Quaternary Geochronology xxx (2015) 1–9

Contents lists available at ScienceDirect

Quaternary Geochronology

journal homepage: www.elsevier.com/locate/quageo

Research paper

Construction ages of the Upton Stone Chamber: Preliminary findings and suggestions for future luminescence research

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ARTICLE INFO

Article history:
Received 17 November 2014
Received in revised form
13 May 2015
Accepted 20 May 2015
Available online xxx

Keywords:
OSL dating
Upton Chamber
Stone chambers
Old Connecticut Path
New England

ABSTRACT

The Upton Chamber in Massachusetts, an earth-covered stone structure 3.4 meters (m) in diameter, with a corbelled stone dome, and a 4.3 m long entrance passageway, is studied with the aim of determining whether optically stimulated luminescence (OSL) dating methods can be used to establish the approximate construction date of the entranceway. Three samples, taken from soil behind the lowest stones in the wall of the entrance passageway, returned OSL ages between 385 and 660 years ago (or from 1625 A.D. to 1350 A.D.; using the year 2011 as the 0 year). One sample, taken below the bottom of the artifact layers in an archeological test pit in front of the chamber entrance, returned OSL ages between 650 and 880 years ago. A modern sample collected from a nearby fluvial channel returned an age between 55 and 175 years. The Upton Chamber OSL sampling results are challenging to interpret because there are mixtures in the samples of both younger and older grains that likely result from human modification, root or soil processes, animal bioturbation (i.e. ants and worms), and/or partial bleaching. The ages were determined using the lowest component of the finite mixture model as applied to a distribution of quartz grains. Further research may enable us to determine whether older components are of anthropomorphic or geological origin.

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1. Introduction, previous studies, and research questions

Although optically stimulated luminescence (OSL) has commonly been used at other pre-European contact archeological sites throughout the United States (e.g. Topper (Waters et al., 2009), Buttermilk Creek (Waters et al., 2011), Cactus Hill (Feathers et al., 2006), etc.), within the Northeastern area of the United States (i.e. the New England area) it has not been routinely applied. More than 300 stone chambers of unknown origin, construction periods, and functions have been cataloged in New England (Whittall, 1981, 1982; and 1984). A chamber located in Upton, Massachusetts (Fig. 1) with an interior domed chamber 3.4 m in diameter and an entrance passageway that is 1 m (width) x 4.3 m (height), is among the largest of these structures (Fig. 2A).

The land on which the chamber is located was inhabited solely by the Nipmuc Indians until 1704 A.D. (Supplemental Fig. S8). The chamber is on the route of an important Native American trail referred to today as the Old Connecticut Path, which connected Boston with the Connecticut River near Hartford. To the west was the 'Praying Indian Village' of Hassanamisco, a four square mile area designated by John Eliot in 1654 as a place for 'Christian Indians.' According to Eliot, the Indians selected Hassanamisco because it was 'the place of their desires' (Eliot, 1670). "Upton was established as a town in 1735 from parts of Hopkinton, Mendon, Sutton and Uxbridge. During the Plantation Period (1620–1675), the southern portion of Upton was included in the 1667 Mendon Grant, while the northern section was unincorporated. No notable colonial settlement took place during this period" (Dudek, 2012).

In 2011, the Federal Communications Commission (FCC) in Washington, D.C. made a determination that the cultural landscape known as the Pratt Hill–Upton Chamber Historic District is a discontinuous historic district that is eligible for listing on the National Register of Historic Places (under Criterion A for its role in the religious and cultural traditions of three tribes-the Narragansett Tribe, the Wampanoag Tribe of Gay Head (Aquinnah), and the Mashpee Wampanoag Tribe). Based upon the limited excavation

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http://dx.doi.org/10.1016/j.quageo.2015.05.017
1871-1014/Published by Elsevier B.V.

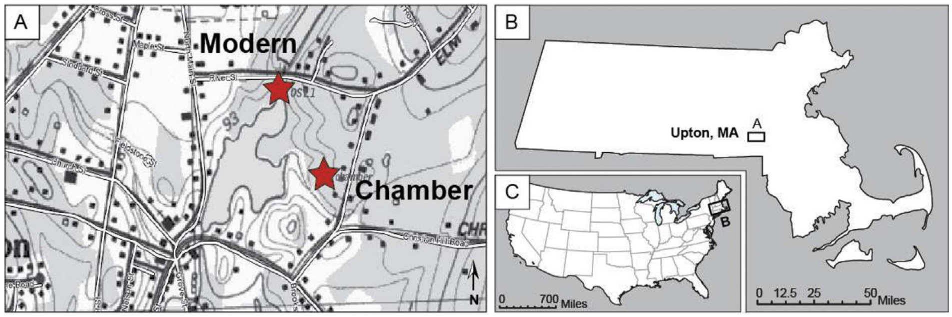

Fig. 1. A. The placement and elevation of the Upton Chamber in Upton as well as the site of the modern creek sample. The Upton Chamber is located within the USGS Milford Massachusetts 7½-minute quadrangle map and can be found at N 42° 10′ 32.8″ and W 71° 35′ 54.4″, NAD27 CONUS. B. Location of Upton within the state of Massachusetts (labeled A). C. Location of the Upton, Massachusetts area within the eastern United States (labeled B).

from the site examination, the Upton Chamber is also recommended as eligible under Criterion D: Information Potential ("has yielded, or may be likely to yield, information important in prehistory or history"), at the local level (Dudek, 2012).

The New England Antiquities Research Association (NEARA) and the Upton Historical Commission (UHC), with additional private donors, have accordingly initiated new research (Martin, 2011a) with OSL techniques using single grain and single aliquot dating for the sediment at the entranceway to Upton Stone Chamber. In particular, the question OSL would answer is: what are the ages of construction?

The geology of the region is well documented in surficial geologic maps (Stone and Stone, 2006) and most landforms in the area are a direct result of the glacial retreat of continental glaciers some 14–16 ka after a terminal position established about 21 ka ago (Hildreth and Stone, 2004). The area of the Upton Chamber contains a fine sandy loam derived from glacial stratified deposits. The soil type is "Canton soil"; it varies in depth from 46 cm to 91.5 cm and is formed directly atop the glacial till (Al Averill, U.S. Dept. of Agriculture, written communication, 2014; Figure S9). Upton Chamber is at the junction of two streams, which may explain the abundance of glacial outwash sand in the area of the chamber.

The aim of this study is to document the sampling, present and discuss OSL measurements, and determine ages of sediment taken from behind the lowest stones in a wall during the masonry reconstruction of the Upton Chamber. Questions that will be considered are:

i) Does OSL dating provide definitive dates for the time of construction for the entranceway to Upton Chamber?,
ii) When multiple OSL equivalent dose (D_E) populations are evident in samples, which age model is the best to use and why? and
iii) Do the OSL D_E populations provide any information about the methods of construction?

2. Methods

2.1. Sampling

On the 25th and 26th of October, 2011 samples were taken under the supervision of the archaeological firm James Milner Associates, Inc., during the masonry rehabilitation of the destabilized and slumping capstone of the entrance passageway (Dudek, 2012). Ten samples for OSL dating were obtained, with the result that three from within the chamber wall and one from an excavation pit in front of the chamber were analyzed for OSL during 2012 and 2013. At the chamber entranceway, samples of gravelly sediment were collected from behind the lower half of the southerly wall at locations shown in Fig. 2B and Table S7, and in front of the entrance as shown in Fig. 3C. A modern stream sample was also collected in 2014, as shown in Figs. S6 and S7. Photographs similar to Fig. 3A–C (listed in Table S6) were made of each sampling step as a 10-cm long steel tube of 4 cm diameter was driven into undisturbed soil to obtain an unexposed sample, and the tube was quickly stored in a black, light-tight bag. Then approximately a liter of sediment was dug out around the sample hole and stored in a plastic bag. A detailed report is archived (Martin, 2011b; Tables S6 and S7; Supplemental Notes #1, Figs. S10–S30).

2.2. Luminescence lab protocol

2.2.1. D_E calculations

The OSL technique relies upon the fundamental principles of radiation dosimetry, whereby a grain of sediment will be exposed to sunlight on its journey, lose its prior luminescence signal, and then be deposited in a final resting place at a "zero" or bleached level. Natural processes of low-level sediment radiation then act to fill the sediment grain again with luminescence, such that the time of deposition (or age) can be determined if two things are accurately measured: (i) the level of incoming radiation that stimulates luminescence growth (the dose rate or D_R) and (ii) the level of luminescence currently held in the grain of interest (the D_E).

The steel tubes were only opened under "safe light" (sodium vapor lighting) conditions in the luminescence laboratory once they were received. After discarding about 3 cm from both opened ends, the entire volume of the middle of the tube was treated in 10% hydrochloric acid (HCl) for 24 h (to dissolve any post-depositional carbonate coatings), 35% H_2O_2 for 24 h (to dissolve the organic and soil carbonates), sieved to collect coarse-grained fractions (with grains ~ 250- and 180 μm in diameter) and 50% hydrofluoric acid (HF) for 50 min (to dissolve surface impurities such as iron oxides from the quartz grains). Before the HF, the coarser grained size (250-180 μm) quartz fractions were separated from the feldspars and any heavy minerals using a Frantz magnetic separator and heavy liquids (lithium sodium polytungstate or LST) ($\rho = 2.58$ gcm^{-3} and ($\rho = 2.67$ gcm^{-3}). After pouring off the HF solution, we put the sample in 25% HCl for 5 min (while in the ultrasonic bath) and finally re-sieved to winnow broken feldspar grains.

All samples were measured for single aliquot and then separately as single grain D_E by loading 100 grains onto a special aluminum disc. We analyzed 2400 grains for each sample except the modern which was only analyzed for 1200 grains because grains of the desired size were in short supply (the modern stream has much coarser grains in the bed load). Irradiation and heating are performed on these discs as a whole, but each grain position is

Please cite this article in press as: Mahan, S.A., et al., Construction ages of the Upton Stone Chamber: Preliminary findings and suggestions for future luminescence research, Quaternary Geochronology (2015), http://dx.doi.org/10.1016/j.quageo.2015.05.017

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