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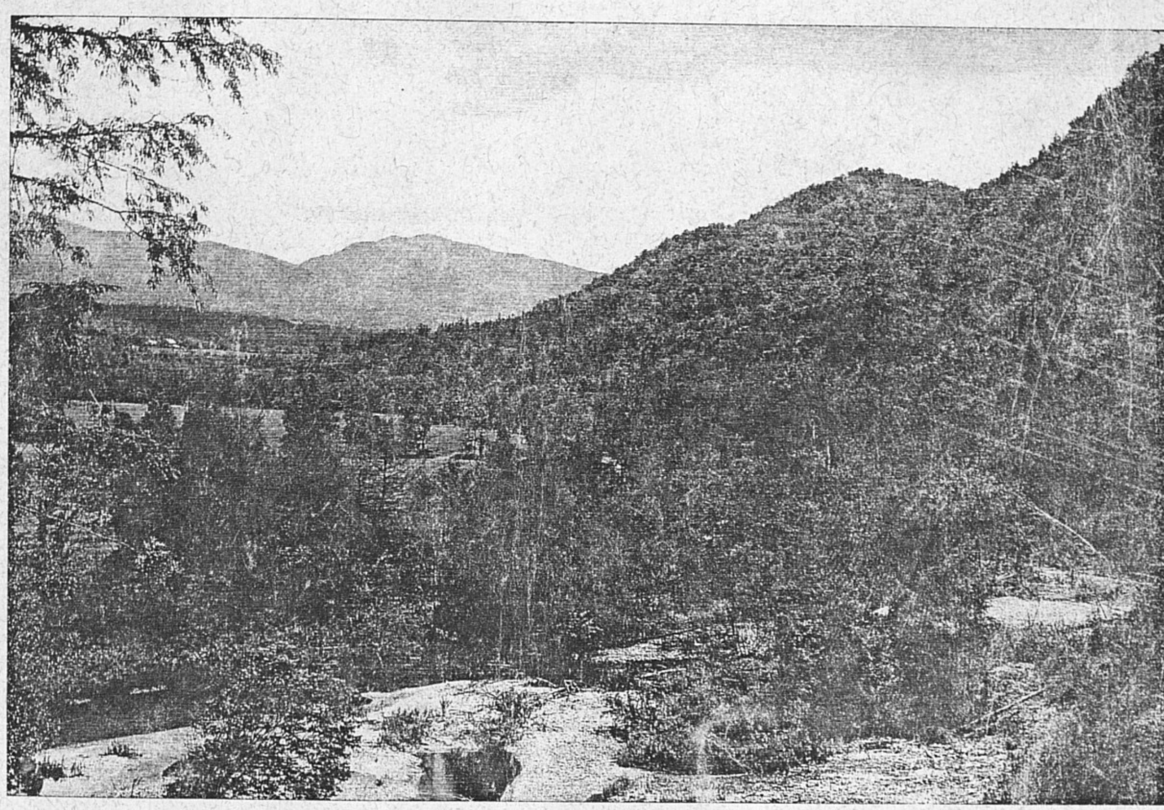
Deglaciation of Southern Chittenden County and Northern Addison County, VT



Deglaciation of Southern Chittenden County and Northern Addison County, VT

A senior, undergraduate thesis by:

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Abstract

Reconnaissance mapping conducted during the summer and fall of 1994 in Lincoln, Huntington, Bristol, Starksboro and Hinesburg, Vermont has led to a more detailed understanding of how glaciers receded from this mountainous area. Unsorted glacial sediment, glacial till, was found to occur along valley sides in the mountainous terrain. Sorted sediment was found in valley bottoms, in areas marginal to valley bottoms, and in deltaic features. Glacial sediment can also be characterized by its association with the glacier upon deposition; in contact with or distal to the ice-margin.

The deglaciation sequence was interpreted by mapping the location of glacial sediment and considering the elevation and location of spillways draining temporarily-impounded glacial lakes. Glacial till is associated with deposition upon glacial advance and sorted sediment is associated with meteoric delta deposition such as the Hollow Brook delta as well as outwash close to the ice margin. In this area, glacial retreat occurred from south to north as indicated by systematic fining of ice contact deposits to the south.

The Hollow Brook delta indicates a massive discharge in the now grossly underfit Hollow Brook. Diversion of the Winooski River by ice to the north increased the discharge in the Hollow Brook Valley. Simultaneous with northward retreat, higher elevations became free of ice before lower elevations. Terraces and deltas throughout the study area suggest many different local and regional lake levels. Evidence in the southern part of the study area is consistent with the systematic ice retreat model of Koteff and Pessl (1981).

Acknowledgments

I would like to thank my advisor, Dr. Paul Bierman, for his patience and all of his gracious help with my research. Dr. Stephen Wright has also provided much welcome guidance as well as being available as a committee member at the last minute for which I am grateful. I would also like to thank Dr. Jack Wilson, committee chairperson, for being available to hear my defence and provide editing comments at the last minute. Dr. Barry Doolan, Dr. Jack Drake, have also been very helpful with the logistics of my thesis.

I would also like to thank my family for their support through this last year; especially Moquecha for her undying patience and sense of humor, and faith in my abilities.

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Introduction

Understanding the distribution of surficial materials is crucial for municipal planners and engineers, among others. In order to better predict the distribution of sediments, understanding paleo-sedimentation is necessary. Armed with this knowledge, wiser decisions can be made regarding such things as proper usage/ conservation of resources, i.e. water, forestry, wildlife, mineral, and cultural resources.

The purpose of this study is to interpret a deglaciation history of southern Chittenden County and northern Addison County, VT based on field observations and background research. In the summer and fall of 1994, I conducted research for my senior undergraduate thesis in geology. The area of research includes South Lincoln and East Middlebury north to Huntington and south Hinesburg, VT (Figure 1).

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Physiographic Setting

Understanding general physiographic attributes of the study area sets the framework and context for deglaciation. Physiographically different regions are characterized by different topographies which is important to consider when studying deglaciation.

The study area encompasses two physiographic regions of Vermont: The Champlain Lowlands and the Green Mountains (Figure 2) (Stewart, 1973). The eastern half of the study area including the Huntington River drainage basin, Lewis and Baldwin Creeks, and the headwaters for the New Haven River basin lie within the Green Mountains (Figure 3). The eastern margin is flanked by some of the highest peaks in Vermont including Camel's Hump, Mount Ellen, Cutts Peak, Mount Abraham, and Lincoln Peak at heights ranging from 4006 ft to 4135 ft. These peaks are part of the spine of the north-south oriented Green Mountain Range of Vermont. The river valley basins of the Huntington River, Lewis and Baldwin Creeks, and the headwaters of the New Haven River are directly adjacent to these high peaks. The Huntington River and the upper New Haven River flow from south to north in their respective basins.

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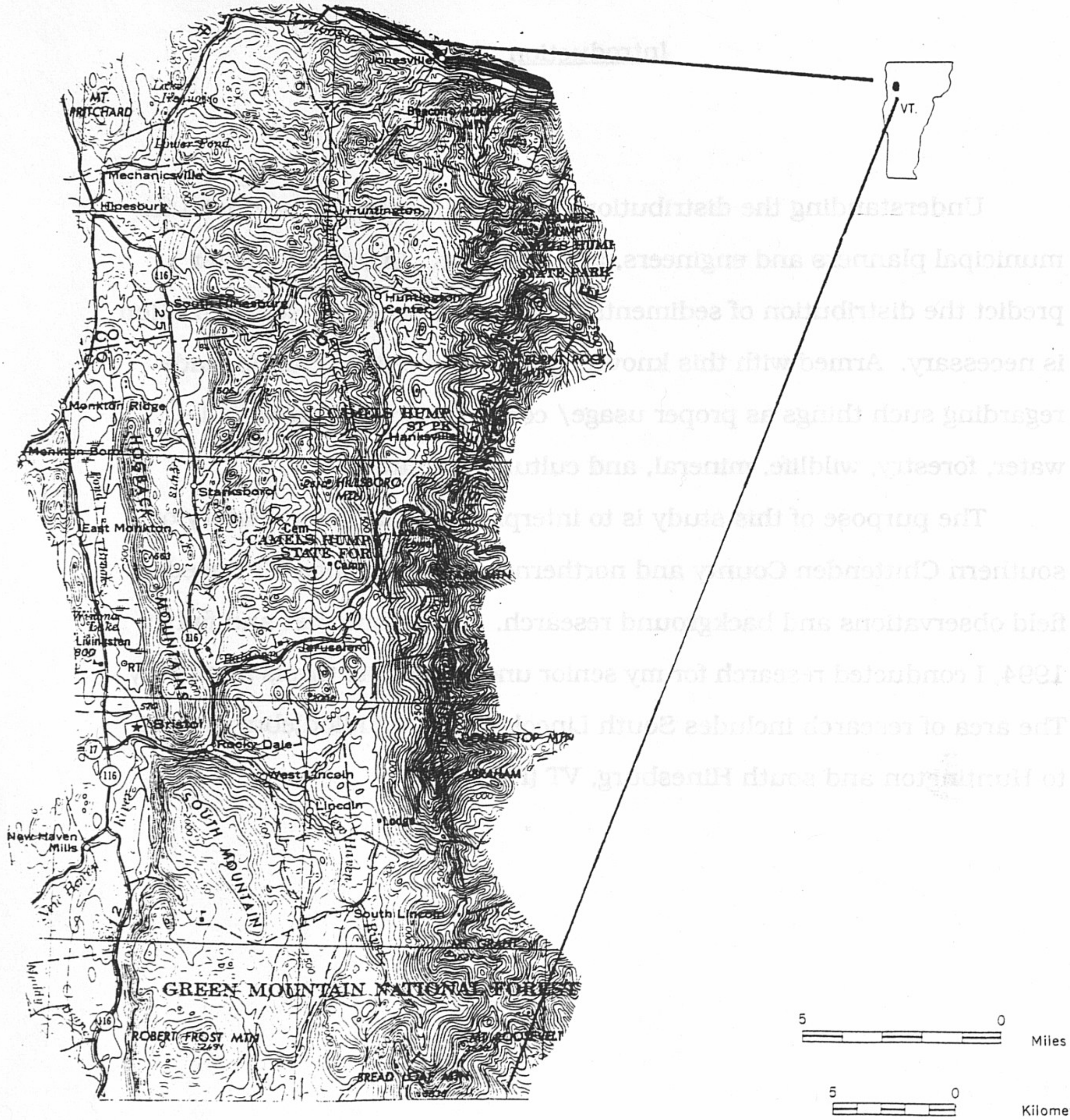

<u>Figure 1</u>. Location of Study area.

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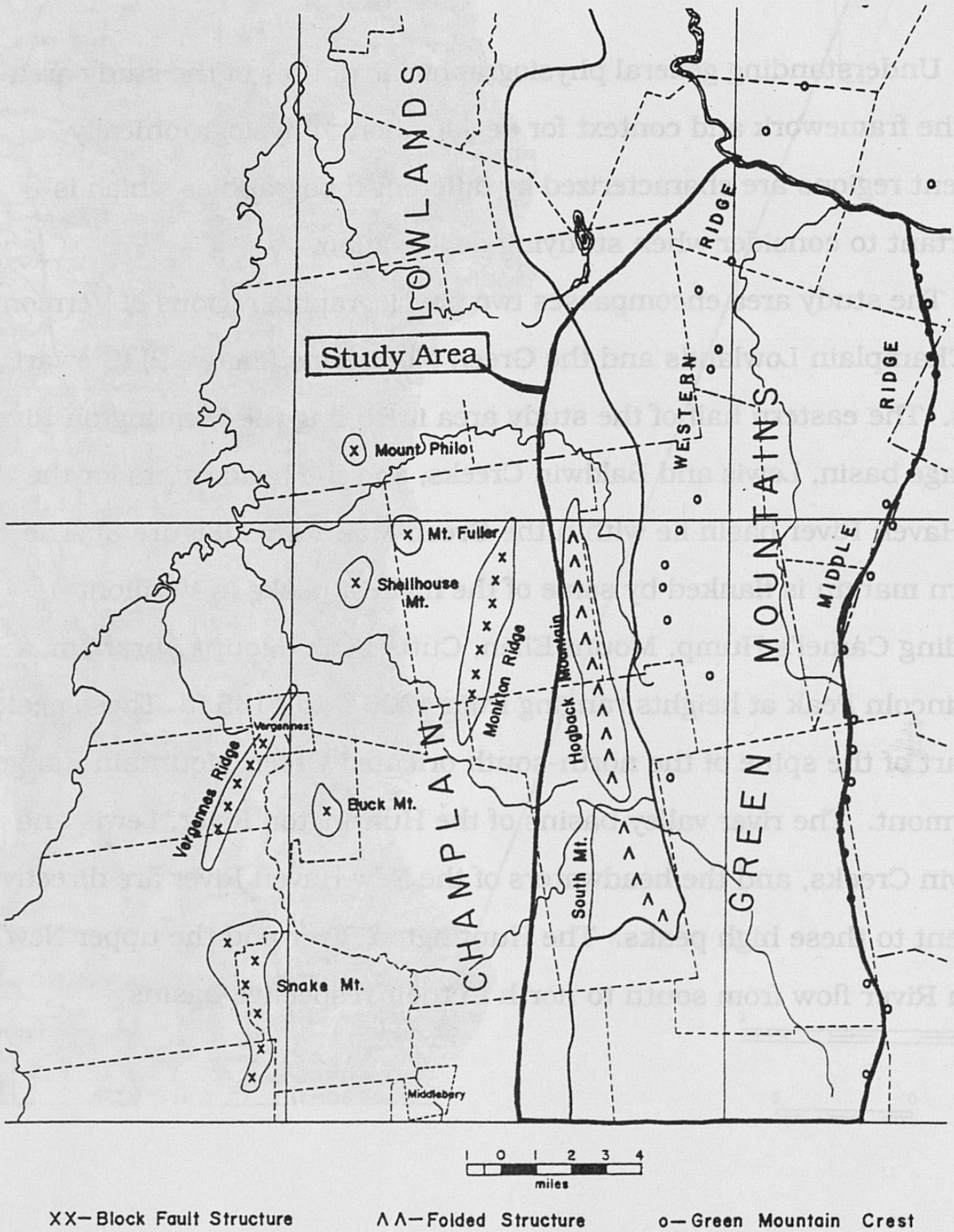

Figure 2. Physiographic subdivisions of the study area (Stewart, 1973).

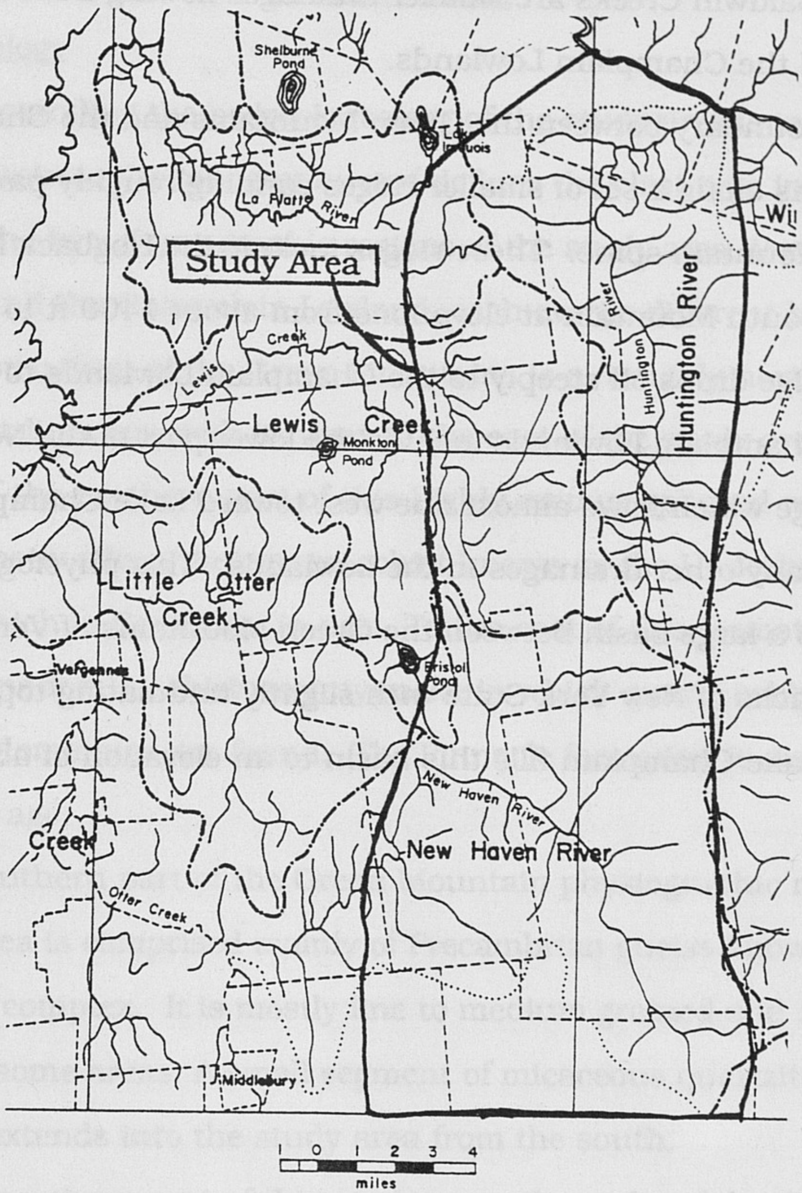

Figure 3. Drainage basins of the study area (Stewart, 1973).

Lewis and Baldwin Creeks are smaller drainages flowing from east to west toward the Champlain Lowlands.

The boundary between the Green Mountains and the Champlain Lowland runs along a set of smaller ridges running roughly parallel to the Green Mountain spine. These ridges include the Hogback Mountain range and South Mountain at elevations from about 1400 ft to 2320 ft asl. This ridge drops off steeply to the Champlain Lowlands to the west.

The Champlain Lowlands include the lower part of the New Haven river drainage which flows almost due west toward Lake Champlain, similar to many other drainages in the Lowlands. This physiographic region forms a large basin between the Green Mountains of Vermont and the Adirondacks of New York State with slightly undulating topography. Currently, Lake Champlain fills this basin to an elevation of about 100 ft asl.

Geologic setting

Bedrock Geology

Understanding the bedrock geology of the study area is important because it controls the topography and defines the clast type in the sediment. The two physiographic regions of the study area, the Green Mountains and the Champlain Lowland, each overlie different bedrock types. The structure of the Green Mountains is a roughly north-south trending anticlinorium with its apex to the east of the study area. The lithologies of the northern part of this highly metamorphosed region consist of mostly silver, grey-green schist known as the Underhill formation which is Cambrian in age. To the east of this formation is the Pinnacle formation, a schistose graywacke in which quartz cobble and boulder conglomerates are found. The Pinnacle formation is also Cambrian in age.

The southern part of the Green Mountain physiographic region in this study area is comprised mainly of Precambrian gneiss known as the Mount Holly complex. It is mostly fine to medium grained and appears schistose in some areas. A small segment of micaceous quartzite/quartz mica schist extends into the study area from the south.

In the northern part of this study area, the rocks of the Green Mountain region are thrust over those of the Champlain Lowland by the Hinesburg thrust fault. Along this fault, there are small, north-south oriented slivers of Cambrian and Ordovician limestones and dolostones. A small anticline to the west consists of grey Winooski Dolostone to the north, purple Monkton and Cheshire quartzites to the south, which are much more resistant to weathering, and another dolostone, the Dunham dolostone sandwiched between these quartzite beds. These lithologies dolostone sandwiched between these quartzite beds. These lithologies are all Cambrian in age. The more resistant Monkton and Cheshire quartzites form the north-south oriented Hogback Mountains and the Dunham dolostone underlies the adjacent valleys.

Surficial Geology

The surficial material can be grouped into seven categories. These include glacial till, ice contact gravel, outwash, lacustrine and marine sands and gravels, lacustrine and marine clays, peat and recent stream alluvium.

Glacial till is described as unsorted, poorly drained material which blankets bedrock and is associated with upland parts of the study area. Outwash and ice contact gravel are identified with upper parts of river valleys and described as well sorted and well drained. Lacustrine sands are identified near valley margins and in pockets abutting South Mountain in the Champlain Lowland. Lacustrine and marine clays are only identified with lower elevations in the Champlain Lowlands. Recent stream alluvium is described as a thin covering over valley floors and is found in the bottom of wider sections of river valleys.

Previous Theories on Local Glacial Retreat

Anyone studying glacial retreat in Vermont is bound to reference Donald H. Chapman. His 1937 paper "Late-glacial and postglacial history of the Champlain Valley" is one of the first to identify lake terrace features associated with post-glacial lakes at various elevations. He also examined crustal rebound features throughout the Champlain valley that will be discussed later. Later in the 1960's, the Vermont Geological Survey mapped surficial material extensively throughout the state. This in turn led to David Stewart's and Paul MacClintock's The Surficial Geology and Pleistocene History of Vermont. Other important research relating to my study area includes Gary Kjelleren's master's thesis regarding the Hollow Brook delta in South Hinesburg.

Glacial advance

The most recent glaciation is evidenced by basal till and bedrock striations. Basal till is unsorted sediment associated with the advance of glaciers. Past researchers relied on measuring the fabric orientation of glacial till believing that this orientation indicates direction of glacial advance in that area. Stewart and MacClintock identified two tills of different clast orientations in this region, the Burlington drift and the Shelburne drift (Stewart and MacClintock, 1969). The Shelburne drift is associated with an earlier glacial advance of the most recent glaciation referred to as the Laurentide Ice Sheet and appeared to have a net southerly orientation whereas the Burlington drift is related to a later advance and appear to have a more southeasterly orientation and different clast lithologies (Figure 4)

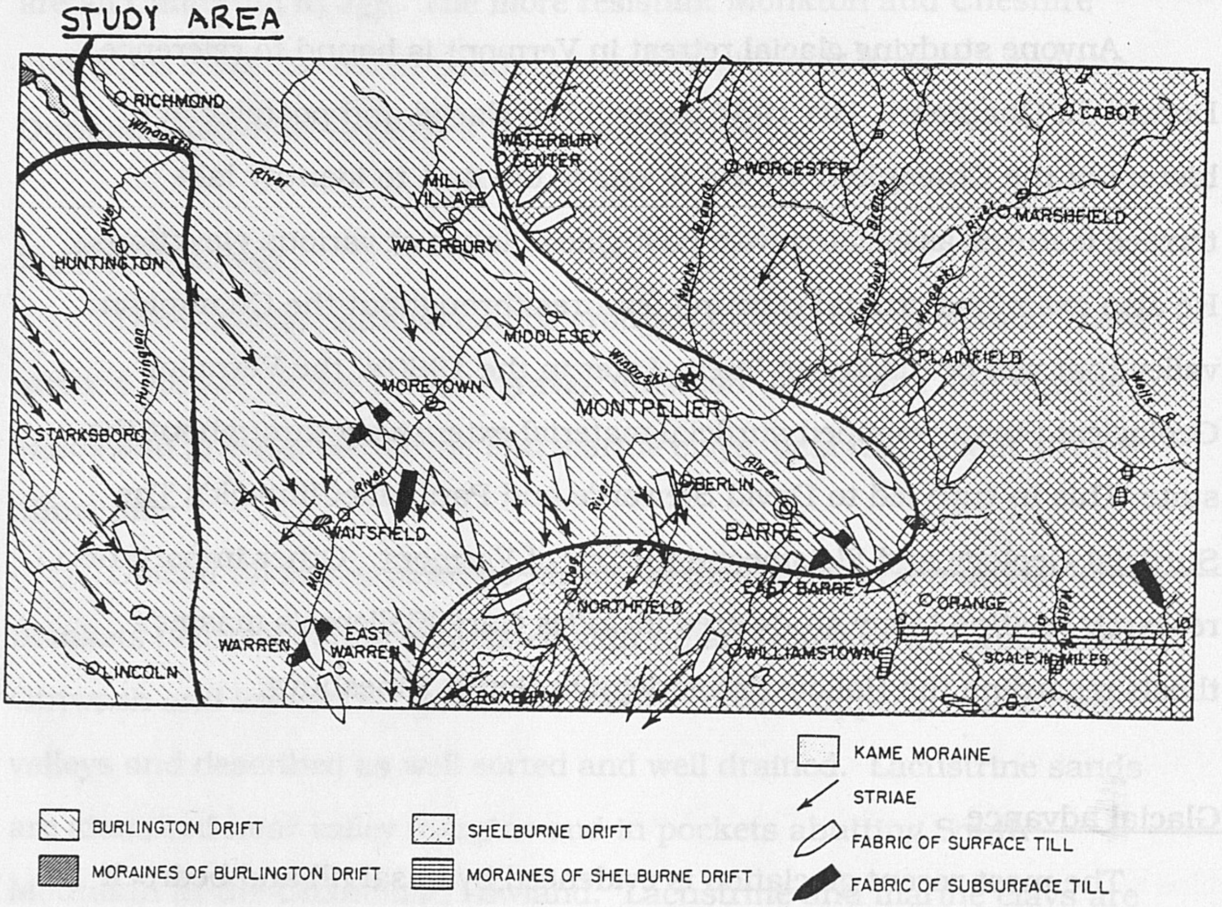

Figure 4. Direction of ice flow of Burlington and Shelburne drifts in vicinity of study area from Stewart and MacClintock, 1969.

(Stewart and MacClintock, 1969). Stewart and MacClintock also identified two distinctly orientations of bedrock striea. In northwestern Vermont, northwesterly oriented striea are found to cut through northeasterly oriented striea which agrees with the fabric orientations of the Shelburne and Burlington drifts (Stewart and MacClintock, 1969). Calkin also identifies northwest oriented striae in Shelburne marbles around Middlebury (Calkin).

High level lakes

Stewart and MacClintock identified five high level glacier-dammed lakes associated with deglaciation in the highlands of the Green Mountains in north-central Vermont by comparing abandoned terraces, deltas, beaches and lake sediment (Stewart and MacClintock, 1969). As the ice downwasted, water was trapped in subdrainages by a more persistent tongue of ice occupying the Winooski River basin. The most easterly subdrainages were occupied by lakes at elevations above 1200 ft asl above sea level. These high-level lakes drained southeast toward glacial Lake Hitchcock where the Connecticut River is today. As ice continued to recede northwest, more subdrainages of the Winooski River continued to fill with lakes and were connected through the eastern portion of the Winooski River valley. As additional spillways opened, these lakes continued to decrease in elevation to just above 900 ft. This last, high-level stage is referred to as Lake Winooski (Figure 5). Stewart and MacClintock also postulated that Lake Winooski drained into Lake Hitchcock until the Hollow Brook valley south of the mouth of the Winooski River valley became free of ice and acted as a an outlet for the Winooski River basin (Figure 6). In 1984, Gary Kjelleren mapped the

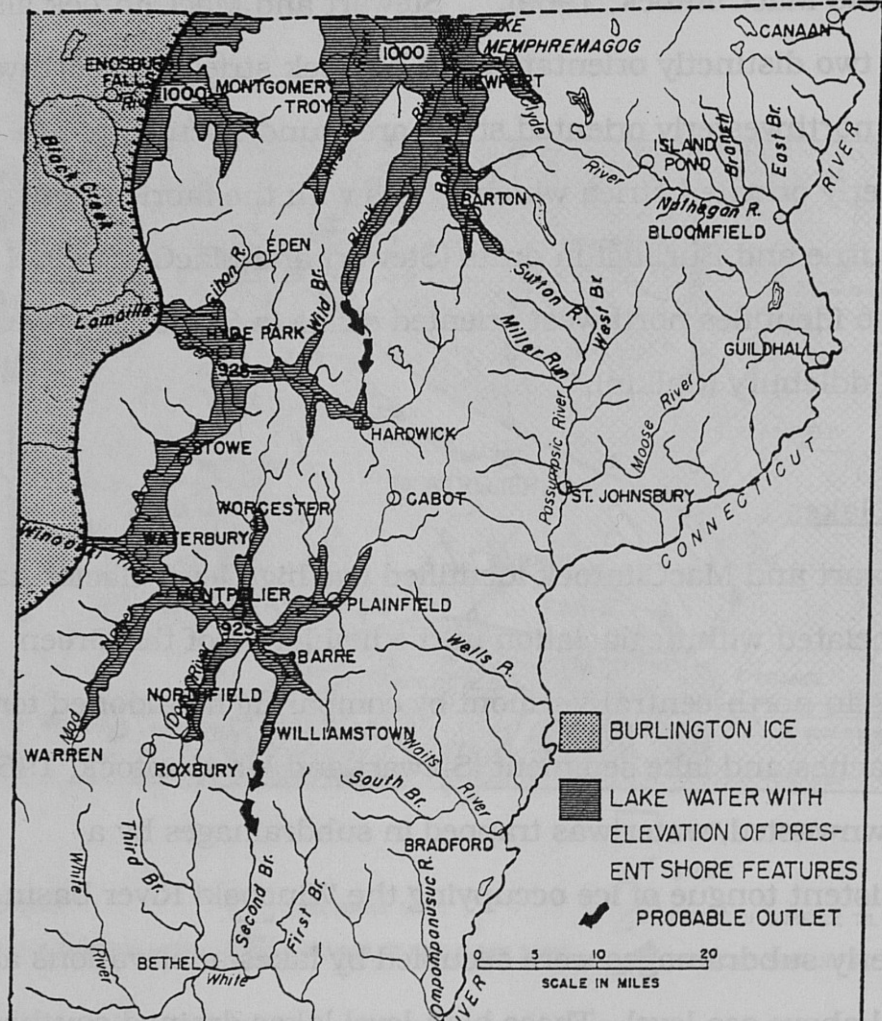

Figure 5. Stewart and MacClintock's last stage of high-level lakes in north-central Vermont from Stewart and MacClintock, 1969.

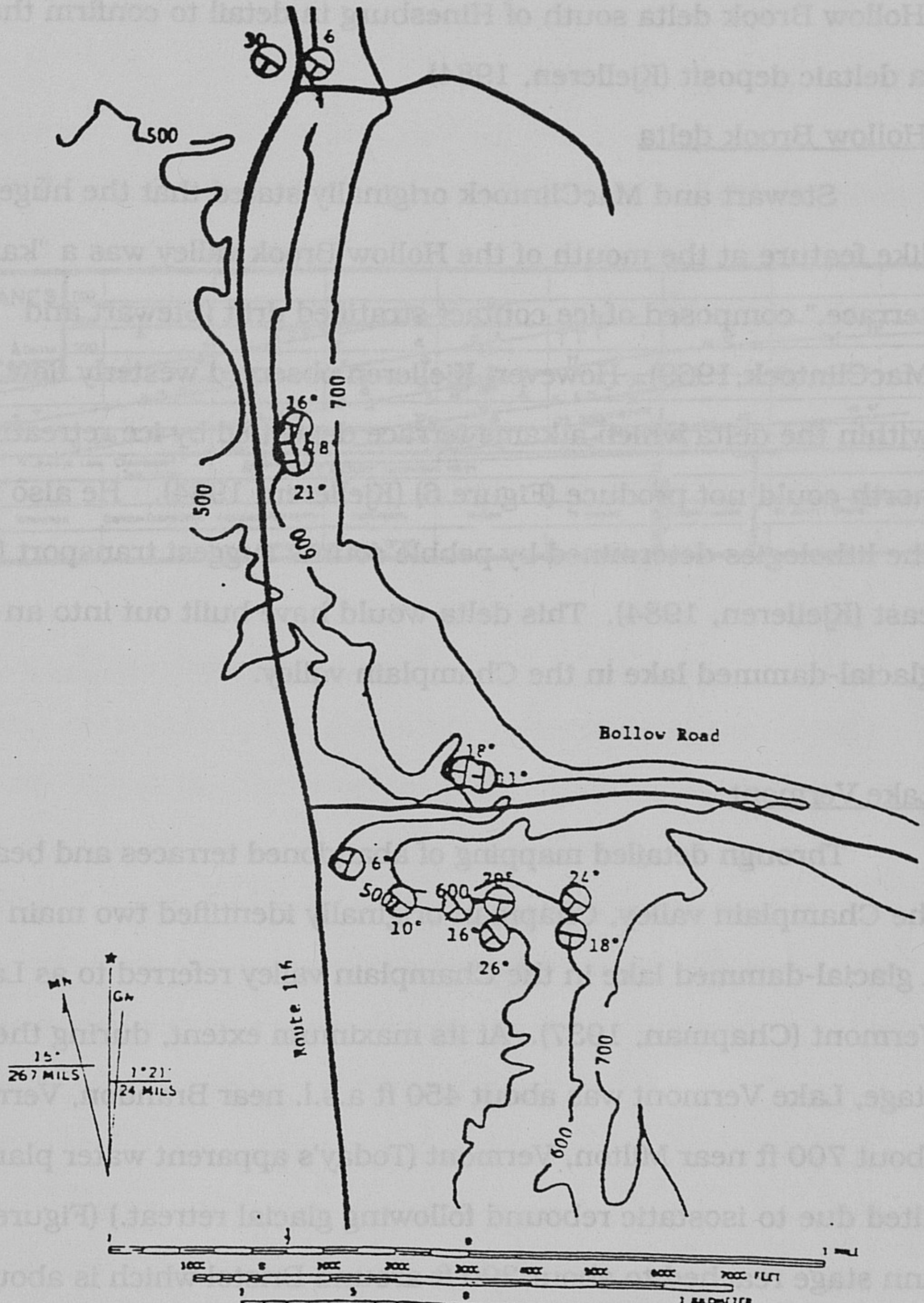

Figure 6. Paleocurrent directions from foreset beds of Hollow Brook deposit from Kjelleren, 1984.

Hollow Brook delta south of Hinesburg in detail to confirm that this was a deltaic deposit (Kjelleren, 1984).

Hollow Brook delta

Stewart and MacClintock originally stated that the huge, terrace-like feature at the mouth of the Hollow Brook valley was a "kame terrace," composed of ice contact stratified drift (Stewart and MacClintock, 1969). However, Kjelleren observed westerly flow directions within the delta which a kame terrace deposited by ice retreating to the north could not produce (Figure 6) (Kjelleren, 1984). He also found that the lithologies determined by pebble counts suggest transport from the east (Kjelleren, 1984). This delta would have built out into an early, glacial-dammed lake in the Champlain valley.

Lake Vermont

Through detailed mapping of abandoned terraces and beaches in the Champlain valley, Chapman originally identified two main stages of a glacial-dammed lake in the Champlain valley referred to as Lake Vermont (Chapman, 1937). At its maximum extent, during the Coveville stage, Lake Vermont was about 450 ft a.s.l. near Brandon, Vermont and about 700 ft near Milton, Vermont (Today's apparent water planes are tilted due to isostatic rebound following glacial retreat.) (Figure 7). Fort Ann stage reached to about 390 ft around Bristol which is about 150 ft below the Coveville stage.

Stewart and MacClintock elaborate on Chapman's lake levels. They identify Quaker Springs Lake Stage shore features approximately 100 ft above the Coveville level (Stewart and MacClintock, 1969). This suggests a higher, earlier lake than the Coveville.

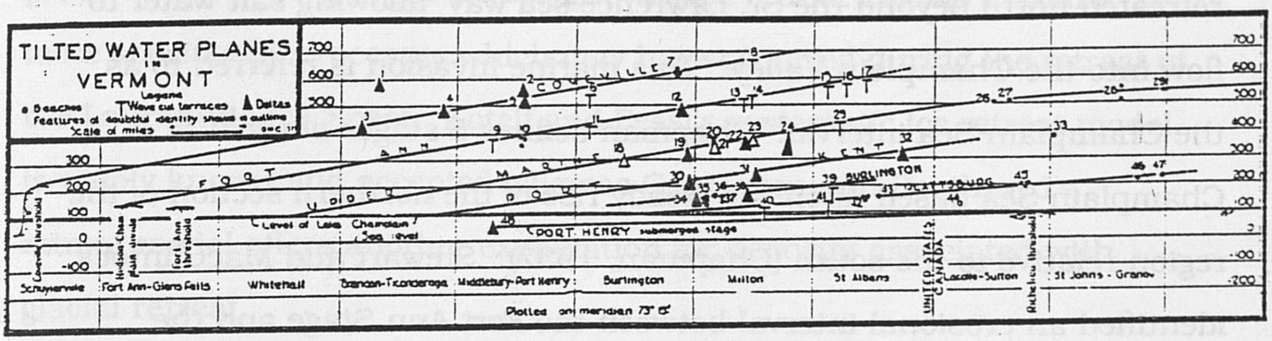

Figure 7. The effect of isostatic rebound on features left from various stages of Lake Vermont from Chapman, 1937. This also shows the relationship of lake stage elevations.

Champlain Sea

Chapman found that the Fort Ann stage of Lake Vermont was followed by a marine invasion (Chapman, 1937). This occurred as ice retreated north beyond the St. Lawrence sea way allowing salt water to flow into the Champlain Valley. This marine invasion is referred to as the Champlain Sea interval. Chapman defines 5 stages of the Champlain Sea based upon the steady rise of the northern section of the region relative to the south (Chapman, 1937). Stewart and MacClintock identified an erosional interval between the Fort Ann Stage and the Champlain Sea (Stewart and MacClintock). Eventually, marine waters are cut off from the Champlain Valley and Lake Champlain is formed.

Retreat Models

Both retreat models discussed in this paper examine glacial retreat processes occurring at the ice margin. These retreat models examine more specifically processes which may have occurred during the retreat of the Laurentide Ice Sheet. Koteff and Pessl's systematic ice retreat model is widely known and accepted whereas Gustavson and Boothroyd's retreat model offers another explanation for deposits associated with glacial retreat.

Koteff and Pessl's Systematic Ice Retreat Model

Koteff and Pessl identify two ice marginal zones: "stagnant zone" and "active zone" (Figure 8). There are shearing planes between these two zones along which sediment is transported. This is referred to as the “dirt machine.” Koteff and Pessl also suggest that the pace of retreat is variable during which the ice margin is stationary at certain time intervals. This systematic ice retreat deposits similar, stratified formations, or morphosequences, along the path of ice retreat. These formations appear as wedge shaped with the wider end at the ice margin (Figure 9). These features also have coarser material at the ice-proximal end and become finer away from the ice margin (Figure 10). Ice blocks would also be present in these deposits. As these ice blocks melted, deformation such as faulting occurred in the surrounding sediment.