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Dendrochronology and Accelerator Mass Spectrometry (AMS) Carbon 14 Dating: A Novel and Potent Combination

Myron O. Stachiw
https://orcid.org/0009-0006-0098-7054
mostachiw@gmail.com

Architectural Historian, East Woodstock, CT, USA

William A. Flynt
https://orcid.org/0009-0006-0098-7054
mostachiw@gmail.com

Architectural Conservator, Dummerston, VT, USA

Abstract: Over the past several decades the use of dendrochronology, or tree-ring dating has become a mainstream buildings archeology tool to firmly establish when framing timbers of historic structures were felled. While not every building tested can or has been successfully dated, a vast majority do allow dating using this method. As a result, dendrochronology has been instrumental in our rethinking of the architectural evolution of many historic building practices. One of the hurdles encountered when conducting such studies is having to work in areas where dated master chronologies are lacking, thus requiring testing against more far-flung masters which may, or may not, yield consistent alignments. One such case involved the supposedly 17th century Hancock-Mitchell house located in Chilmark on Martha's Vineyard, an island off the coast of Cape Cod, Massachusetts, first settled by Europeans in 1641. While initial dendrochronological testing did not yield conclusive results, further sampling in this house as well as in three others on the island resulted in a provisional oak master chronology for the island. In an attempt to confirm the accuracy of this master, a novel use of Accelerator Mass Spectrometry (AMS) Carbon 14 dating was employed whereby two rings, carefully selected based on their provisional dates in conjunction with the Carbon 14 recalibration curve, were sampled from one timber fragment. The results of these tests proved unequivocally that the dendrochronology dating was correct and the house was in fact constructed in the mid 18th century, and not in the mid 17th century as has been long believed.

Keywords: dendrochronology, wooden buildings, Hancock-Mitchell house, investigation

Introduction

Over the past several decades the use of dendrochronology, or tree-ring dating has become a mainstream buildings archeology tool to firmly establish when framing timbers of historic structures were felled. While not every building tested can or has been successfully dated, a vast majority do allow dating using this method. As a result, dendrochronology has become instrumental in our rethinking of the architectural evolution of many historic buildings and building practices. One of the hurdles encountered when conducting such studies is having to work in areas where dated master chronologies for specific tree species are lacking, thus requiring testing against more far-flung masters which may, or may not, yield consistent alignments. One such case involved the Hancock-Mitchell house located in the town Chilmark on Martha's Vineyard, an island 8 kilometers off the coast of Cape Cod, Massachusetts, first settled by Europeans in 1641 [1, 3] (Fig. 1).

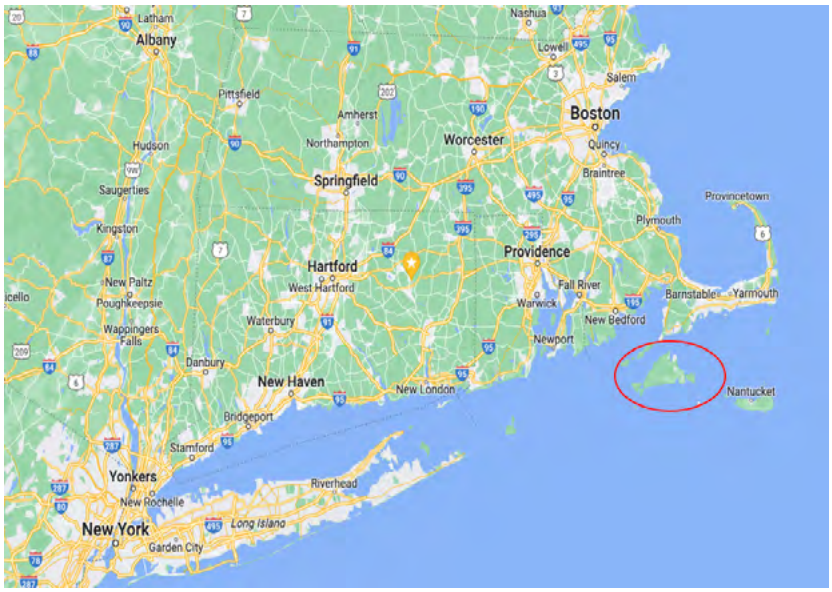


Fig. 1. Map of southern New England. The red oval indicates the island of Martha's Vineyard [3]

Fig. 2. Hancock-Mitchell House, 2014 (Sheriff's Meadow Foundation, Inc. 2013 [4])

The building is owned by Sheriff's Meadow Foundation, a land trust which preserves the former farmland of more than 100 hectares on which the building is located. Based on the research of an earlier investigator who identified the building as being built in the mid 17th century, the land trust raised a considerable amount of money from private donors to restore the building.

Presentation of research materials

Local knowledge and previous research conducted on the property had identified a portion of the building (Fig. 2) as having been constructed in the mid 17th century as a place where noted Indian missionary Thomas Mayhew, Jr., and his son John, also a missionary, preached to the Indians in their efforts to Christianize the native population of the island [8, 9, 10]. I was engaged to conduct a study of the history and evolution of the house and undertook extensive physical and documentary research in a process known as building archaeology. My conclusions, assisted by a dendrochronology study conducted by William Flynt, dated the building as having been initially constructed nearly a century later than believed by everyone, from the previous researchers to the local historical commission, the island's preservation trust, and the property owner.

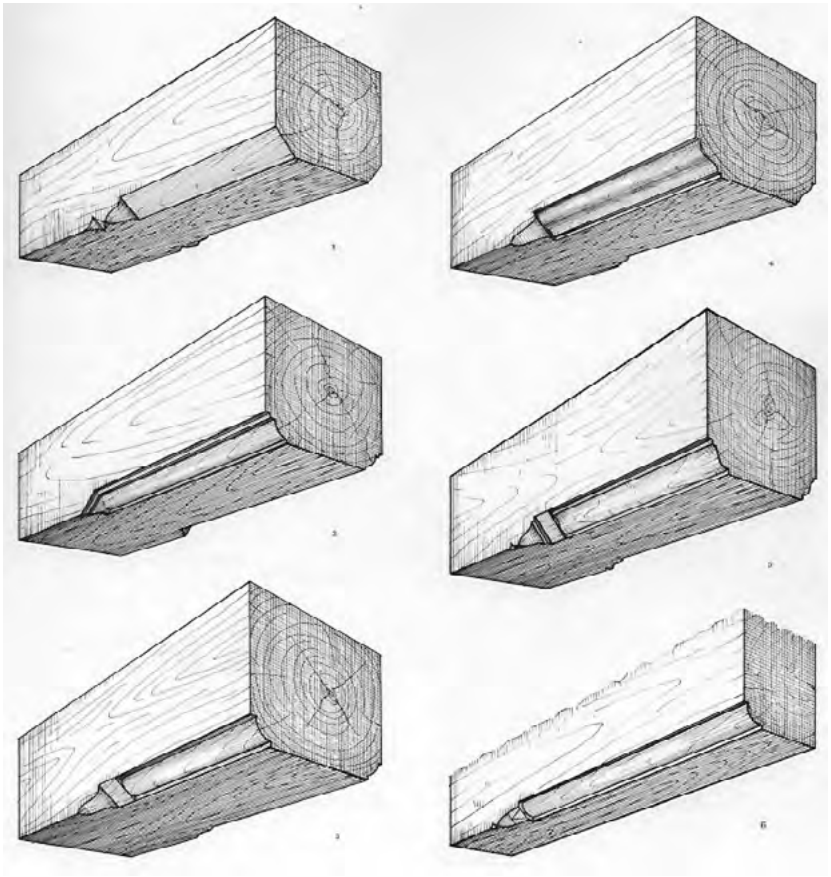


Fig. 3. Examples of 17th century chamfers on principal framing members of 17th century Massachusetts Bay houses (From: Abbott Lowell Cummings, *The Framed Houses of Massachusetts Bay, 1625–1725* (Belknap Press of Harvard University Press, 1979) [1]

The attribution of a 17th century construction date by earlier investigators was based on the presence of several construction methods found in the earliest part of the building. These included the presence of decorative carving of chamfers on the exposed timber framing elements (Fig. 3 & 4); and the filling of the exterior walls of the earliest part of the structure with clay and straw (Fig. 5). Both of these features were common in the region in the 17th century [6], a part of the post-medieval building traditions of the English settlers who populated the region during the 17th century [7]. In most of the mainland New England communities, these particular building practices disappeared by the second or third decades of the 18th century, replaced by the aesthetics of classicism [11].

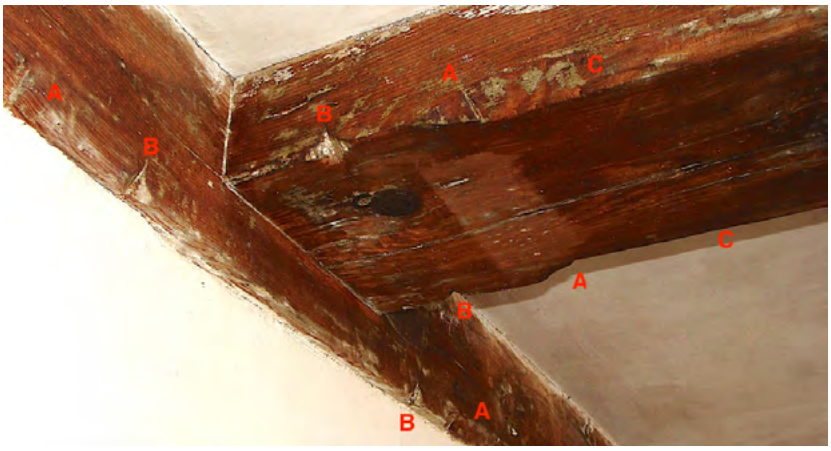


Fig. 4. A, B and C indicate chamfers cut into the framing members of the Vincent House, an early 18th century dwelling in Martha's Vineyard (Myron O. Stachiw, 2015)

Fig. 5. Top: Clay and straw infill in the exterior wall of the Hancock-Mitchell House, Chilmark, Massachusetts (Myron O. Stachiw, 2015)

Bottom: Detail of the clay and straw infill in the exterior wall of the house. The clay and straw mixture were applied over oak splints let into the vertical framing members (Myron O. Stachiw, 2015)

Based on my documentary and physical investigations, which included stylistic attribution of finishes as well as dating of construction materials such as nails, the building underwent three major phases of construction and additions (Fig. 6). These suggested initial construction of the Phase 1 structure in the mid-18th century, an addition in the early 19th century which essentially doubled the size of the house, and a second addition to the rear of the building several decades later.

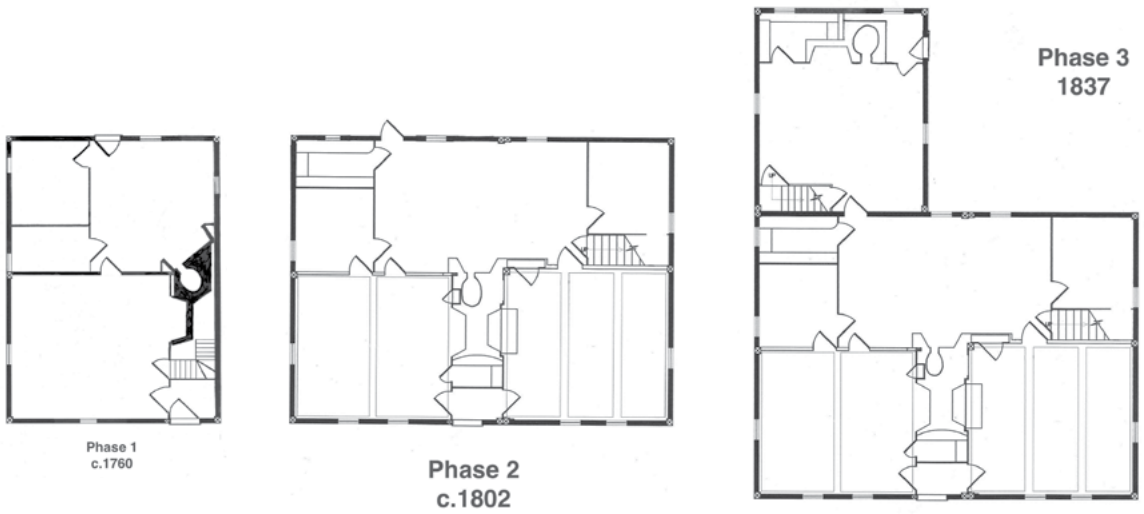


Fig. 6. Three phases of construction and expansion of the Hancock-Mitchell House (Drawings by Myron O. Stachiw)

The goal of the dendrochronology study undertaken by William Flynt was to ascertain the dates of these three major phases of the building's construction history. Phase 1 and 2 oak samples could not be successfully dated due to the lack of local oak master chronologies on Martha's Vineyard, as our efforts to date a building through dendrochronology on the island were the first to be undertaken, Furthermore, the results obtained did not align with existing dated master chronologies for oak from regions nearby but off of the island; oak was the material of the framing of the first and second phases of construction. However, it was possible to determine that the age difference between Phases 1 and 2 was 42 years. All physical and documentary evidence of Phase 2 construction and finishes suggested a date between 1790 and 1810, indicating a date of construction of 1750s-1760s for Phase 1. Phase 3 hemlock framing dated well with mainland hemlock master chronologies as having been constructed in 1836.

Parsonage House, West Tisbury

Look-Horwitz-House, West Tisbury

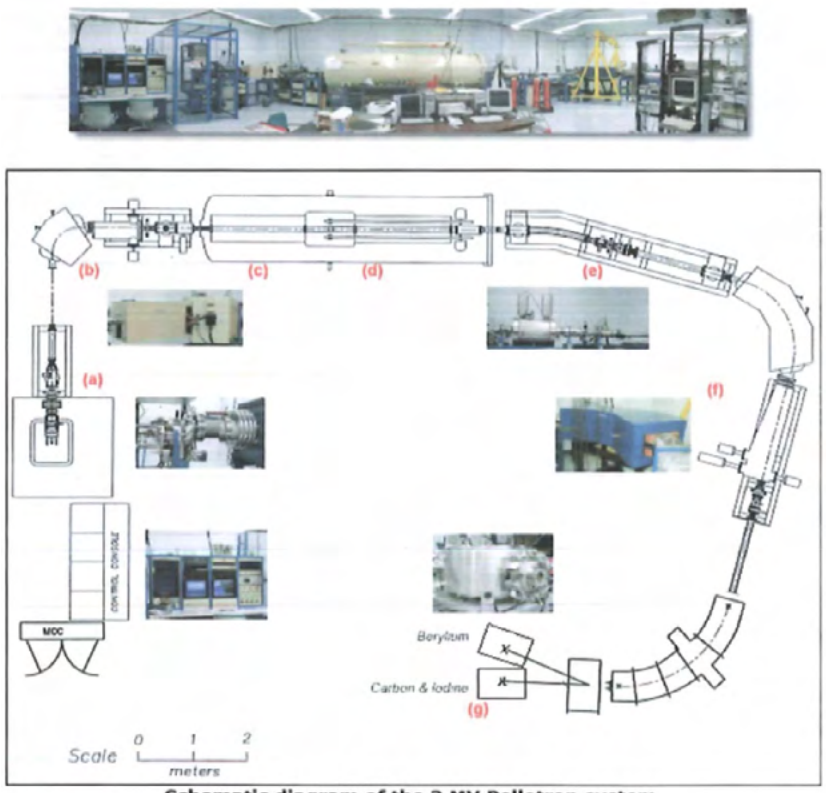
Butler-Strock House, Edgartown

Fig. 7. Three houses on Martha's Vineyard where dendrochronology dating was undertaken (William A Flynt and Myron O. Stachiw, 2014)

During the ongoing restoration process more of the house framing was exposed. This lead to a request for further dendrochronology testing, as the conclusions resulting from our research and the initial dendrochronology study could not be accepted by the client and the community as reliable. If several other early island buildings could be sampled, the chances of aligning all buildings and getting one or more to successfully date against mainland master chronologies would increase. Three homeowners of early houses on the island agreed to participate and sampling of these buildings was undertaken, as well as additional sampling at the Hancock-Mitchell house (Fig. 7).

Most of the oak timbers sampled were successfully aligned to create a floating master chronology, that is, one where age differences can be established between samples, but not assigned specific calendar dates. Comparing the oak data against a number of oak master chronologies from nearby areas not on the island, certain samples from each of the structures appeared to align well with specific dates that were offset in conformance with what the floating master displayed. This revealed the Butler-Strock house timbers were felled after the 1743 growing season ceased, the Parsonage' s timbers were felled primarily in the winter of 1744/5, and the Phase 2 timbers of the Look-Horwitz house were harvested in the winter of 1786/7. At the Hancock-Mitchell house, phase 1 timbers were felled in the winter of 1759, with a few felled a year earlier, while phase 2 timbers were cut down during 1800 and 1801.

While William Flynt was confident that the results were accurate, a book titled *Pioneer Houses of Martha's Vineyard* was published by one of the previous researchers who dated the Hancock-Mitchell house to the 17th c. [7]. He continued to argue for the 17th c. date for the house and also claimed similar dates for two of the other three houses for which we had obtained mid- to late-18th century dates through dendrochronology. This caused us to look for yet another way to confirm our new dating results.



Schematic diagram of the 3 MV Pelletron system, constructed by National Electrostatics Corporation (Middleton, WI).

Fig. 8. Diagram of the accelerator mass spectrometer at the University of Arizona Accelerator Mass Spectrometry Laboratory

Dendrochronologist Paul Krusic of Cambridge University suggested it might be possible to use Accelerator Mass Spectrometry Carbon 14 (AMS14C) testing on one or more samples to see if it could help confirm (or refute) the provisional dating as being correct (Fig. 8). With AMS 14C testing it is possible to narrow down a

date to plus/minus 20 years or less, a marked improvement over the traditional dating using C14 of plus or minus several hundred years. New data from deep coring of ice in the Arctic and Antarctica, and from glaciers and deep ocean sediments around the world over the past half-century have yielded much new data which has allowed a corrective to the traditional belief, established in the 1950s when C14 dating was first developed, that C14 in the atmosphere was constant through time. As a result, researchers at the University of Arizona Accelerator Mass Spectrometry Laboratory have developed a new calibration curve for C14 in the atmosphere for the period 1550–1950 AD (Fig. 9).

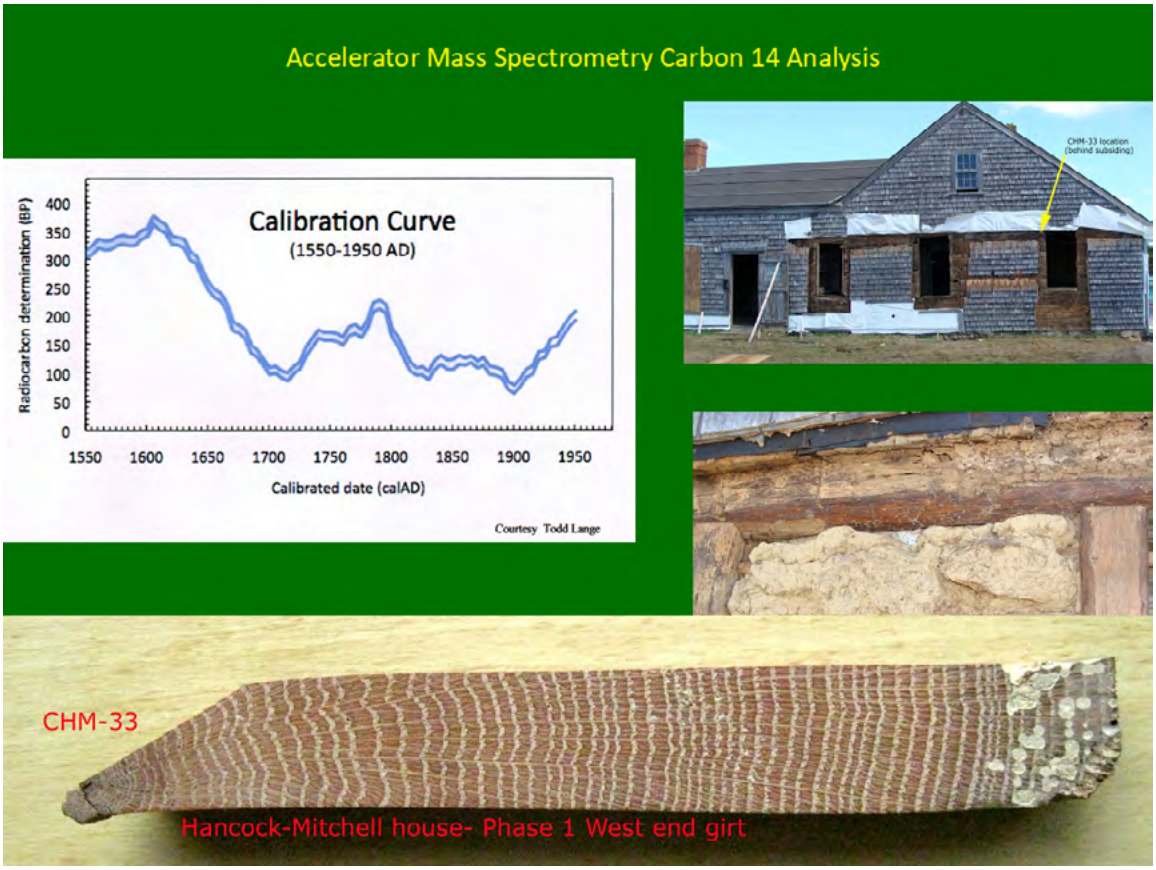


Fig. 9. Upper left: revised calibration curve for Carbon 14, 1550–1950 AD; **Upper right:** location of sample CHM-33 from the Phase 1 west end girt of the Hancock-Mitchell House; **Middle right:** detail of the west end girt from which sample CHM-33 was taken; **Bottom:** sample CHM-33 from the oak west end girt of the Hancock-Mitchell House (William A Flynt and Myron O. Stachiw, 2014)

Radiocarbon dating using Accelerator Mass Spectrometry differs from the usual decay counting methods in that the amount of Carbon 14 in the sample is measured directly, rather than by waiting for the individual radioactive decay events to occur. This makes the technique 1000 to 10,000 times more sensitive than decay counting. The enhanced sensitivity is achieved by accelerating sample atoms as ions to high energies using a particle accelerator, and using nuclear particle detection techniques.

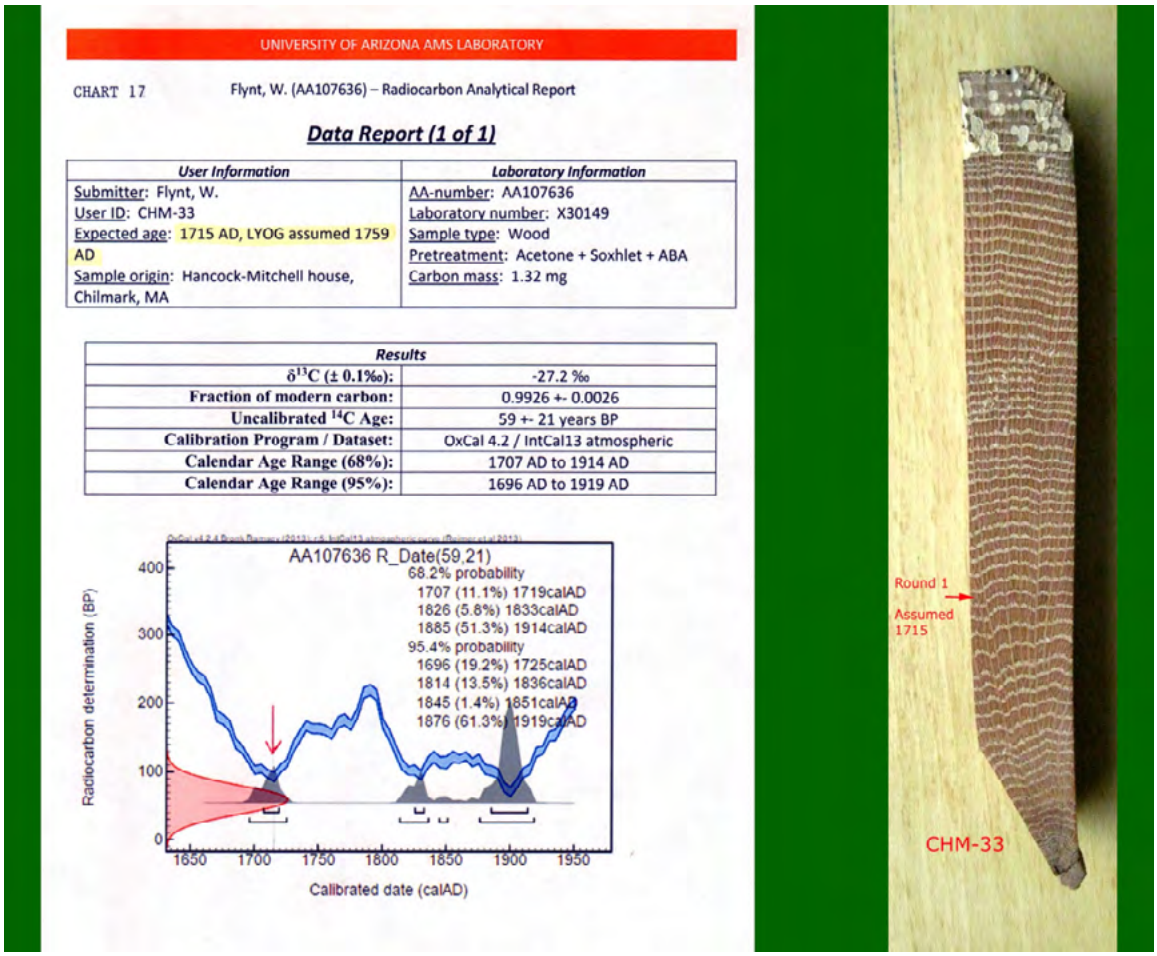


Fig. 10. Radiocarbon Analytic report, Sample CHM-33, assumed 1715 date tree ring (University of Arizona Accelerator Mass Spectrometry Laboratory)

We worked with Todd Lange at the University of Arizona AMS Laboratory who noted that the carbon 14 calibration curve for the northern hemisphere declined throughout the 17th century before reversing course in the early 18th century (Fig. 9, upper left). This offered the possibility for a two-part analysis that had the potential to eliminate the plus/minus 20 year dating range, but had never been attempted by the University of Arizona AMS Laboratory. The idea was to select a sample from a tree ring suspected as being at a unique position on the curve and, if confirmed, to then sample a ring at a second transition point on the curve and hope the results align with expectations. Should the two tests produce results as expected, this would indicate the sample is correctly dated as determined by the dendrochronology analysis.

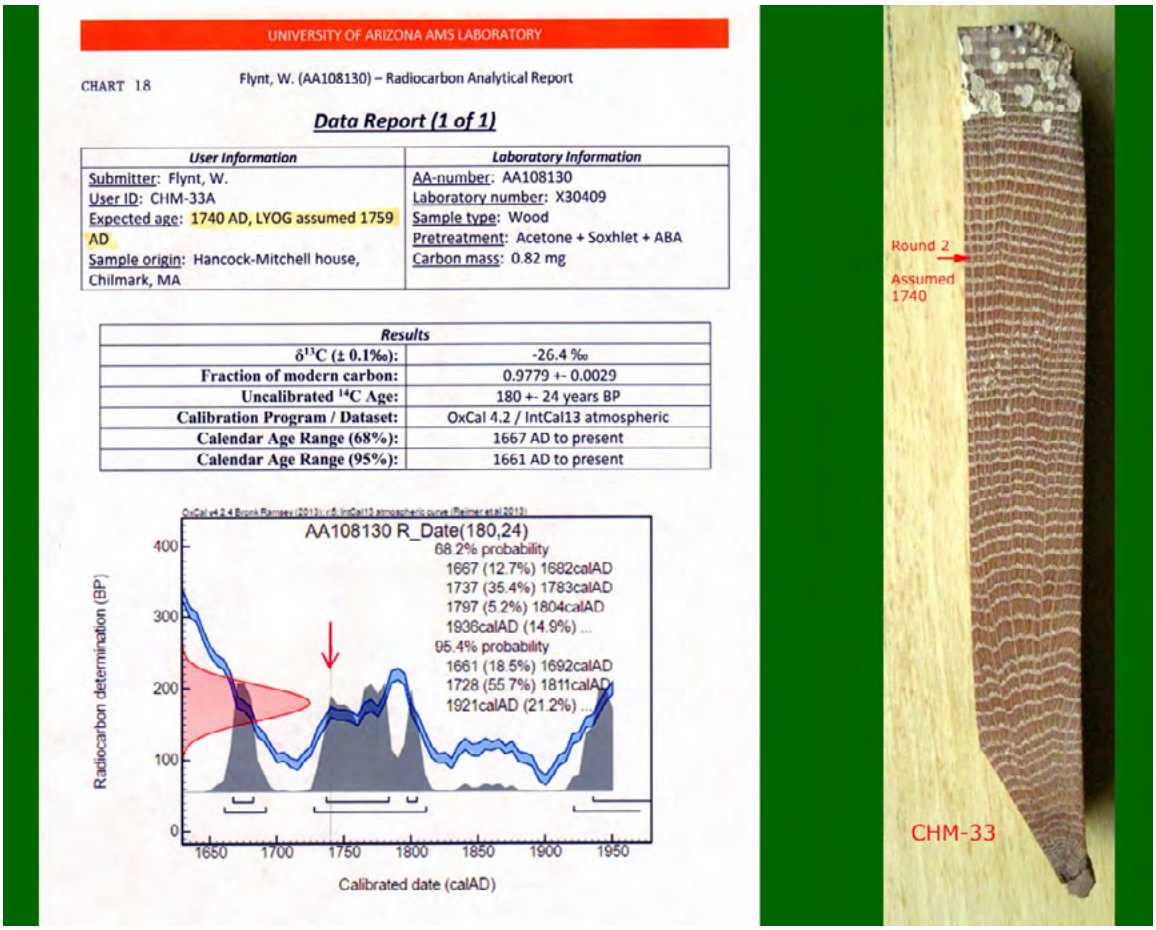


Fig. 11. Radiocarbon Analytic report, Sample CHM-33, 1740 date tree ring (University of Arizona Accelerator Mass Spectrometry Laboratory)

Working with the Hancock-Mitchell Phase 1 sample that tentatively dated the timber to having been felled in 1759, material was extracted from the ring assumed to be 1715, as it should correlate with the lowest part of the 18th century "dip" in the calibration curve (Fig. 10). This image depicts the results of the sample analysis. Of importance here are the gray shaded areas indicating where the sample's newly-calibrated Carbon 14 content falls along the calibration curve. Three areas of strength are noted, one in the early 18th century, one in the early 19th century, and one at the turn of the 20th century. Knowing which Phase 1 timber the sample came from, it is safe to dismiss the 20th century spike and most likely the early 19th century show of strength, leaving only the early 18th century alignment, which actually peaks at just about 1715, a promising result.

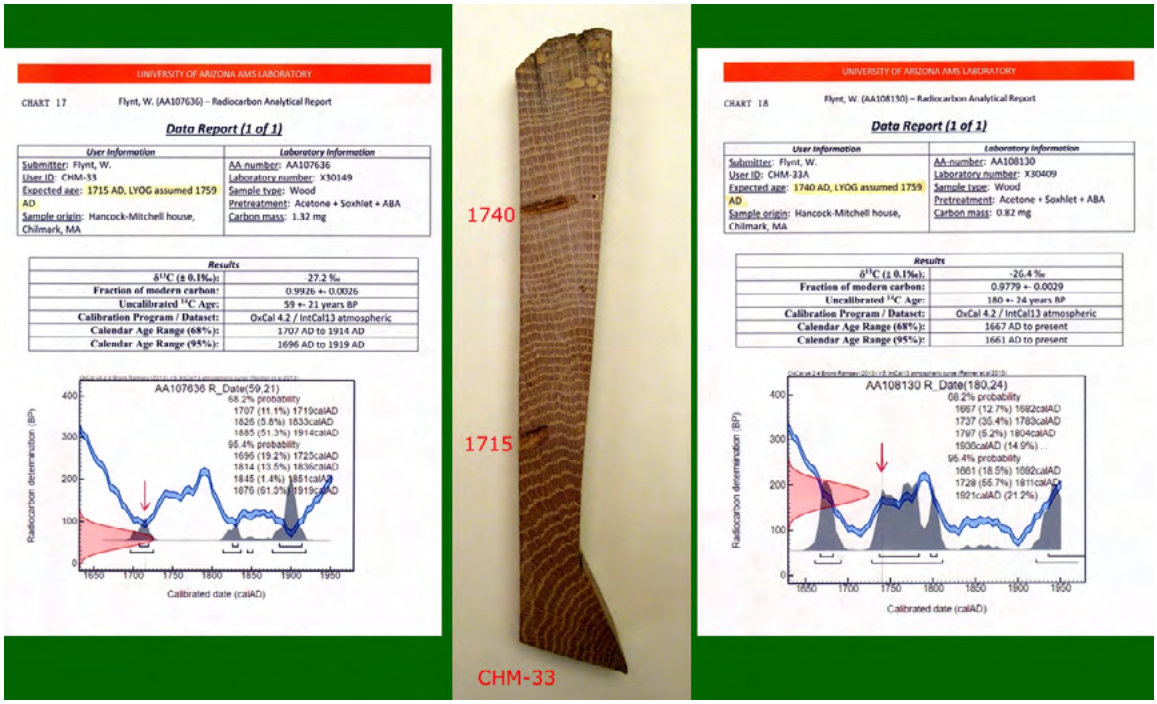


Fig. 12. Radiocarbon Analytic Reports, Sample CHM-33. Confirmation of C14 dating of 1715 and 1740 tree ring dates (University of Arizona Accelerator Mass Spectrometry Laboratory)

A second test was initiated using material from the ring 25 years younger (assumed to be 1740) as the Carbon 14 calibration curve rises to 1740 and then meanders for a time (Fig. 11). Should the sample reflect this increase in Carbon 14, it would then negate the 19th and 20th century results noted on this report, as in neither case is there as dramatic an increase over the ensuing 25 years. This image displays the results of the second analysis indicating the increased amounts of Carbon 14 in the sample. While there are numerous areas along the Carbon 14 calibration curve where this sample could date to, the strong peak at 1740 is the **only** place where these results correlate with those of the first test (Fig. 12). Thus, the AMS Carbon 14 analyses confirmed the correct dating of the sample, which in turn validated the Martha's Vineyard oak master chronology we developed, and the dating we derived for the buildings associated with it.

Conclusions

This confirmation of the dates of construction obtained for the buildings based on our detailed research and dendrochronological dating is an important step in reinterpreting the early history of building on the island of Martha's Vineyard based on scientifically-derived data rather than on faulty conjecture. These findings reveal that the housewrights and carpenters on the island continued to employ their traditional building practices for several generations after these same practices were given up by housewrights and carpenters in many of the communities of mainland New England, replaced by the new stylistic aesthetics of classicism.

While dendrochronological methods successfully provide absolute felling dates most of the time, when results are less clear, this two- pronged Accelerator Mass Spectrometry Carbon-14 analysis provides us with a remarkable new tool to significantly improve the accuracy of dating historic buildings.

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Dendrochronologia i akceleratorowa mas-spektrometria (AMS) datowania za pomocą C-14: nowe i potężne połączenie

Streszczenie: W ciągu ostatnich kilku dziesięcioleci dendrochronologia, czyli datowanie słojów drewna, stała się głównym narzędziem w archeologii budowlanej umożliwiającym dokładne określenie, kiedy wycięto drewno do historycznych budowli. Chociaż nie każdy testowany budynek może zostać pomyślnie datowany, zdecydowana większość umożliwia datowanie przy użyciu tej metody. W rezultacie dendrochronologia odegrała ważną rolę w naszej reinterpretacji ewolucji architektonicznej wielu historycznych metod budowlanych. Jedną z przeszkód napotykanych w prowadzeniu takich badań jest praca w obszarach, w których nie ma datowanych głównych baz danych chronologii, co wymaga sprawdzenia z bardziej odległymi chronologiami, które mogą, ale nie muszą, zapewnić spójną zgodność.

Jeden z takich przypadków dotyczył rzekomego XVII-wiecznego domu Hancocka-Mitchella, położonego w Chilmark na Martha's Vineyard, wyspie u wybrzeży Cape Cod w stanie Massachusetts, zasiedlonej po raz pierwszy przez Europejczyków w 1641 roku. Chociaż wstępne badania dendrochronologiczne nie dały jednoznacznego wyniku, późniejsze pobranie próbek z tego domu, a także trzech innych na wyspie, doprowadziło do wstępnej chronologii dębu na wyspie. Aby potwierdzić dokładność tej próbki, zastosowano nowatorskie zastosowanie akceleracyjnej spektrometrii mas (AMS) do datowania C-14, w wyniku której dwa pierścienie (starannie wybrane na podstawie ich poprzednich dat w połączeniu z kartą kalibracyjną węgla-14) pobrano z ten sam fragment drewna Wyniki tych badań jednoznacznie wykazały, że datowanie dendrochronologiczne było prawidłowe i że dom faktycznie powstał w połowie XVIII w., a nie w połowie XVII w., jak dotychczas sądzono.

Słowa kluczowe: dendrochronologia, konstrukcje drewniane, dom Hancock-Mitchell, badania