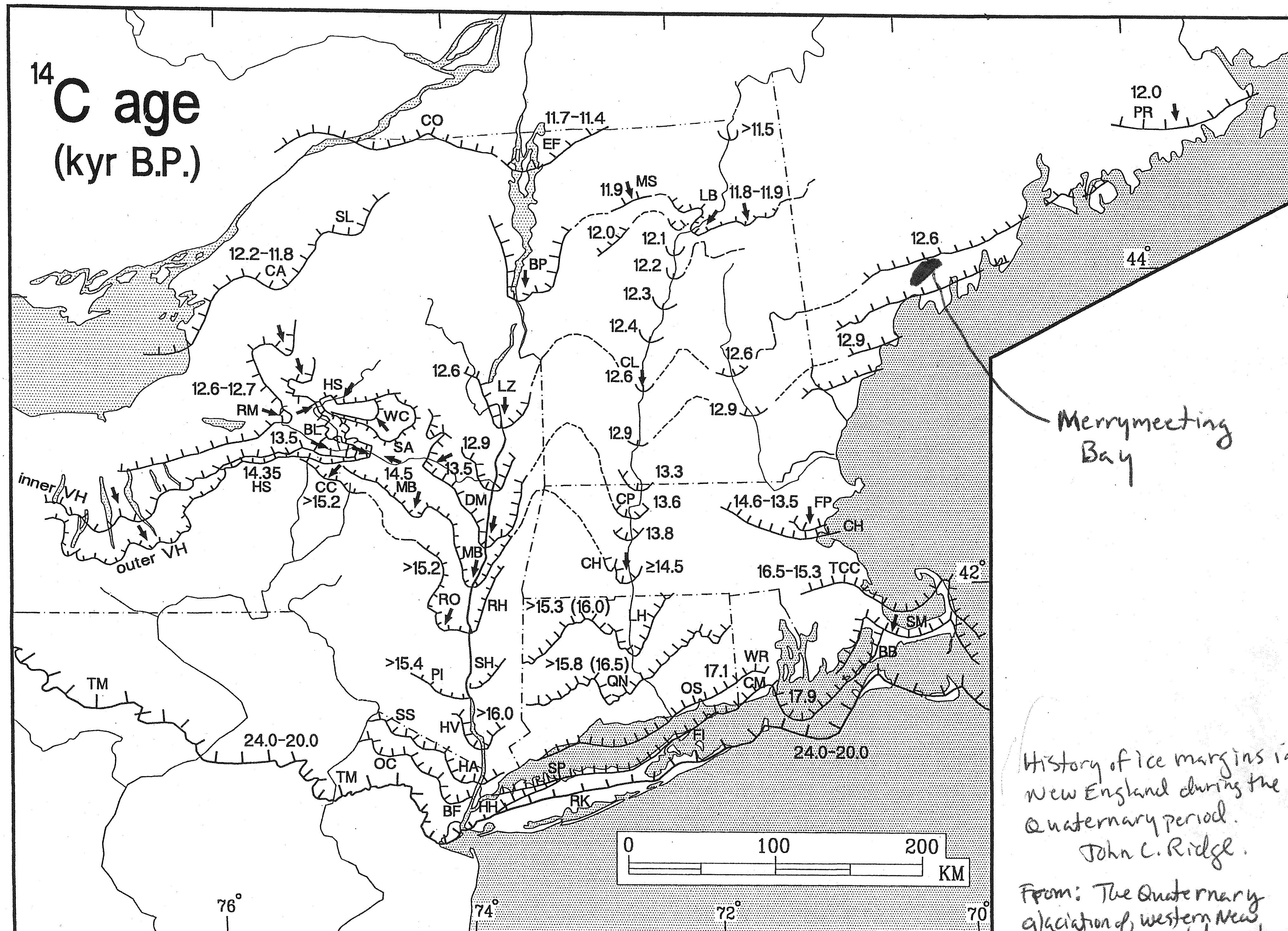

History of ice margins in New England during the Quaternary period. John C. Ridge.

From: The Quaternary glaciation of western New England with correlations to surrounding area.

Quaternary Glaciations – Extent and Chronology, Part II
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The Quaternary glaciation of western New England with correlations to surrounding areas

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Abstract

Over the last 20 years there have been major improvements to our understanding of the Quaternary glaciation of New England. Numerous Accelerator Mass Spectrometer (AMS) ^{14}C ages of terrestrial plant fossils have eliminated some of the errors associated with ^{14}C ages of lake-bottom bulk sediment samples and marine fossils. The rebirth of Antevs' New England varve chronology and its ^{14}C calibration have added precision to the Late Wisconsinan deglaciation chronology and a means of precisely testing correlations of deglacial events. Palaeomagnetic studies of both declination and polarity have allowed precise correlation between New England and adjacent areas.

The exact chronology of pre-Late Wisconsinan glaciation is still poorly constrained because of difficulties in determining numerical ages. The terrestrial glacial record of New Jersey dictates that New England was glaciated at least twice in pre-Wisconsinan time, at least once when the geomagnetic field had a reversed polarity (pre-Illinoian, Marine Isotope Stage (MIS) 22 or older, ≥850 ka) and again during the Illinoian (160-180 ka BP, MIS 6). Controversy exists concerning pre-Late Wisconsinan till in central and northern New England with its weathering supporting an Illinoian age and amino acid ages from reworked marine fossils in Boston Harbor supporting an Early Wisconsinan age.

In the Connecticut Valley of southern New Hampshire and Vermont the advance of Late Wisconsinan ice buried advance outwash and lake beds were deposited in tributaries impounded by advancing ice. Late Wisconsinan ice reached its limit on islands along the southern coast at 24.0-20.0 ^{14}C ka BP (28.0-23.7 cal ka BP). The overall pattern of deglaciation was one of spurts of ice recession punctuated by readvances and end moraine building, and acceleration of ice recession over time. The early chronology of deglaciation (20.0-15.0 ^{14}C ka BP, 23.7-18.0 cal ka BP) has been inferred from correlations to Greenland ice core records and varve sequences have been used to crudely constrain the chronology. The later part of deglaciation (15.0-11.5 ^{14}C ka BP, 18.0-13.4 cal ka BP) has been determined precisely where basal ice-proximal varves are matched to the ^{14}C-calibrated New England varve chronology in the Connecticut, Merrimack, Passumpsic, and Winooski Valleys. The resulting precise chronology of deglaciation in central and northern New England is about 1500 years younger than in previous models largely based on bulk sediment lake-bottom ^{14}C ages. A comparison of terrestrial ^{14}C ages for ice margins in the Merrimack Valley with marine ^{14}C ages for contemporaneous marine ice margins in southern Maine suggest that a 600-1300-yr marine reservoir correction should be applied to the marine chronology. Correlations between New England and New York have been formulated with the matching of independent palaeomagnetic declination records from both areas and the connection of ice-front positions that appear to align geographically. There appears to be a contemporaneity of readvances in both regions that also match cold intervals on Greenland ice core records. These observations support a rapid response of the last ice sheet's ablation system to cold events. Following deglaciation a delayed isostatic tilting occurred across central to northern New England with water planes dipping 0.85-0.94 m/km towards the south-south-east. The non-glacial remnants of glacial lakes in the upper Connecticut Valley persisted until at least 10.5 ^{14}C ka BP (12.5 cal ka BP) and may have been seen by the first humans in the area. While isostatic uplift was well underway in southern and central New England recession of ice in Canada allowed the invasion of marine water into the Champlain Basin at about 11.0 ^{14}C ka BP (13.0 cal ka BP). This age estimate is consistent with previous studies that attempted to remove a reservoir error from marine ^{14}C ages of Champlain Sea fossils.

1. Introduction

This paper is a review of the Quaternary glacial history of New England except for Maine, which is covered by Thompson *et al.* (this volume) in detail. Correlations and comparisons will be given to adjacent New Jersey, New York, and Maine when they are relevant to determining the ages of pre-Wisconsinan glaciation, evaluating the synchroneity of Late Wisconsinan glacial readvances, and evaluating differences between terrestrial and marine ^{14}C ages. This review will focus heavily on developments over the last 20 years that have greatly changed our understanding and resolution of New England's glacial record.

Until recently the glacial chronology of New England was largely based on spot occurrences of ^{14}C ages and interpretations tied to weathering characteristics. Over most of New England traceable end moraines are scarce as compared to regions further west making morphostratigraphical correlation difficult. The use of morphostratigraphy has largely been limited to stratified deposits with the detailed mapping of morphosequences, a mapping tech-

Table 2. Abbreviations of moraines, ice margins, and glacial readvances in Figures 5, 6, and 7.

BB	Buzzards Bay Moraine
BF	Bloomfield ice margin
BL	Barneveld-Little Falls Readvance
BP	Bridport Readvance
CA	Carthage-Harrisonville ice margin
CC	Cassville-Cooperstown Moraine
CH	Chicopee Readvance
CL	Claremont moraines
CM	Charlestown Moraine
CO	Covey Hill ice margin
CP	Camp Meeting Cutting ice margin
DM	Delmar Readvance
EF	Enosburg Falls ice margin
FI	Fishers Island Moraine
FP	Fresh Pond Moraine
HA	Lake Hackensack ice margin
HH	Harbor Hill Moraine
HS	Hinckley-St. Johnsville Readvance
HV	Haverstraw ice margin
LB	Littleton-Bethlehem Readvance
LC	Lake Charles ice margin
LH	Lake Hitchcock dam ice margin
LZ	Luzerne Readvance
MB	Middleburg Readvance
MS	Middlesex Readvance
OC	Ogdensburg-Culvers Gap Moraines
OS	Old Saybrook Moraine
PI	Pellets Island Moraine
PR	Pineo Ridge Moraine
QN	Quinnipiac ice margin
RH	Red Hook Moraine
RK	Ronkonkama Moraine
RM	Rome Readvance
RO	Rosendale Readvance
SA	Salisbury Readvance
SH	Shenandoah Moraine
SL	Star Lake Moraine
SM	Sandwich Moraine
SP	Sands Point Moraine
SS	Sussex Moraine
TCC	L. Taunton-Cape Cod ice margin
TM	Late Wisconsinan Terminal Moraine
VH	Valley Heads Moraines
WC	West Canada Readvance
WR	Wolf Rock Moraine

3.3 Initial advance of Late Wisconsinan ice

Relatively little is known about the period of advance of Late Wisconsinan ice across New England because it is often difficult to distinguish sub-till deposits put down during the advance of the last ice sheet from deposits of earlier glaciations. Pre-glacial weathering of sub-till deposits has been the primary way of identifying deposits from earlier glaciations. A lack of weathering in sub-till deposits, however, leaves one guessing although it has been tempting to interpret non-weathered fluvial and lacustrine deposits as representing the advance of Late Wisconsinan ice. Another difficulty has been determining the chronology of the first arrival of ice in various places. There are few ^{14}C ages that document the first arrival of the last ice sheet and most of these ^{14}C ages are at the limit of the ^{14}C dating technique on the southern coast of New England, making interpretations of the rest of the region highly speculative. In the absence of numerical ages there is currently no precise chronology for the first arrival of Late Wisconsinan ice across New England.

In the Connecticut Valley of southern Vermont and New Hampshire it has been possible to make some interpretations of the character of the land surface, especially in valleys, when the Late Wisconsinan ice first arrived. Detailed superficial mapping has revealed a variety of weathered and unweathered deposits beneath till of the Last Glaciation. In the Connecticut Valley at West Lebanon, New Hampshire (Fig. 1) a non-weathered fluvial gravel (interpreted to be advance outwash) has been found along the valley side beneath Late Wisconsinan till (Larsen, 1987a). The fluvial unit as well as well records with a similar extensive sub-till gravel unit to the south (Ridge, 1990) suggest that during ice advance the valley was occupied by a large braided river to an elevation at least 35 m above the modern Connecticut River. The fluvial deposits cannot be the product of deposition during Late Wisconsinan ice recession and burial by till of a readvance because a deep glacial lake occupied the Connecticut Valley during final ice recession.

A very common situation in the Connecticut Valley of southern Vermont and New Hampshire is highly weathered schist and micaceous gneiss, colluvium, and bouldery stream deposits beneath unweathered glacial lake beds that are varved and contain ice-rafted debris. All these sub-till units occur as a package beneath Late Wisconsinan till (Ridge, 1988, 1999, 2001). These deposits are preserved in east-west trending tributaries of the Connecticut River from Claremont to Walpole, New Hampshire (Fig. 1; Cold, Little Sugar, and Sugar River valleys of New Hampshire and the Williams River valley of Vermont) where they were protected from the scour of southward advancing Late Wisconsinan ice. The unweathered lake beds in these valleys appear to represent lakes impounded in tributaries by the southward advance of a lobate Late Wisconsinan ice front in the Connecticut Valley. Along the Cold River near Walpole a saprolite and overlying colluviated soil and rock debris are preserved beneath lake beds. This section has been interpreted (Ridge, 1988, 1999) as a sequence produced by Sangamonian (MIS 5) weathering that was followed by mass wastage during the Early to Middle Wisconsinan (MIS 3 and 4), and lake ponding during the advance of Late Wisconsinan ice (MIS 2). This is the simplest explanation but stands as a hypothesis untested by numerical dating techniques. In all the river valleys mentioned above, sub-till lake beds have been found extending below modern stream levels indicating a greater degree of valley dissection just prior to lake ponding than exists today.

In some of the valleys mentioned above it is difficult without detailed mapping to determine whether some of the