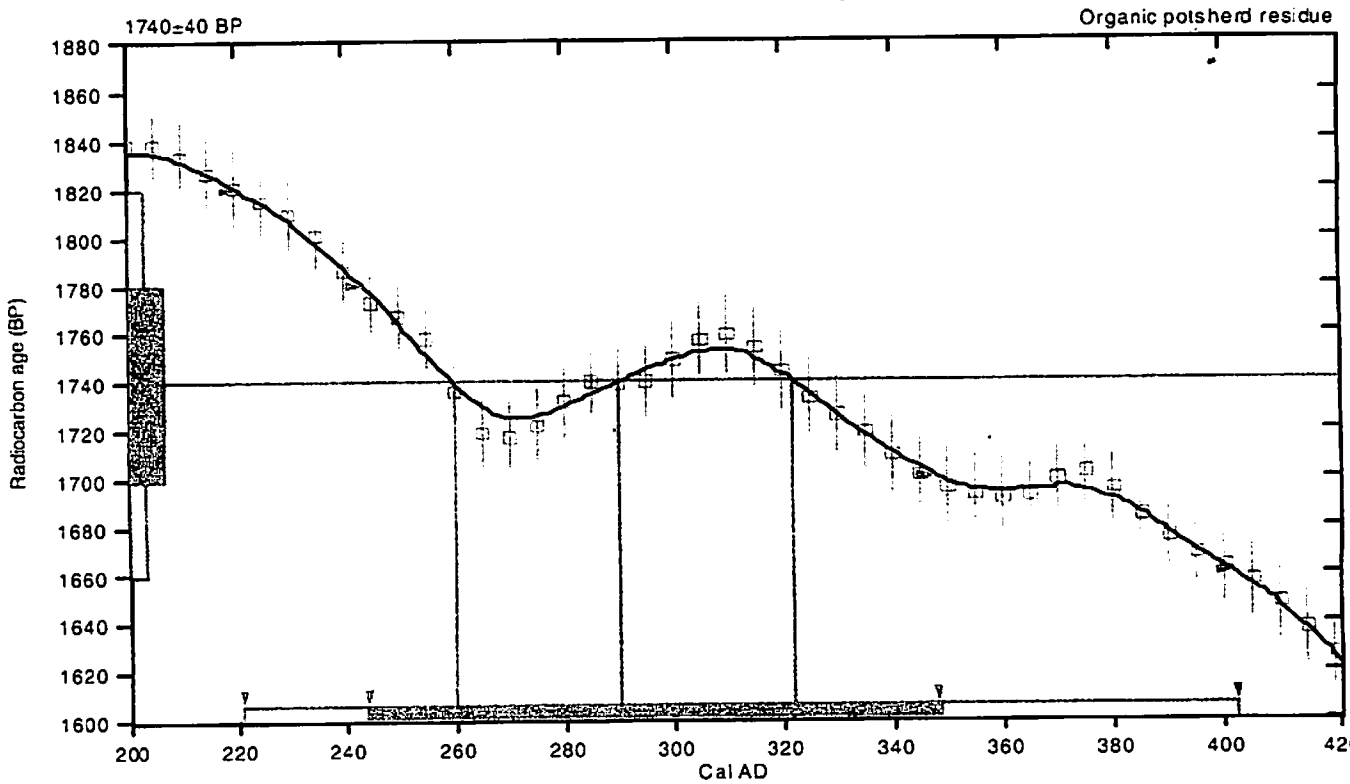
Conventional radiocarbon age: **1740±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 220 to 400 (Cal BP 1730 to 1550)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 260 (Cal BP 1690) and
Cal AD 290 (Cal BP 1660) and
Cal AD 320 (Cal BP 1630)

1 Sigma calibrated result: (68% probability) Cal AD 240 to 350 (Cal BP 1710 to 1600)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.1:lab. mult=1)

Laboratory number: **Beta-296097**

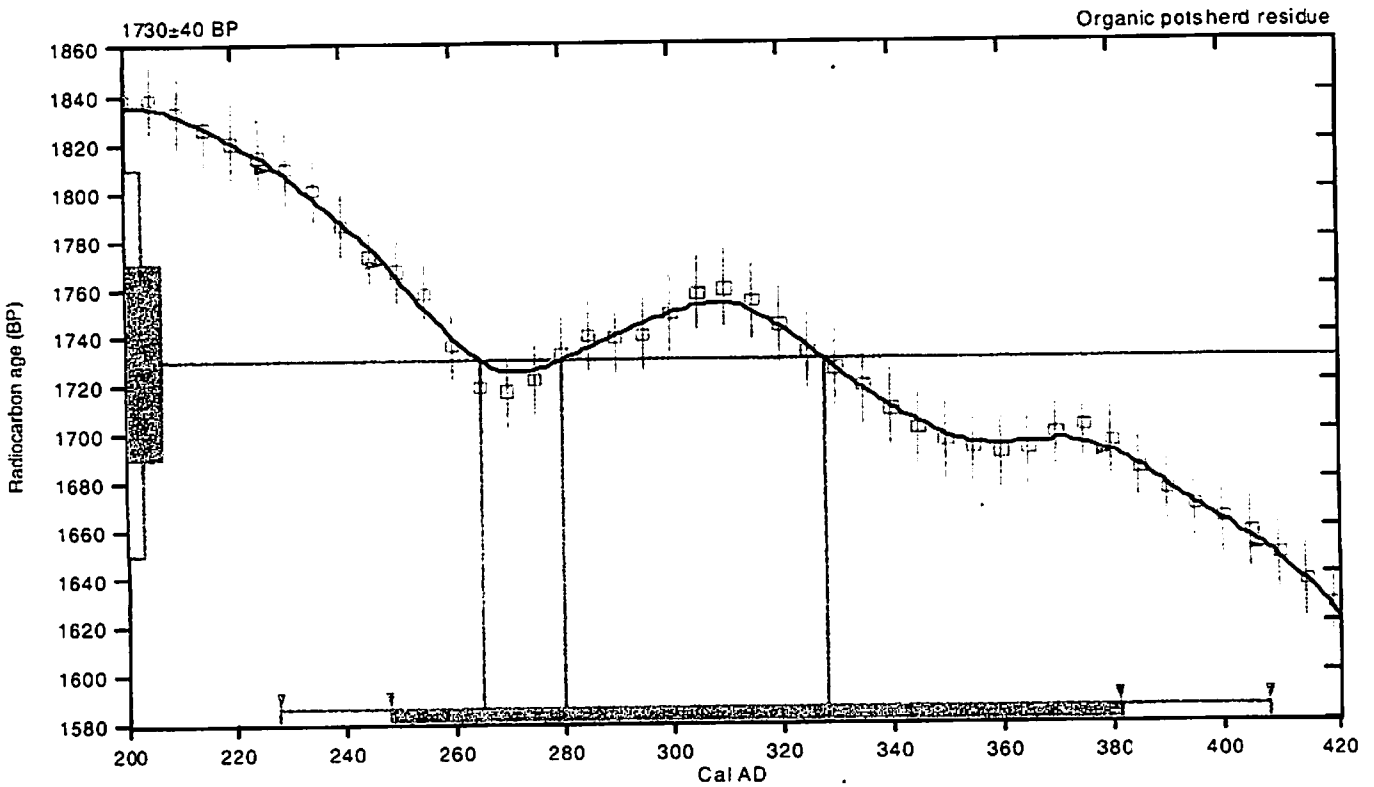
Conventional radiocarbon age: **1730±40 BP**

2 Sigma calibrated result: **Cal AD 230 to 410 (Cal BP 1720 to 1540)**
(95% probability)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 260 (Cal BP 1680) and
Cal AD 280 (Cal BP 1670) and
Cal AD 330 (Cal BP 1620)

1 Sigma calibrated result: Cal AD 250 to 380 (Cal BP 1700 to 1570)
(68% probability)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.9:lab. mult=1)

Laboratory number: **Beta-296098**

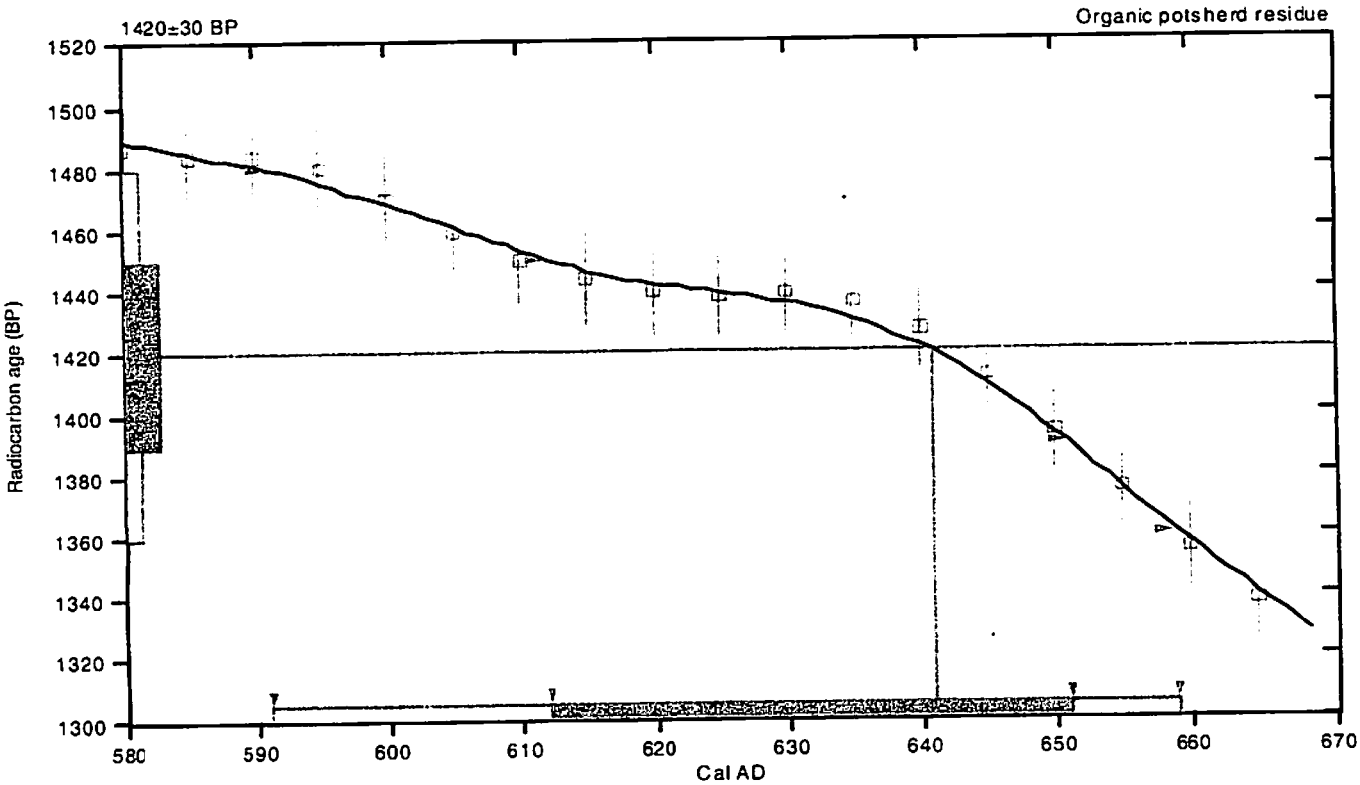
Conventional radiocarbon age: **1420±30 BP**

2 Sigma calibrated result: **Cal AD 590 to 660 (Cal BP 1360 to 1290)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 640 (Cal BP 1310)

1 Sigma calibrated result: Cal AD 610 to 650 (Cal BP 1340 to 1300)
(68% probability)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.9:lab. mult=1)

Laboratory number: **Beta-296099**

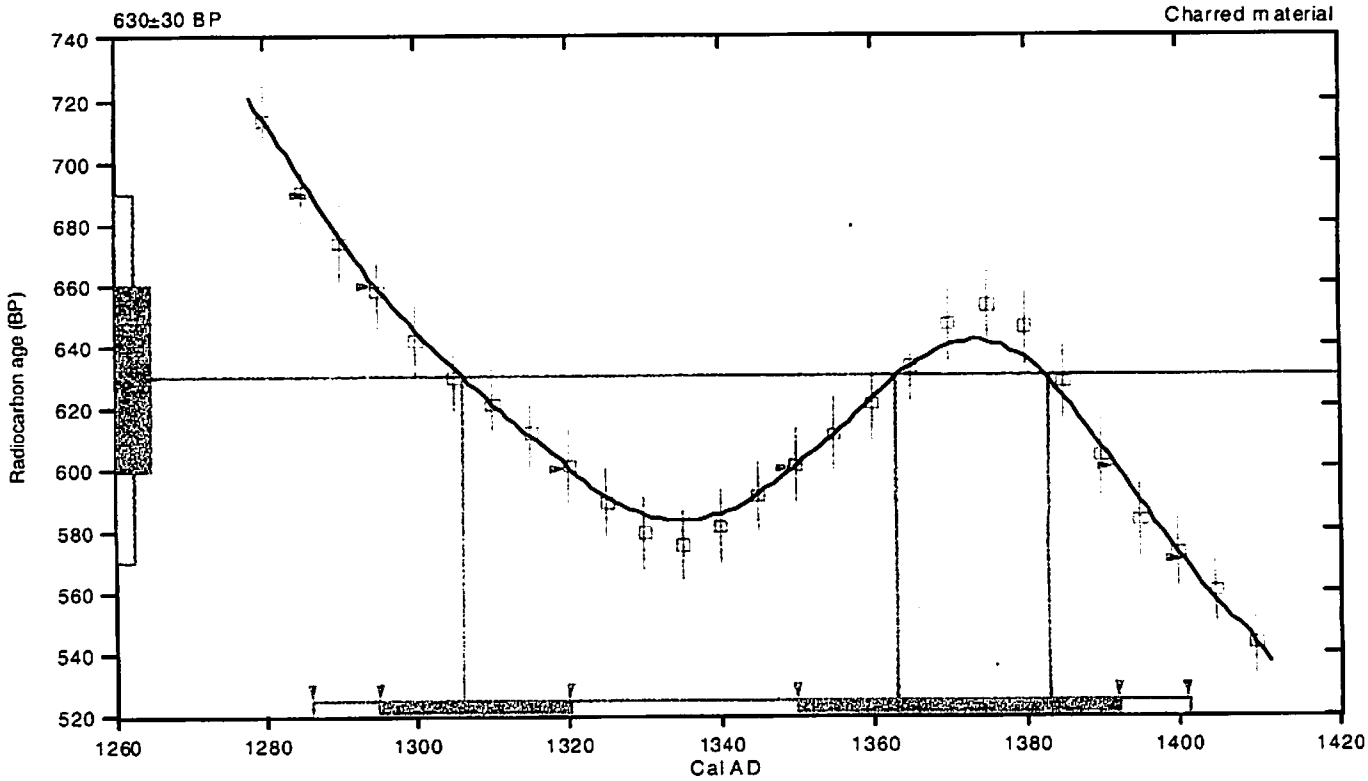
Conventional radiocarbon age: **630±30 BP**

2 Sigma calibrated result: **Cal AD 1290 to 1400 (Cal BP 660 to 550)**
(95% probability)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1310 (Cal BP 640) and
Cal AD 1360 (Cal BP 590) and
Cal AD 1380 (Cal BP 570)

1 Sigma calibrated results: Cal AD 1300 to 1320 (Cal BP 660 to 630) and
(68% probability) Cal AD 1350 to 1390 (Cal BP 600 to 560)



References:

Database used
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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.2:lab. mult=1)

Laboratory number: **Beta-296100**

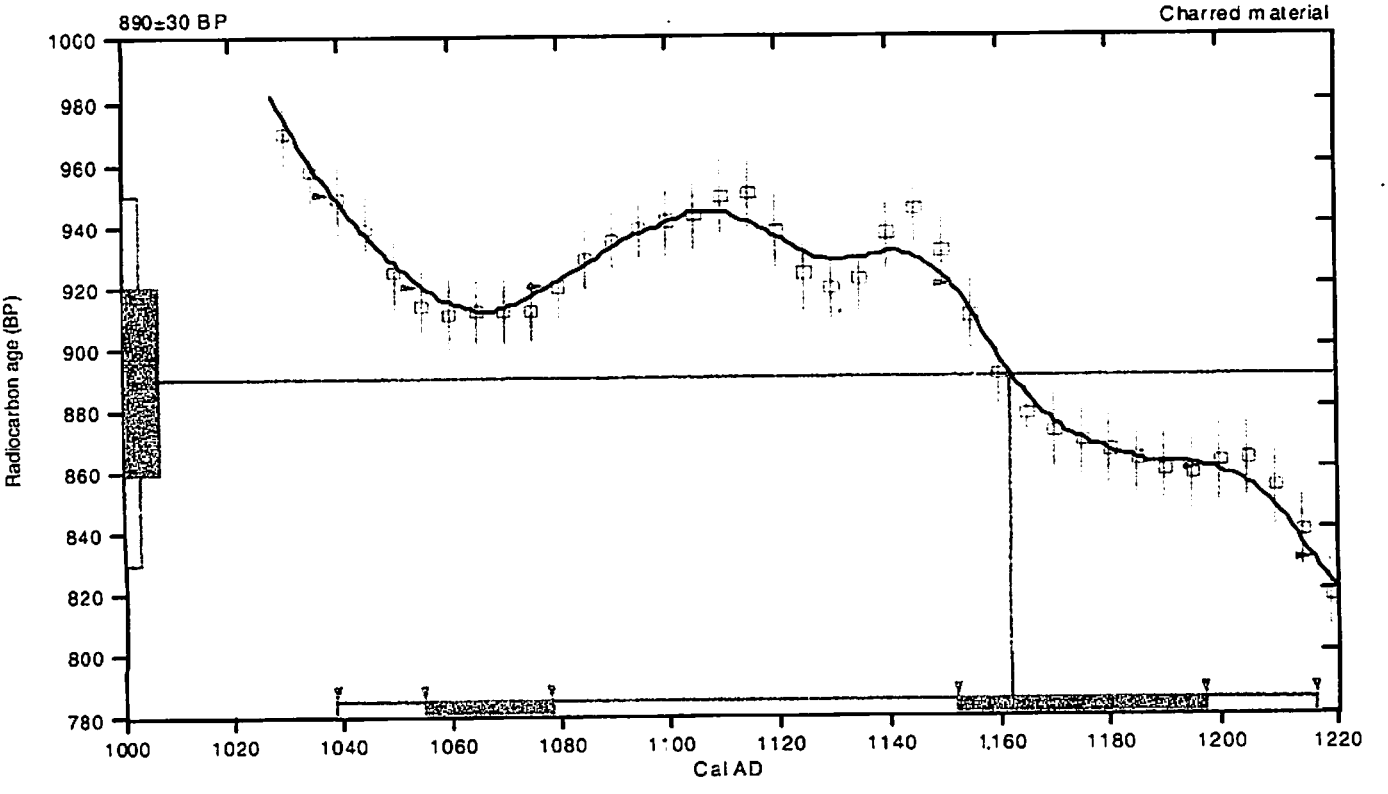
Conventional radiocarbon age: **890±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1040 to 1220 (Cal BP 910 to 730)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1160 (Cal BP 790)

1 Sigma calibrated results: (68% probability) Cal AD 1060 to 1080 (Cal BP 900 to 870) and Cal AD 1150 to 1200 (Cal BP 800 to 750)



References:

Database used

INTCAL04

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Mathematics

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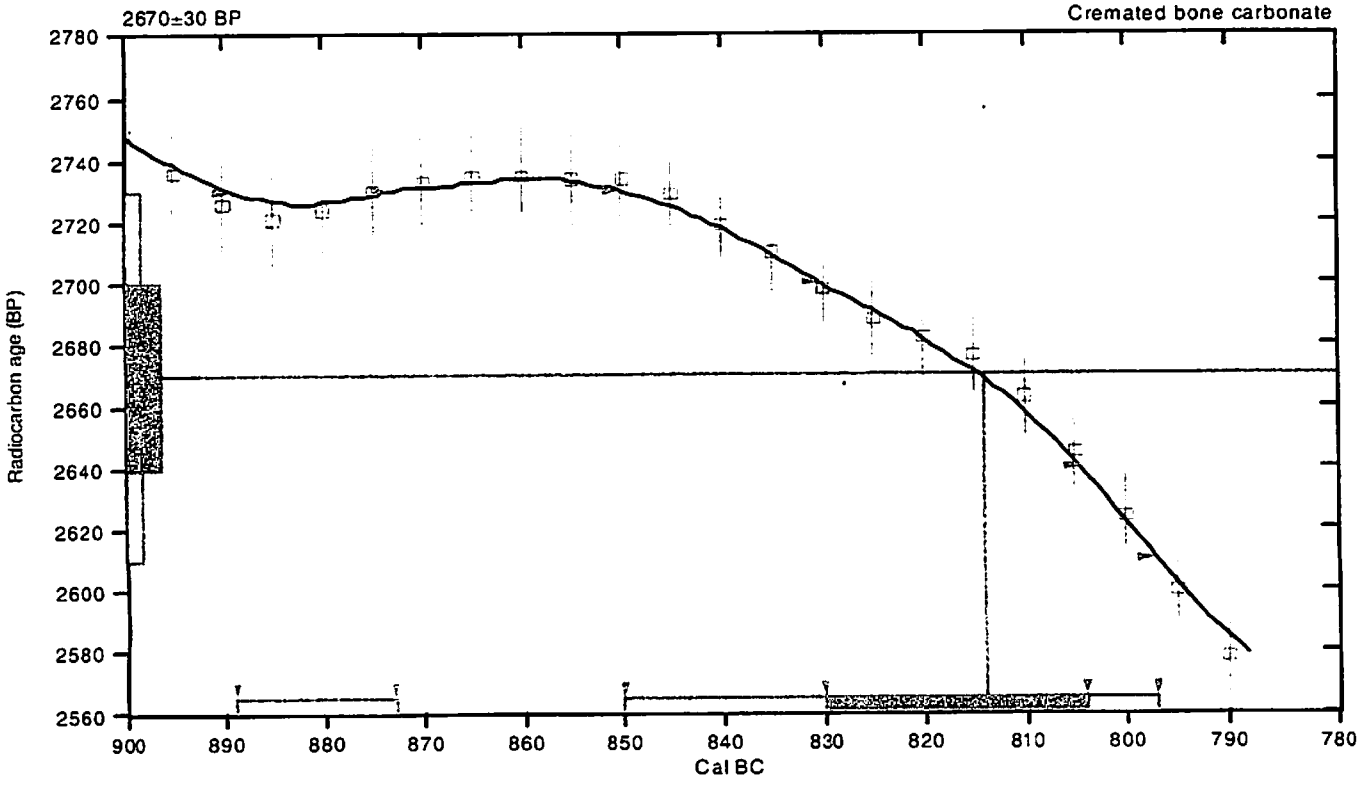
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number:	**Beta-296101**
Conventional radiocarbon age:	**2670±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 890 to 870 (Cal BP 2840 to 2820) and Cal BC 850 to 800 (Cal BP 2800 to 2750)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 810 (Cal BP 2760)
1 Sigma calibrated result: (68% probability)	Cal BC 830 to 800 (Cal BP 2780 to 2750)



References:

Database used

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Mathematics

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.8:lab. mult=1)

Laboratory number: **Beta-296103**

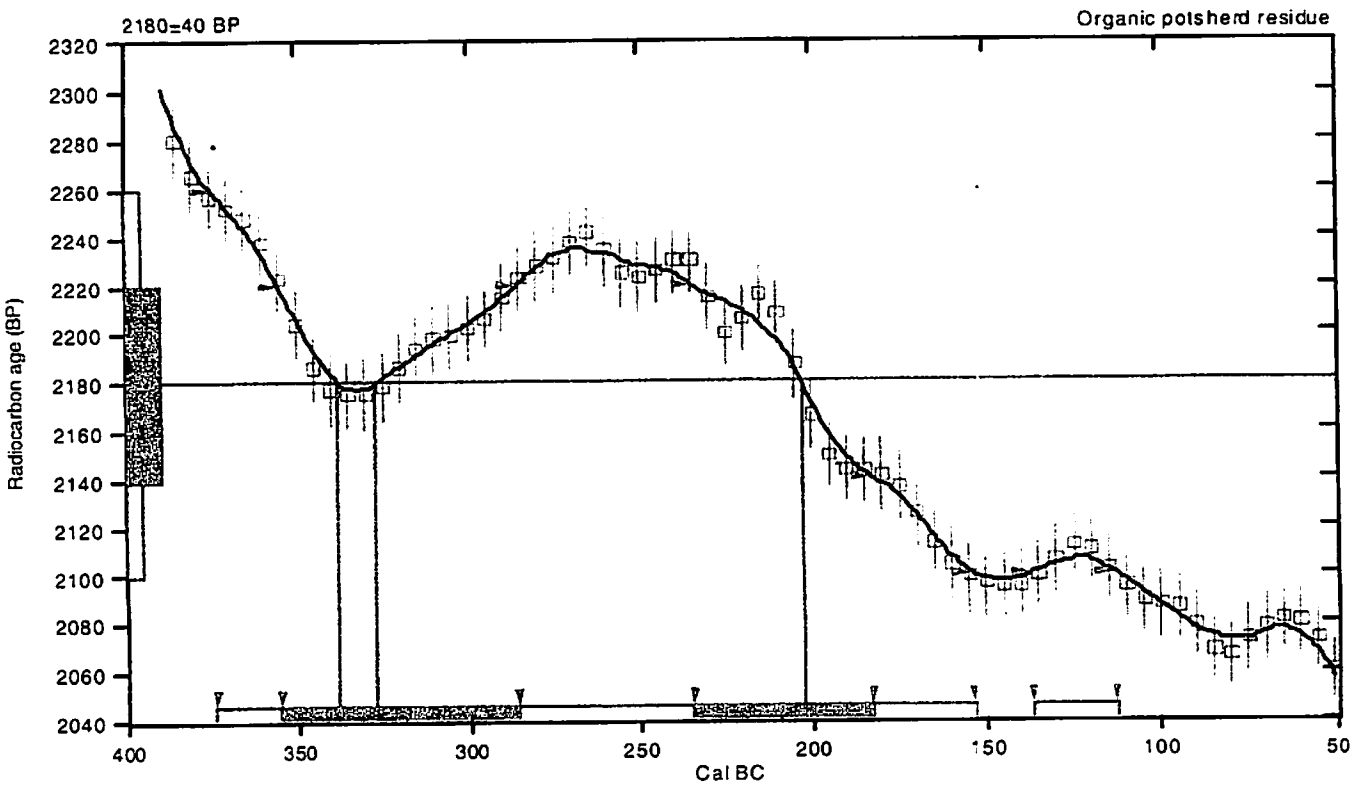
Conventional radiocarbon age: **2180±40 BP**

2 Sigma calibrated results: **Cal BC 370 to 150 (Cal BP 2320 to 2100) and**
(95% probability) **Cal BC 140 to 110 (Cal BP 2090 to 2060)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 340 (Cal BP 2290) and
Cal BC 330 (Cal BP 2280) and
Cal BC 200 (Cal BP 2150)

1 Sigma calibrated results: Cal BC 360 to 290 (Cal BP 2300 to 2240) and
(68% probability) Cal BC 240 to 180 (Cal BP 2180 to 2130)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number: **Beta-296104**

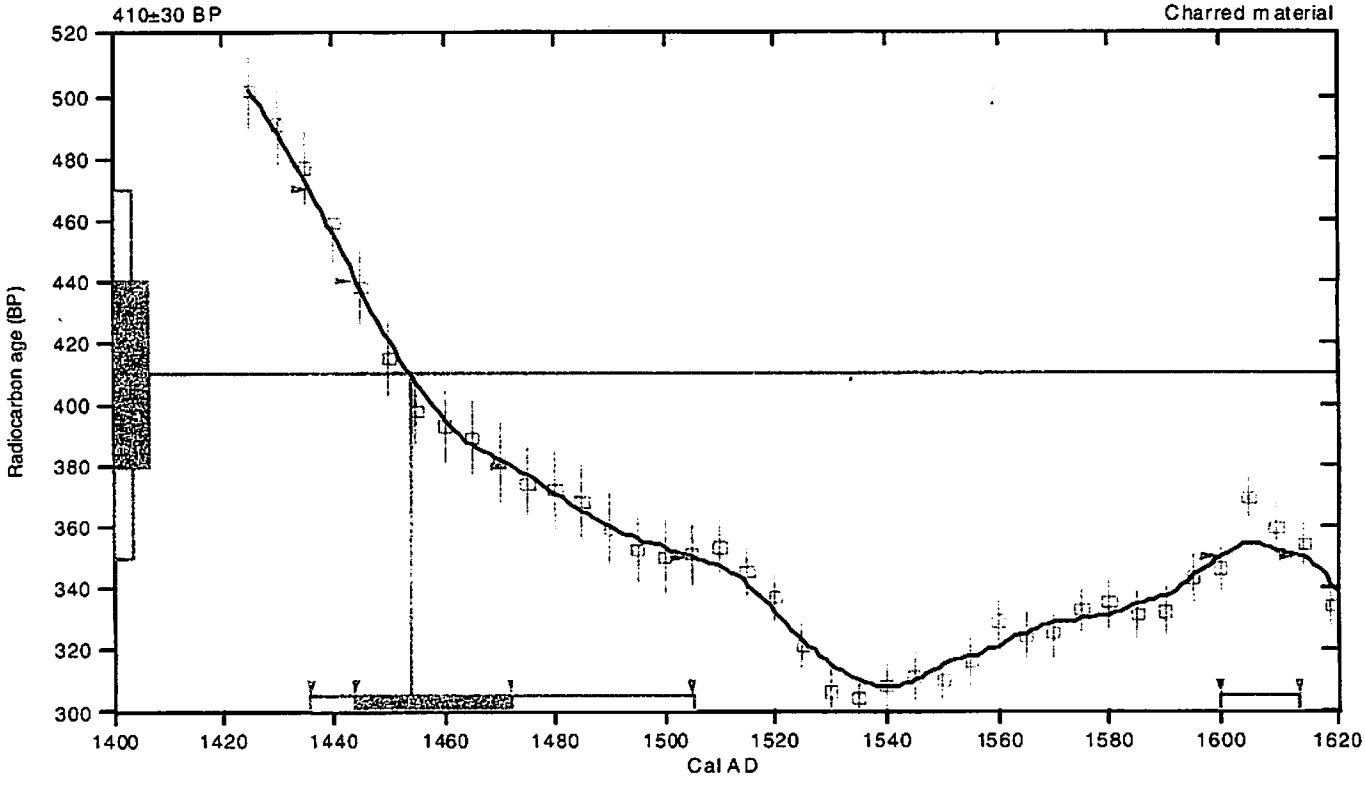
Conventional radiocarbon age: **410±30 BP**

2 Sigma calibrated results: **Cal AD 1440 to 1500 (Cal BP 510 to 440) and**
(95% probability) **Cal AD 1600 to 1610 (Cal BP 350 to 340)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1450 (Cal BP 500)

1 Sigma calibrated result: Cal AD 1440 to 1470 (Cal BP 510 to 480)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.1:lab. mult=1)

Laboratory number: **Beta-297529**

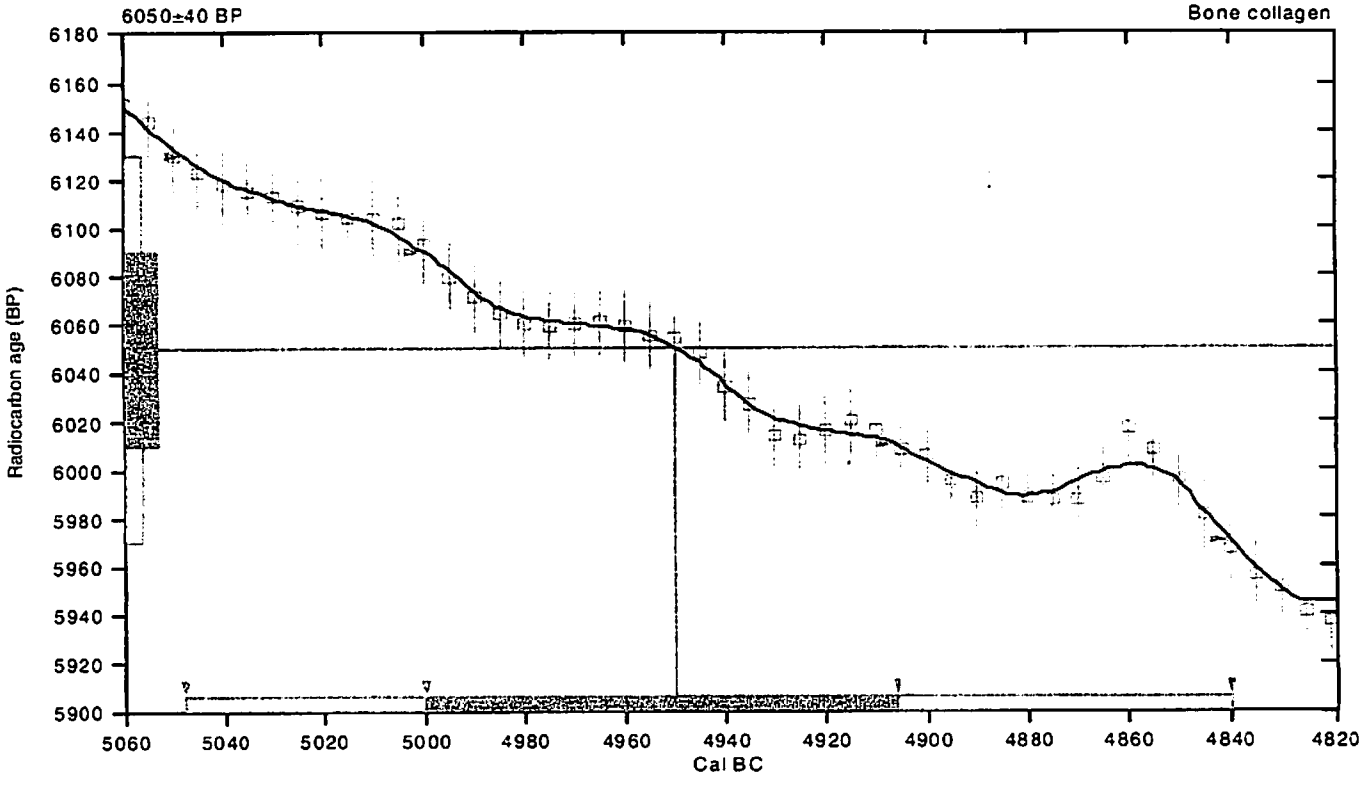
Conventional radiocarbon age: **6050±40 BP**

2 Sigma calibrated result: **Cal BC 5050 to 4840 (Cal BP 7000 to 6790)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 4950 (Cal BP 6900)

1 Sigma calibrated result: Cal BC 5000 to 4910 (Cal BP 6950 to 6860)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.1:lab. mult=1)

Laboratory number: **Beta-297530**

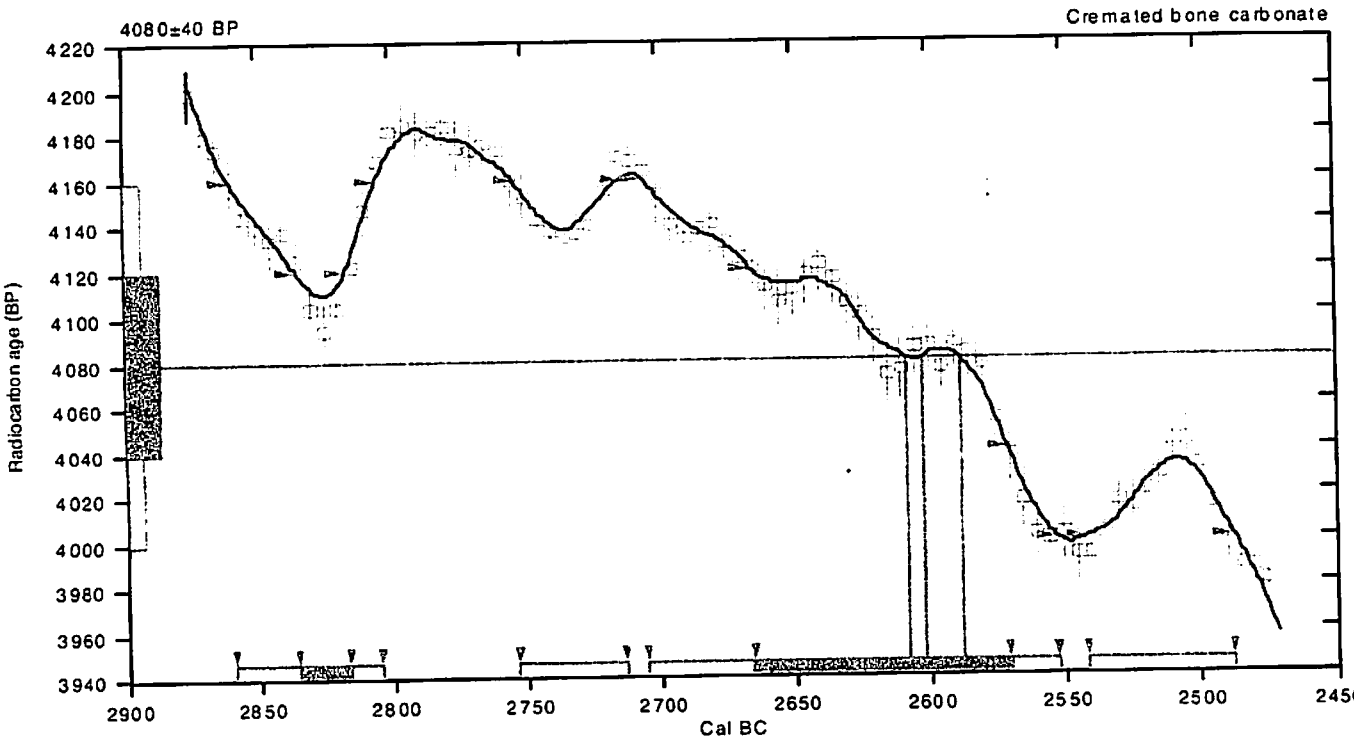
Conventional radiocarbon age: **4080±40 BP**

2 Sigma calibrated results: (95% probability)
Cal BC 2860 to 2800 (Cal BP 4810 to 4760) and
Cal BC 2750 to 2710 (Cal BP 4700 to 4660) and
Cal BC 2710 to 2550 (Cal BP 4660 to 4500) and
Cal BC 2540 to 2490 (Cal BP 4490 to 4440)

Intercept data

Intercepts of radiocarbon age with calibration curve:
Cal BC 2610 (Cal BP 4560) and
Cal BC 2600 (Cal BP 4550) and
Cal BC 2590 (Cal BP 4540)

1 Sigma calibrated results: (68% probability)
Cal BC 2840 to 2820 (Cal BP 4790 to 4770) and
Cal BC 2670 to 2570 (Cal BP 4620 to 4520)



References:

Database used
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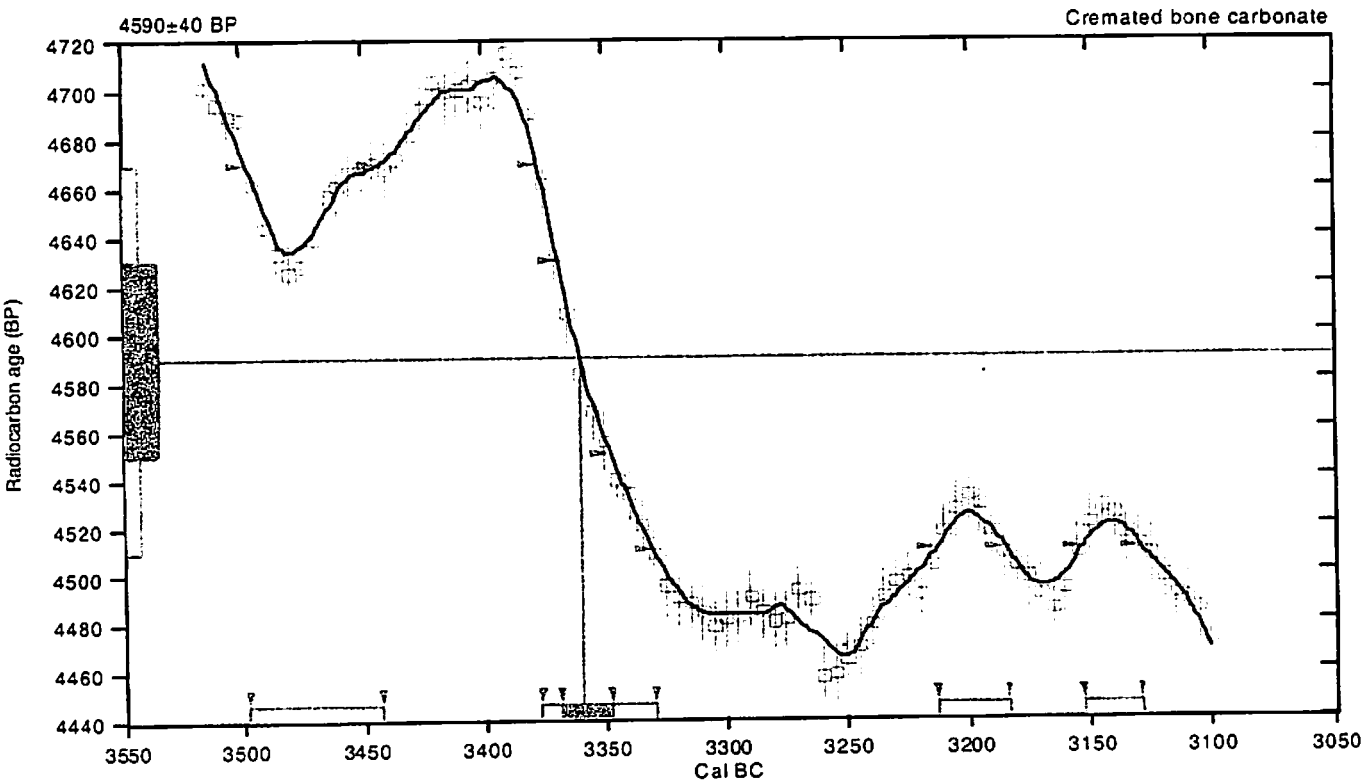
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.6:lab. mult=1)

Laboratory number:	**Beta-297531**
Conventional radiocarbon age:	**4590±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 3500 to 3440 (Cal BP 5450 to 5390) and Cal BC 3380 to 3330 (Cal BP 5330 to 5280) and Cal BC 3210 to 3180 (Cal BP 5160 to 5130) and Cal BC 3150 to 3130 (Cal BP 5100 to 5080)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 3360 (Cal BP 5310)
1 Sigma calibrated result: (68% probability)	Cal BC 3370 to 3350 (Cal BP 5320 to 5300)



References:

Database used

INTCAL04

Calibration Database

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Mathematics

A Simplified Approach to Calibrating C14 Dates

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-30.4:lab. mult=1)

Laboratory number: **Beta-298247**

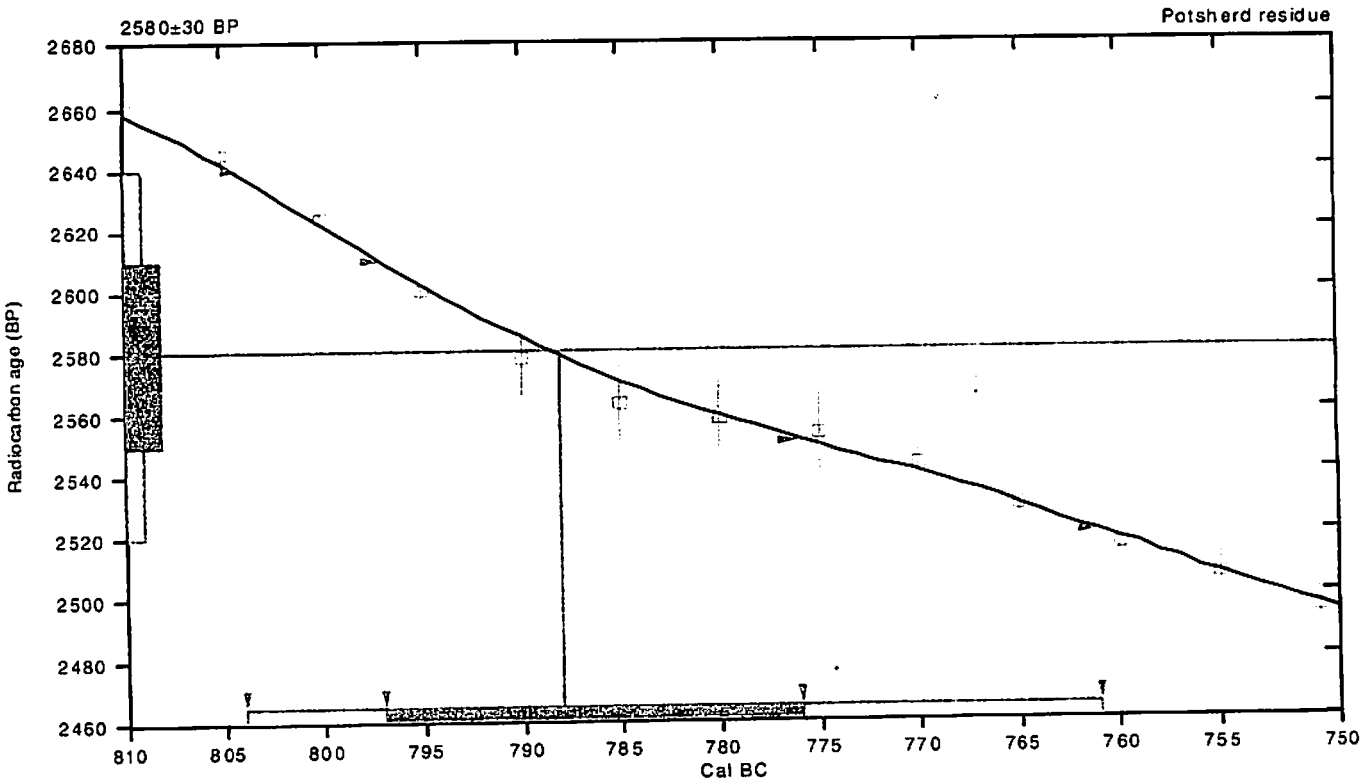
Conventional radiocarbon age: **2580±30 BP**

2 Sigma calibrated result: **Cal BC 800 to 760 (Cal BP 2750 to 2710)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 790 (Cal BP 2740)

1 Sigma calibrated result: Cal BC 800 to 780 (Cal BP 2750 to 2730)
(68% probability)



References:

Database used
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Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-32:lab. mult=1)

Laboratory number: **Beta-298248**

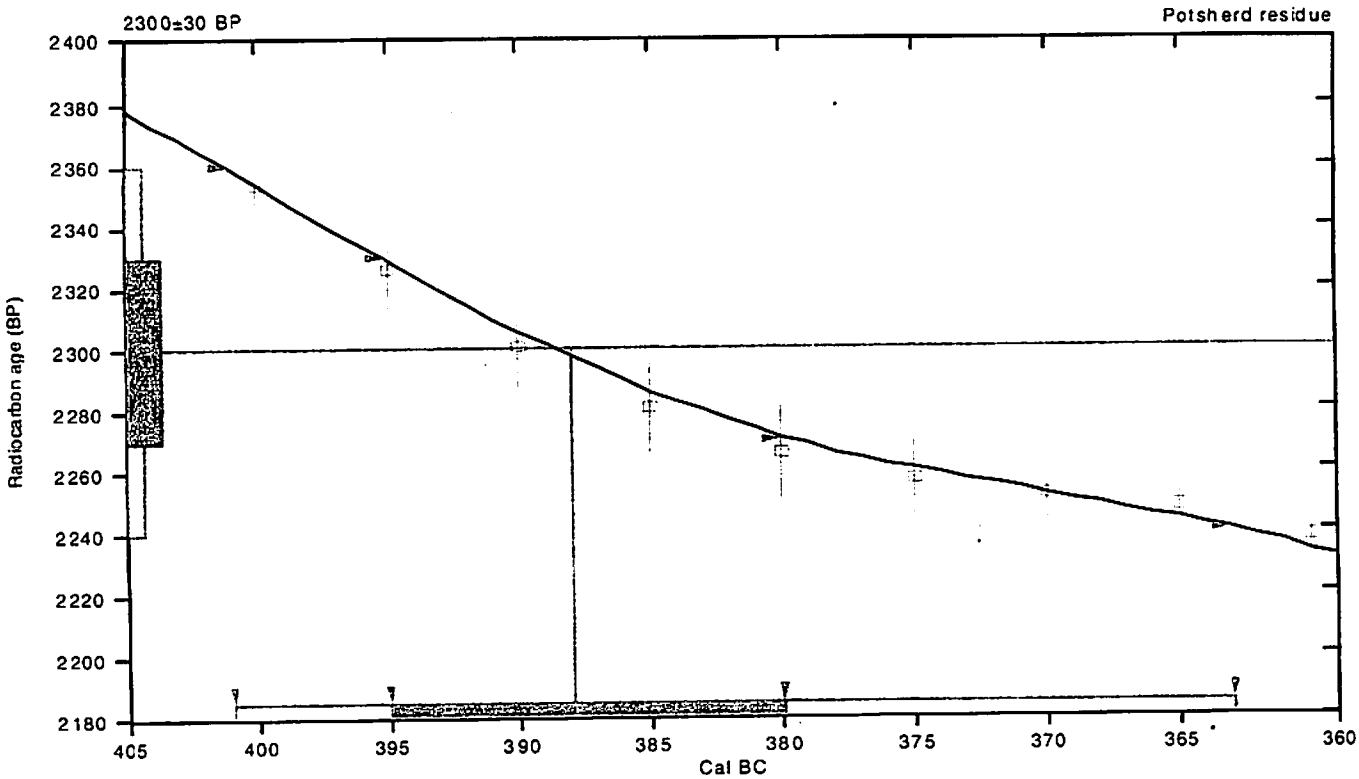
Conventional radiocarbon age: **2300±30 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 400 to 360 (Cal BP 2350 to 2310)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 390 (Cal BP 2340)

1 Sigma calibrated result: (68% probability) Cal BC 400 to 380 (Cal BP 2340 to 2330)



References:

Database used

INTCAL04

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Mathematics

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-29.2:lab. mult=1)

Laboratory number: **Beta-298249**

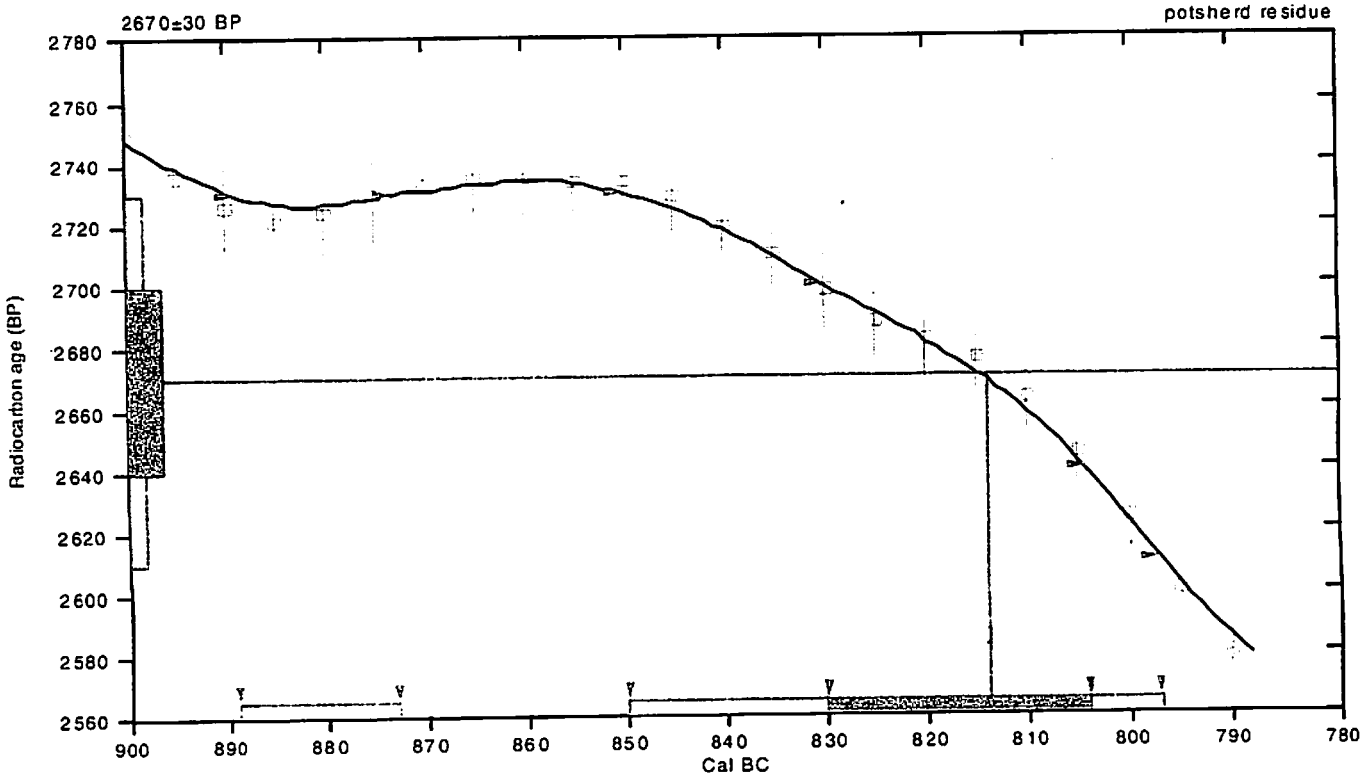
Conventional radiocarbon age: **2670±30 BP**

2 Sigma calibrated results: **Cal BC 890 to 870 (Cal BP 2840 to 2820) and**
(95% probability) **Cal BC 850 to 800 (Cal BP 2800 to 2750)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 810 (Cal BP 2760)

1 Sigma calibrated result: Cal BC 830 to 800 (Cal BP 2780 to 2750)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-31.6:lab. mult=1)

Laboratory number: **Beta-298250**

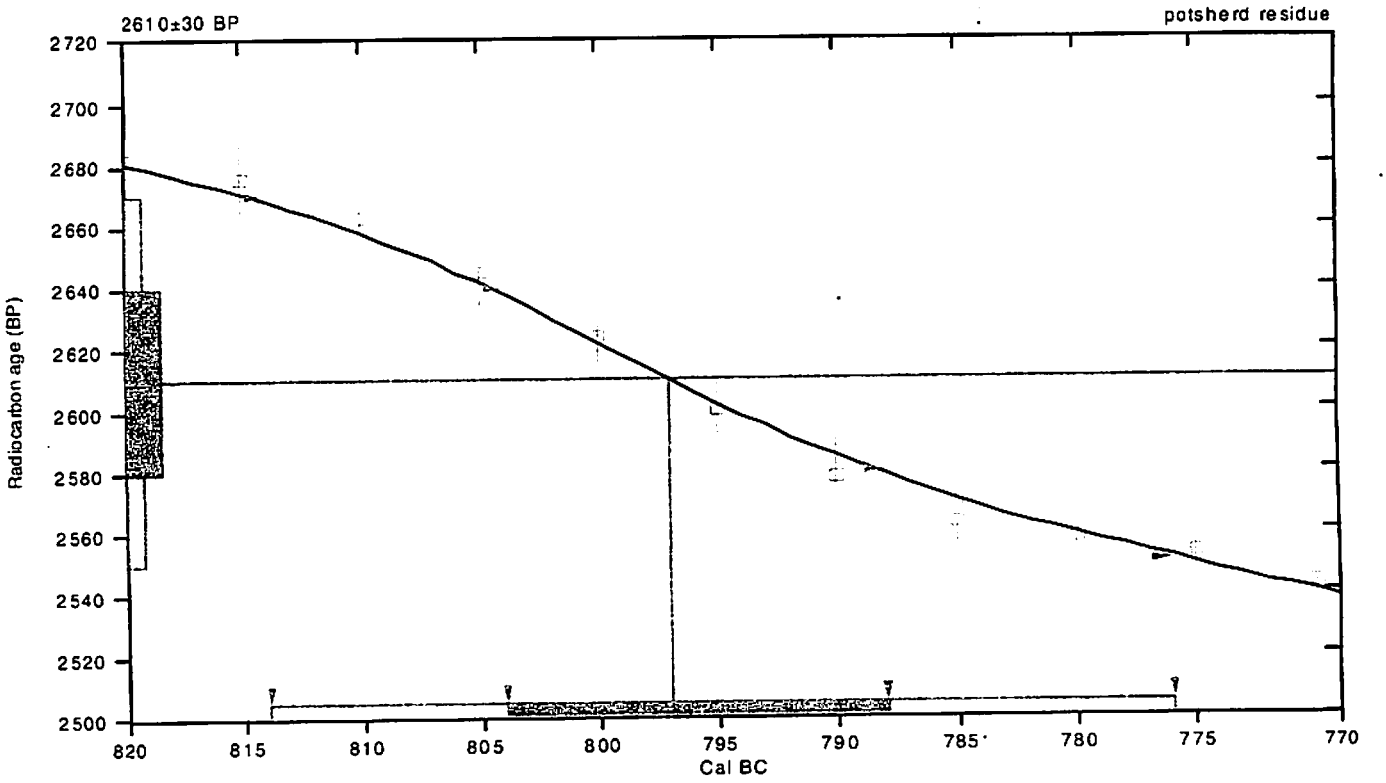
Conventional radiocarbon age: **2610±30 BP**

2 Sigma calibrated result: **Cal BC 810 to 780 (Cal BP 2760 to 2730)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 800 (Cal BP 2750)

1 Sigma calibrated result: Cal BC 800 to 790 (Cal BP 2750 to 2740)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number: **Beta-298251**

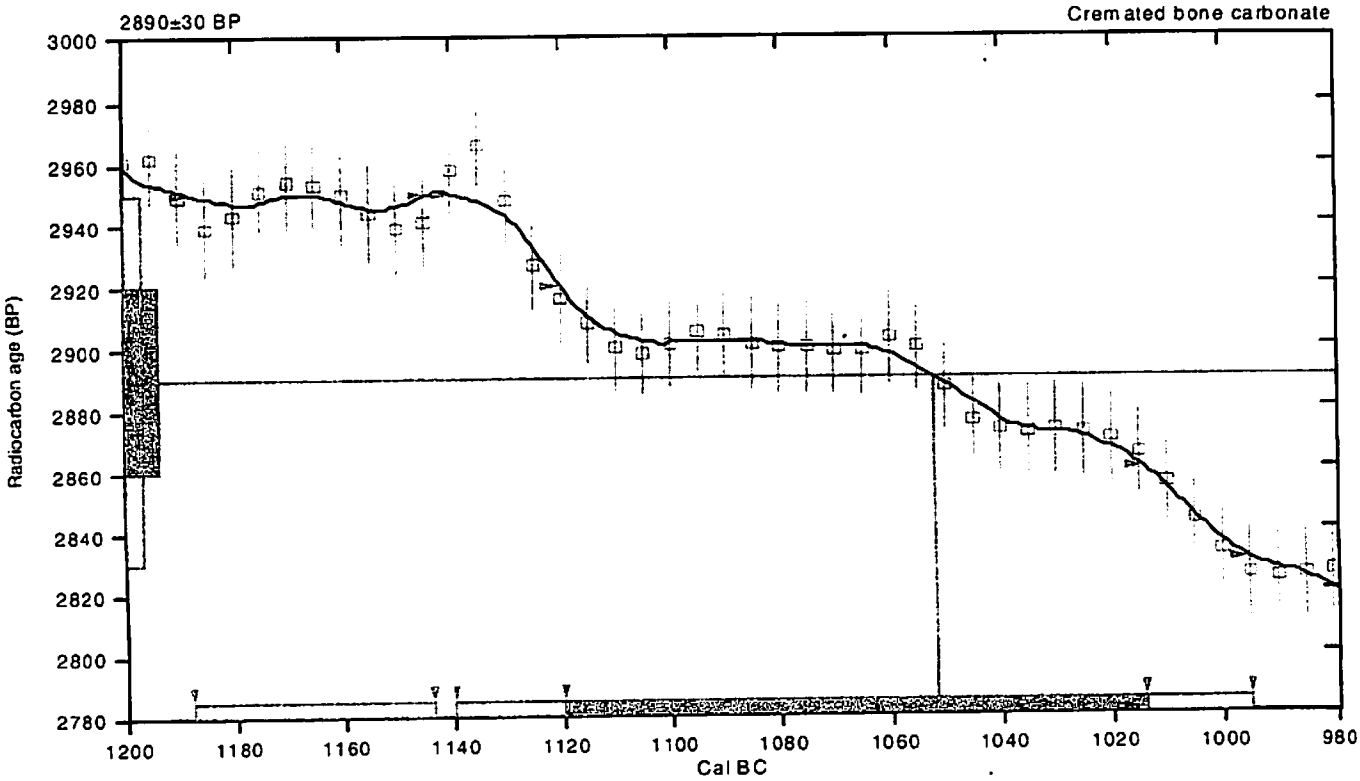
Conventional radiocarbon age: **2890±30 BP**

2 Sigma calibrated results: **Cal BC 1190 to 1140 (Cal BP 3140 to 3090) and**
(95% probability) **Cal BC 1140 to 1000 (Cal BP 3090 to 2940)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 1050 (Cal BP 3000)

1 Sigma calibrated result: (68% probability) Cal BC 1120 to 1010 (Cal BP 3070 to 2960)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.9:lab. mult=1)

Laboratory number: **Beta-298252**

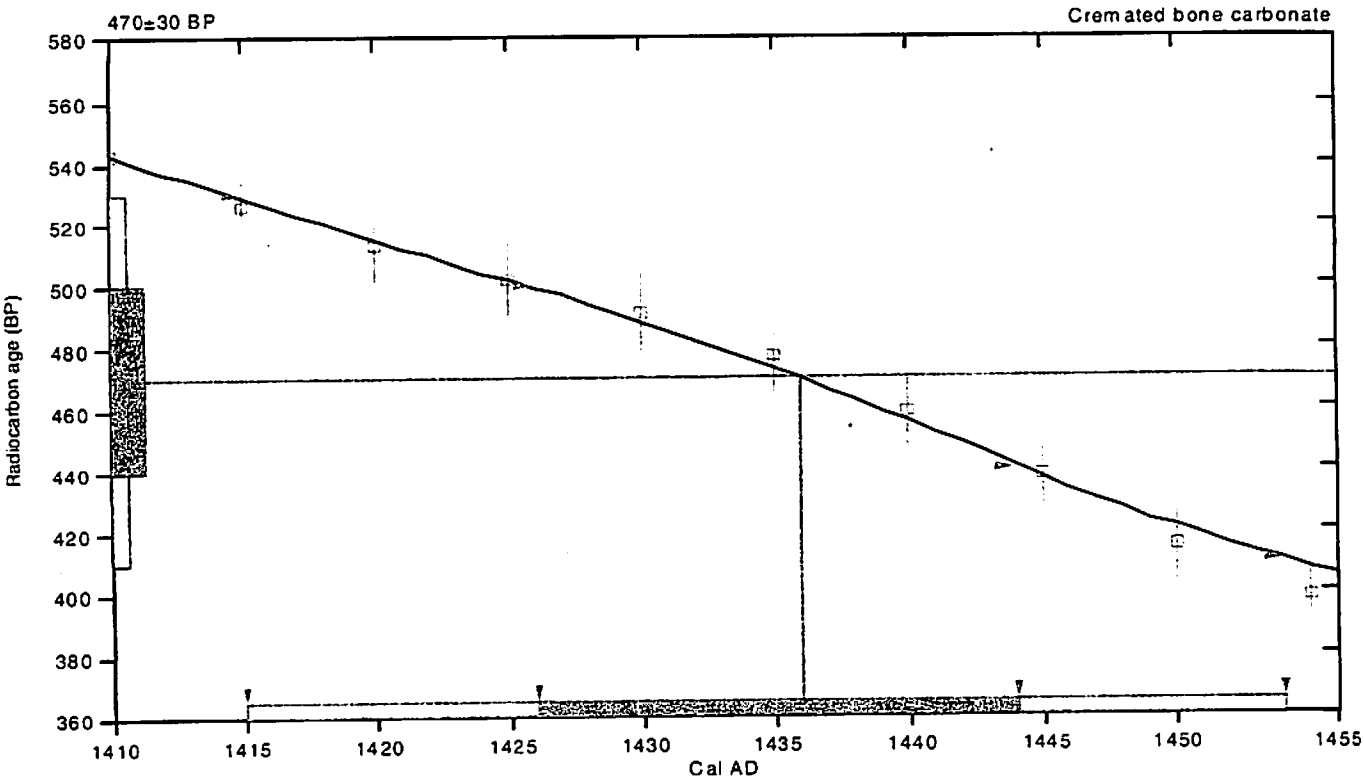
Conventional radiocarbon age: **470±30 BP**

2 Sigma calibrated result: **Cal AD 1420 to 1450 (Cal BP 540 to 500)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1440 (Cal BP 510)

1 Sigma calibrated result: Cal AD 1430 to 1440 (Cal BP 520 to 510)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.6:lab. mult=1)

Laboratory number: **Beta-298253**

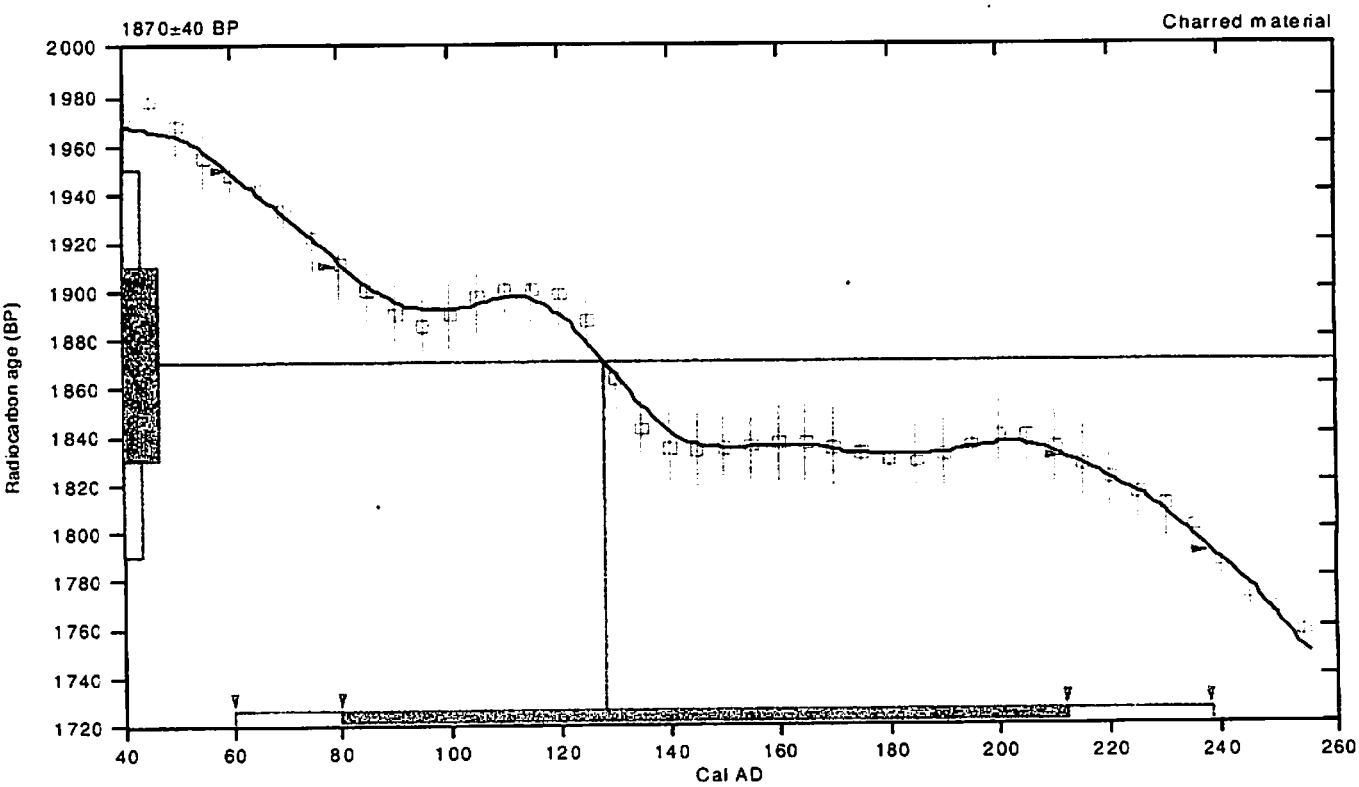
Conventional radiocarbon age: **1870±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 60 to 240 (Cal BP 1890 to 1710)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 130 (Cal BP 1820)

1 Sigma calibrated result: (68% probability) Cal AD 80 to 210 (Cal BP 1870 to 1740)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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FIGURE 1. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGBT-2
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 1630 ± 16 RCYBP
1-sigma Calibrated Age Range (68.2%): 1555-1520 CAL yr. BP
2-sigma Calibrated Age Range (95.4%): 1570-1480; 1470-1410 CAL yr. BP
$\delta^{13}C$ (‰): -21.3 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

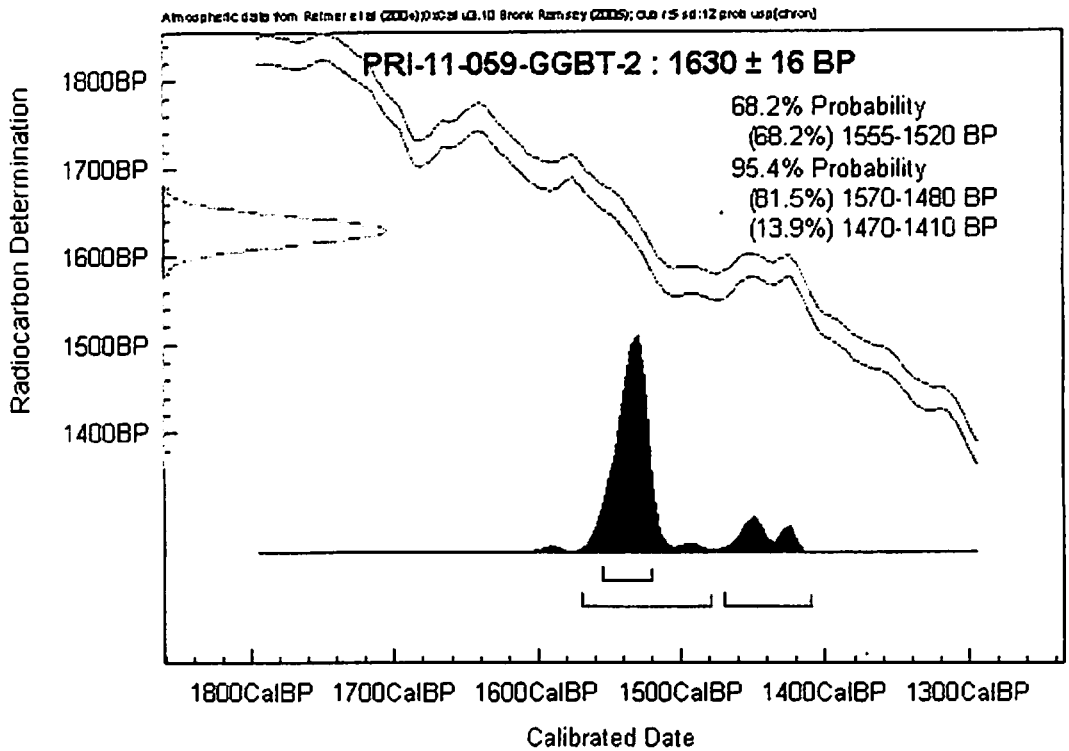

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FIGURE 2. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGBT-2
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 1630 ± 16 RCYBP
1-sigma Calibrated Age Range (68.2%): AD 395-430
2-sigma Calibrated Age Range (95.4%): AD 380-470; 480-540
$\delta^{13}C$ ($^{o}/_{oo}$): -21.3 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

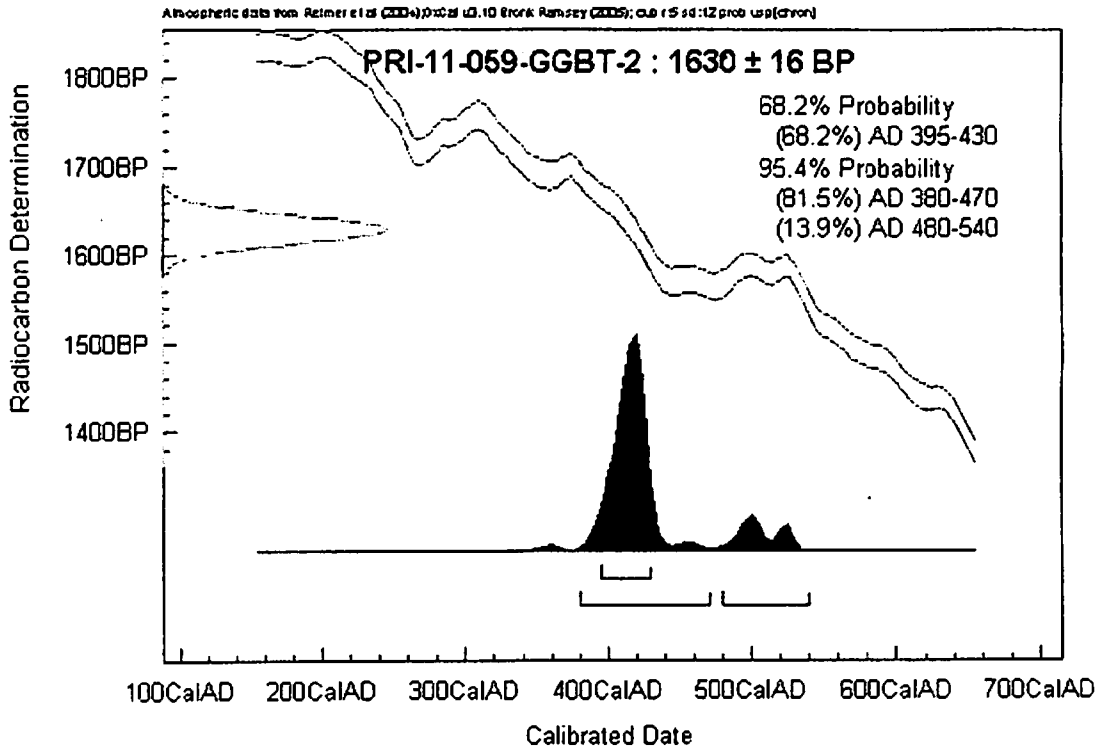

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FIGURE 3. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGFL-4
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 1658 ± 22 RCYBP
1-sigma Calibrated Age Range (68.2%): 1595-1585; 1570-1525 CAL yr. BP
2-sigma Calibrated Age Range (95.4%): 1690-1670; 1620-1520 CAL yr. BP
$\delta^{13}C$ (‰): -25.9 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

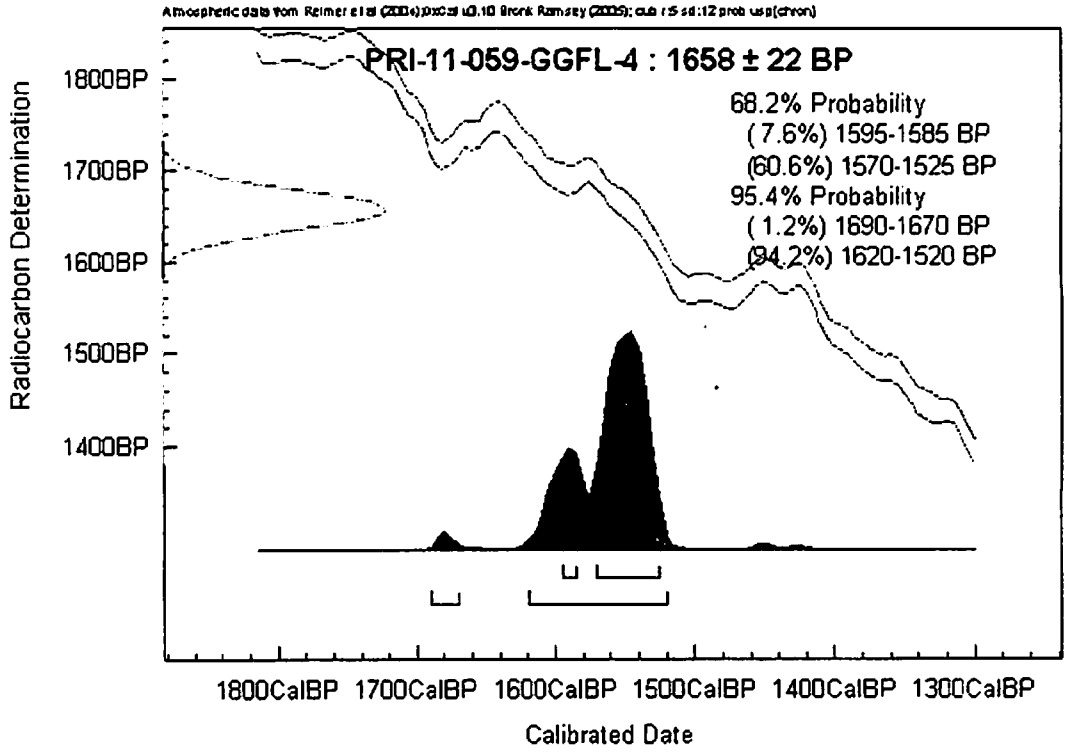

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FIGURE 4. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGFL-4
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 1658 ± 22 RCYBP
1-sigma Calibrated Age Range (68.2%): AD 355-365; 380-425
2-sigma Calibrated Age Range (95.4%): AD 260-280; 330-430
$\delta^{13}C$ ($^{o}/_{oo}$): -25.9 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

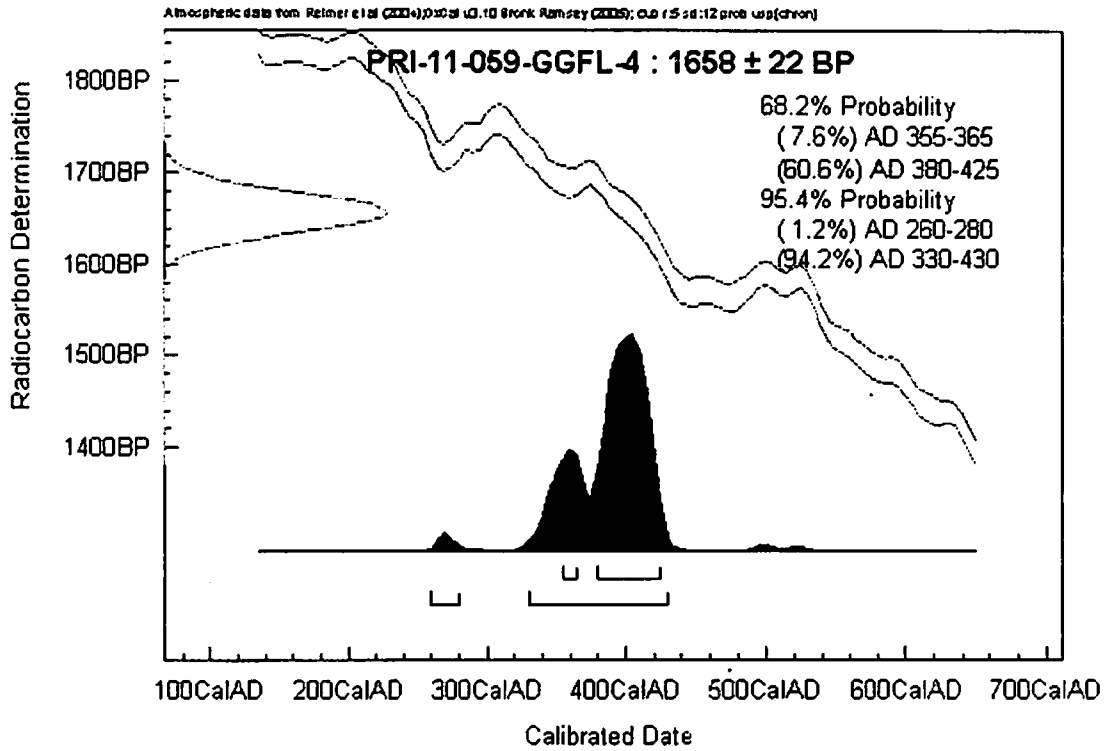

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FIGURE 5. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGFE-01
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 1754 ± 16 RCYBP
1-sigma Calibrated Age Range (68.2%): 1705-1690; 1670-1625 CAL yr. BP
2-sigma Calibrated Age Range (95.4%): 1720-1610 CAL yr. BP
$\delta^{13}C$ (‰): -26.0 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

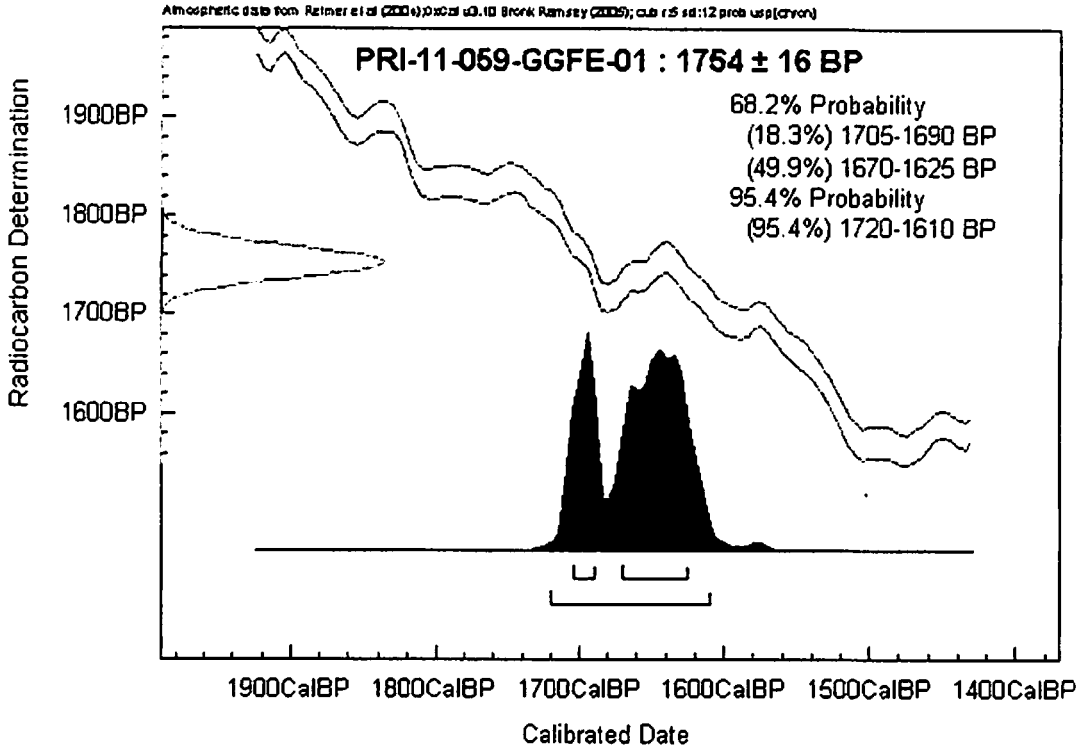

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FIGURE 6. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGFE-01
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 1754 ± 16 RCYBP
1-sigma Calibrated Age Range (68.2%): AD 245-260; 280-325
2-sigma Calibrated Age Range (95.4%): AD 230-340
$\delta^{13}C$ (‰): -26.0 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

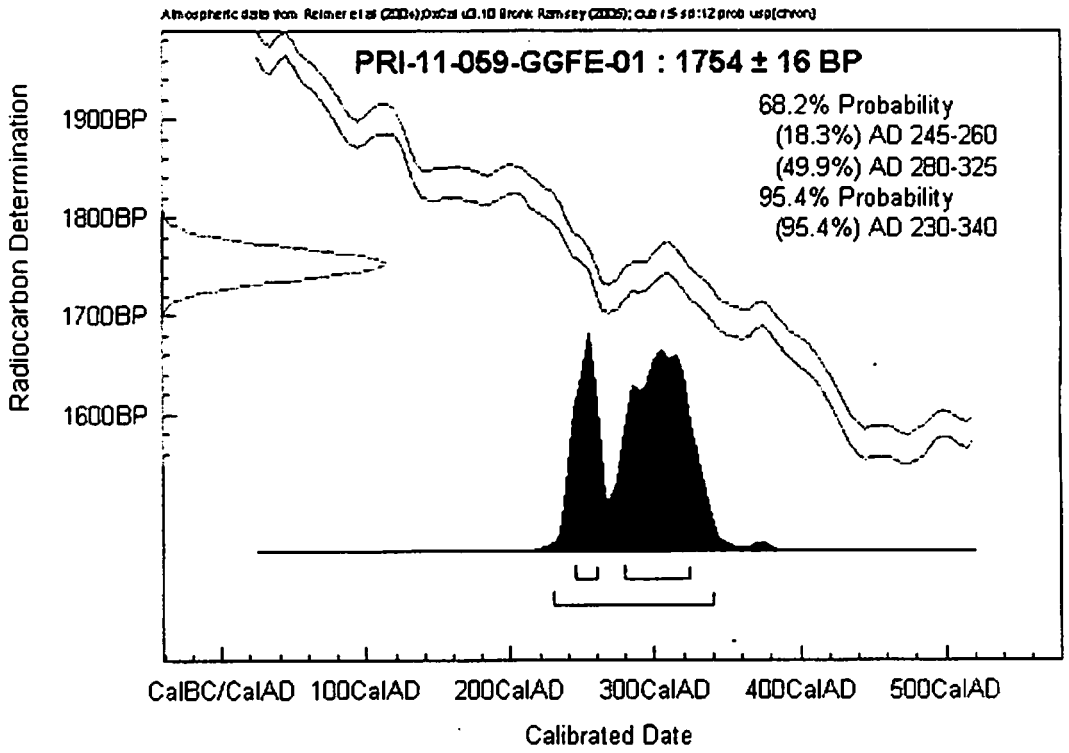

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FIGURE 7. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGLAC-2
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 3270 ± 30 RCYBP
1-sigma Calibrated Age Range (68.2%): 3560-3520; 3510-3450 CAL yr. BP
2-sigma Calibrated Age Range (95.4%): 3580-3440; 3430-3400 CAL yr. BP
$\delta^{13}C$ ($^{o}/_{oo}$): -28.7 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

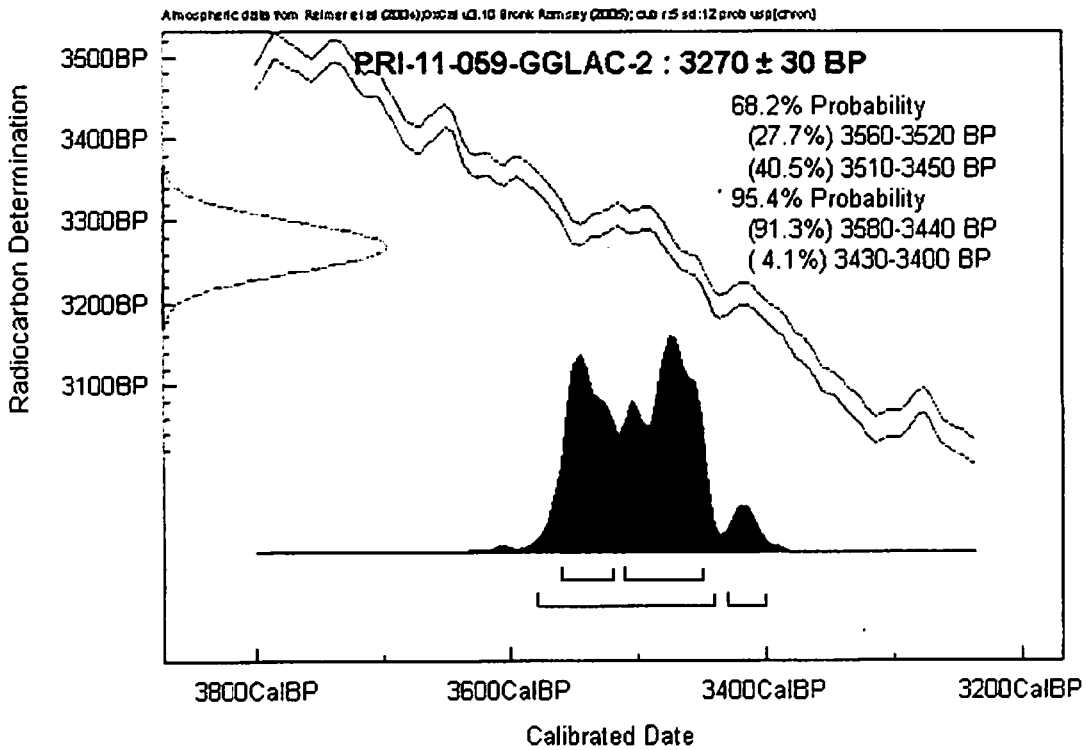

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FIGURE 8. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-059-GGLAC-2
Sample Identification: Charred ceramic residue
Conventional AMS ^{14}C Date: 3270 ± 30 RCYBP
1-sigma Calibrated Age Range (68.2%): 1610-1570; 1560-1500 BC
2-sigma Calibrated Age Range (95.4%): 1630-1490; 1480-1450 BC
$\delta^{13}C$ (‰): -28.7 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

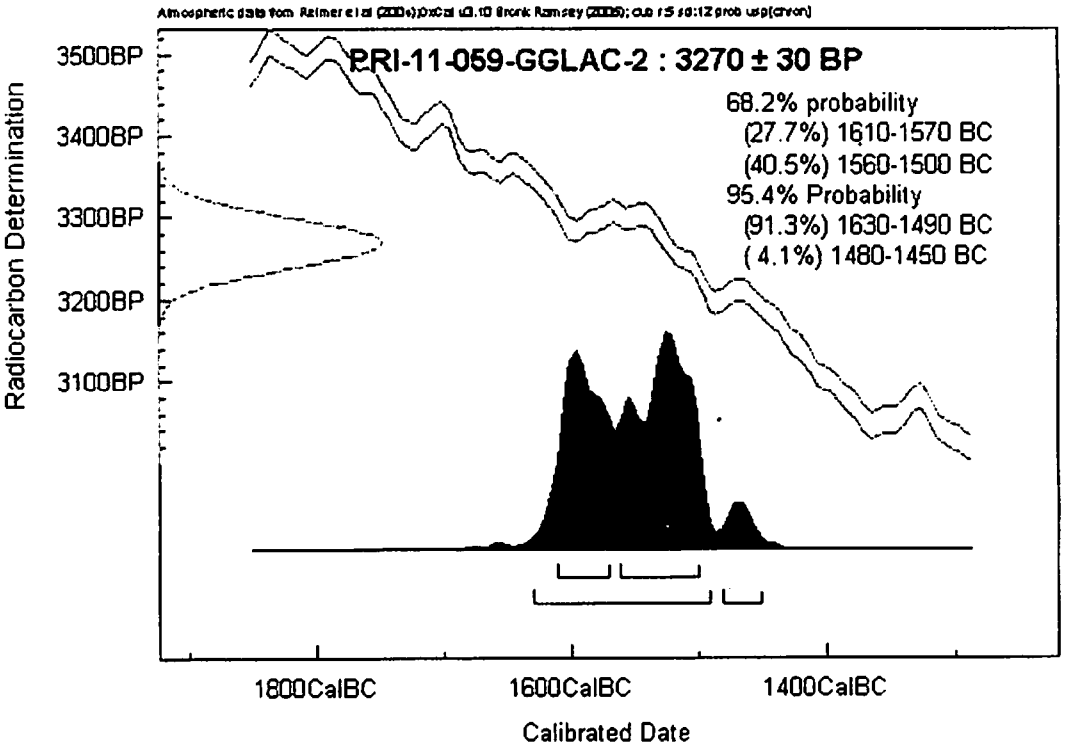

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FIGURE 8. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-081-MIACEP-1
Sample Identification: Burned food residue
Conventional AMS ^{14}C Date: 2648 ± 29 RCYBP
1-sigma Calibrated Age Range (68.2%): 2775-2745 CAL yr. BP
2-sigma Calibrated Age Range (95.4%): 2850-2820; 2800-2730 CAL yr. BP
• ^{13}C (‰): -23.9 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)

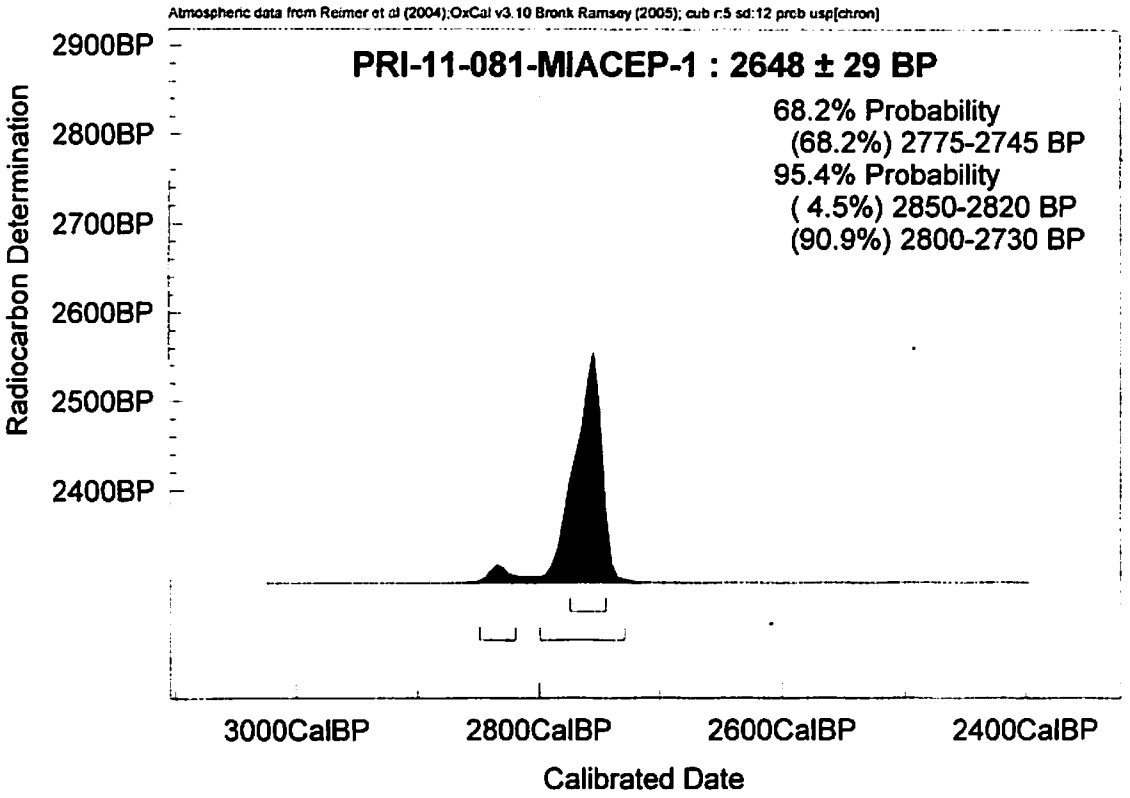

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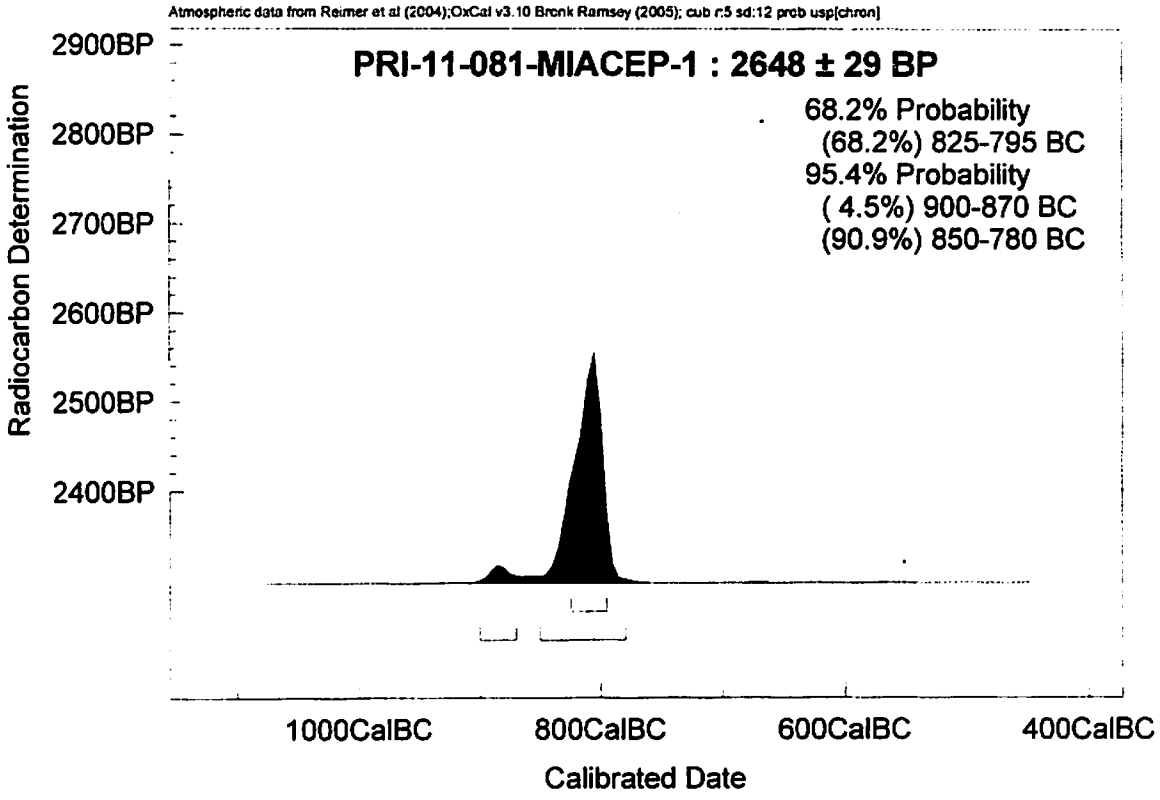
FIGURE 9. PRI RADIOCARBON AGE CALIBRATION

Laboratory Number: PRI-11-081-MIACEP-1
Sample Identification: Burned food residue
Conventional AMS ^{14}C Date: 2648 ± 29 RCYBP
1-sigma Calibrated Age Range (68.2%): 825-795 BC
2-sigma Calibrated Age Range (95.4%): 900-870; 850-780 BC
• ^{13}C (‰): -23.9 (Measured for ^{14}C calculation, not valid for dietary or paleoenvironmental interpretations)



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Telford, R. J., E. Heegaard, and H. J. B. Birks, 2004, *The Holocene* 14(2):296-298.

Site No.	Sample Number	Lab Number	OSL Age	Comments
21-BK-099	BT-181	UIC 2939	1525+/-290	
21-CW-247	EP-712	UIC 2935	1150+/-160	Smooth Middle WL vessel
21-CW-247	EP-688	UIC 2936	1940+/-680	
21-CA-738	TL-14	UIC 2945	1810+/-200	Sample no. error corrected
21-CA-226	KH-23	UIC 2943	2350+/-190	
21-HB-026	LC-559	UIC 2946	815+/-60	
21-HB-026	LC-007	UIC 2947	2730+/-200	
21-CA-109	MX-006			Insufficient qtz for analysis
21-CW-235	FL-068	UIC 2937	2730+/-200	Sample no. error corrected
21-CA-067	RP-335	UIC 2944	1710+/-130	

Table 1: Optically stimulated luminescence (OSL) ages on quartz grains from pottery shards, Becker Cass, Crow Wing and Hubbard counties, Minnesota (1/13/2012)

Sample	Laboratory number	Particle size (μm)	Aliquots [a]	Equivalent dose (Gray) [b]	H_2O (%)	External dose (mGray/yr)	Internal dose (mGray/yr)	Cosmic dose (mGray/yr) [c]	Dose rate (mGray/yr)	OSL age (yr) [d]
BT-181	UIC2939	150-250	43/60	3.98 ± 1.68	10 ± 3	2.20 ± 0.11	0.41 ± 0.02	0.22 ± 0.02	2.61 ± 0.13	1525 ± 290
EP-712	UIC2935	150-250	59/60	2.66 ± 0.32	10 ± 3	1.30 ± 0.06	1.01 ± 0.05	0.22 ± 0.02	2.31 ± 0.12	1150 ± 160
EP-688	UIC2936	150-250	57/60	4.85 ± 1.68	10 ± 3	2.37 ± 0.12	0.13 ± 0.01	0.22 ± 0.02	2.50 ± 0.13	1940 ± 680
FL-068 *	UIC2945	15-=250	59/60	5.27 ± 0.28	10 ± 3	2.29 ± 0.12	0.62 ± 0.03	0.22 ± 0.02	2.91 ± 0.15	1810 ± 200
KH-23	UIC2943	150-250	55/60	6.23 ± 0.30	10 ± 3	1.79 ± 0.09	0.87 + 0.05	0.22 ± 0.02	2.65 ± 0.13	2350 ± 190
LC-559	UIC2946	150-250	49/60	1.65 ± 0.10	10 ± 3	1.94 ± 0.10	0.08 ± 0.01	0.22 ± 0.02	2.03 ± 0.11	815 ± 60
LC-007	UIC2947	150-250	52/60	6.29 ± 0.20	10 ± 3	1.91 ± 0.10	0.40 ± 0.02	0.22 ± 0.02	2.31 ± 0.12	2730 ± 200
MX-066	UIC2938	Insufficient quartz for analysis								
TL-14 *	UIC2937	150-250	57/60	7.20 ± 0.27	10 ± 3	2.21 ± 0.11	0.50 ± 0.03	0.22 ± 0.02	2.71 ± 0.14	2730 ± 200
RP-385	UIC2944	150-250	28/30	3.95 ± 0.13	10 + 3	1.91 ± 0.10	0.41 ± 0.02	0.22 ± 0.02	2.32 ± 0.12	1710 ± 130

[a]Aliquots used in equivalent dose calculations versus original aliquots measured.
[b]Equivalent dose calculated on quartz fraction with about 3-6 grains/aliquot and analyzed under blue-light excitation (470 ± 20 nm) by single aliquot regeneration protocols (Murray and Wintle, 2003).
[c]From Prescott and Hutton (1994).
[d]Ages calculated using a residual corrected cluster analysis on the indicated aliquots (Pierson et al., 2010).
* These two sample numbers are reversed andneed to be switched for the analysis

References

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