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Late Wisconsinan ice sheet flow across northern and central Vermont, USA

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ABSTRACT

A compilation of over 2000 glacial striation azimuths across northern and central Vermont, northeastern USA, provides the basis for interpreting a sequence of ice flow directions across this area. The oldest striations indicate widespread ice flow to the southeast, obliquely across the mountains. Similarly oriented striations between northern Vermont and the ice sheet's terminus in the Gulf of Maine suggest that a broad area of southeast ice flow existed at the Last Glacial Maximum. Younger striations with more southerly azimuths on both the mountain ridgelines and within adjacent valleys indicate that ice sheet flow trajectories in most areas rotated from southeast to south, parallel to the North–South alignment of the mountains, as the ice sheet thinned. This transition in ice flow direction was time transgressive from south to north with the Green Mountains eventually separating a thick south-flowing lobe of ice in the Champlain Valley from a much thinner lobe of south-flowing ice east of the mountains. While this transition was taking place yet ice was still thick enough to flow across the mountains, ice flow along a narrow ~65 km long section of the Green Mountains shifted to the southwest such that ice was flowing into the Champlain Valley. The most likely process driving this change was a limited period of fast ice flow in the Champlain Valley, a short-lived ice streaming event, that drew down the ice surface in the valley. The advancing ice front during this period of fast ice flow may be responsible for the Luzerne Readvance south of Glens Falls, New York. Valley-parallel striations across the area indicate strong topographic control on ice flow as the ice sheet thinned.

1. Introduction

The Laurentide Ice Sheet first advanced across New England approximately 35–45 kyr BP and reached its maximum extent 23–28 kyr BP (Lamothe et al., 2013; Ridge et al., 2012). The earliest surficial geologic map of Vermont (Hitchcock et al., 1861) shows many glacial striae which Hitchcock (1878) combined with observations from across North America to show the Laurentide Ice Sheet's extent and “course of motion.” Since this early work and Goldthwait's compilation of glacial striations and erratic dispersal fans across New York and New England (in Antevs, 1922), geologists have recognized that ice flow across New England during the late Wisconsinan was generally towards the southeast and south.

Glacial striations, in conjunction with other glacial lineations, have been used in numerous studies to assess both small- and large-scale patterns of ice flow (e.g. Lamarche, 1971). While glacial striations have been measured as part of many mapping projects in Vermont, regional compilations of striation data are limited to Goldthwait (Figs. 5–3 in Flint, 1957), those occurring on the Surficial Geologic Map of Vermont (Stewart and MacClintock, 1970), Ackerly and Larsen (1987), and Wright (2006). The purpose of this paper is to use a large data set of accurately measured and located glacial striations across northern and central Vermont to reassess our understanding of changing Laurentide Ice Sheet flow directions across this area and to propose a model that explains why flow directions changed during deglaciation (Fig. 1).

2. Background and previous work

The timing of ice sheet retreat across New England is based on correlated and dated sections of glacial lake sediments, the North American Varve Chronology (Ridge et al., 2012). Based on that chronology, the ice sheet was retreating up the Connecticut river valley, past the southeastern corner of Vermont, approximately 15.5 kyr B.P. and was approaching the Québec border by ~13.4 kyr B.P., deglaciating Vermont over a span of ~2100 years

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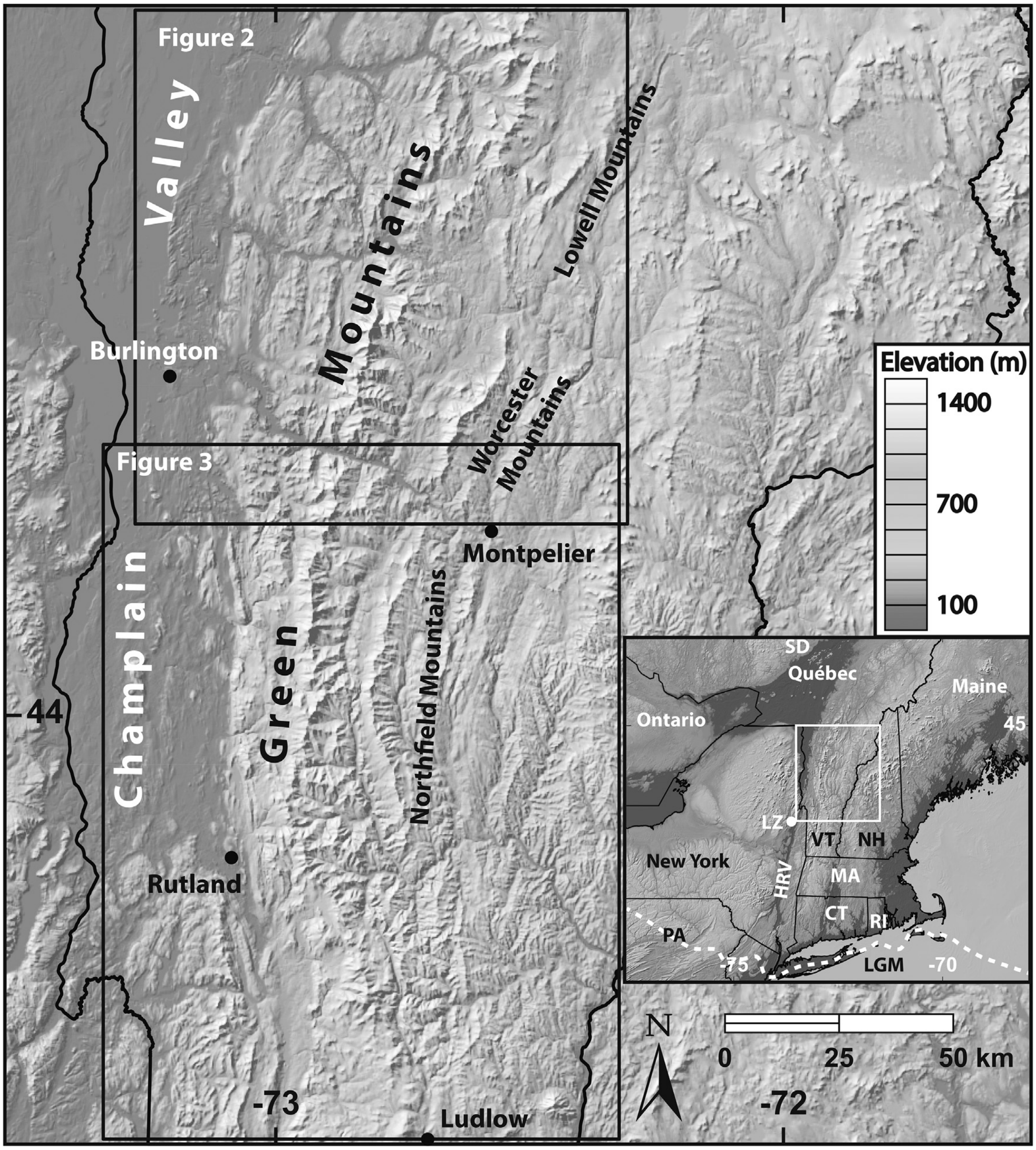

Fig. 1. Map of central and northern Vermont showing the extent of the field area and some of Vermont's major physiographic features. Elevation ranges between ~30 m in the Champlain Valley and over 1300 m for the highest peaks in the Green Mountains. Boxes outline extent of maps in Figs. 2 and 3. SD: St. Didace pluton, HRV: Hudson River Valley, VT: Vermont, NH: New Hampshire, PA: Pennsylvania, MA: Massachusetts, CT: Connecticut, RI: Rhode Island; White dot shows location of Luzerne Readvance (LZ), Dashed line shows approximate position of Last Glacial Maximum terminus (LGM).

(Ridge et al., 2012). However, by their nature the varve record is restricted to the valleys once occupied by glacial lakes and cannot be used to directly date deglaciation of the adjacent mountains.

While the first geologic map of Vermont showed a few glacial striations (Hitchcock et al., 1861), most early work on the state's glacial geology focused on the evolution of glacial lakes and subsequent down-cutting of stream channels through those lake sediments (e.g. Chapman, 1937; Merwin, 1908). The first comprehensive surficial mapping program in the state was systematically undertaken during the 1960's and compiled to produce the Vermont State Surficial Geology Map (Stewart and MacClintock, 1970). Stewart (1961) and Stewart and MacClintock (1969) summarized the results of this extensive mapping effort and put forth their interpretations of Vermont's glacial history. Based largely on till fabric measurements and several stratigraphic sections displaying what they interpreted to be multiple tills, they postulated the existence of three separate Wisconsinan till sheets deposited by ice flowing first from northwest to southeast (depositing the Bennington Drift Sheet), second from northeast to southwest (depositing the Shelburne Drift Sheet), and finally by ice flowing again from northwest to southeast (depositing the Burlington Drift Sheet). The aerial distribution of these till sheets and interpreted ice flow directions was illustrated in an inset map that accompanied the Vermont State Surficial Geology Map (Stewart and MacClintock, 1970).

Using erratic dispersal fans emanating southeast and south from