1-1-1972

Woodfordian Glacial History of the Champlain Lowland, Burlington to Brandon, Vermont

Connally, S. Gordan

Calkin, Parker E.

Trip G-6

WOODFORDIAN GLACIAL HISTORY OF THE CHAMPLAIN LOWLAND, BURLINGTON TO BRANDON, VERMONT

by

G. Gordon Connally and Parker E. Calkin
State University of New York at Buffalo

INTRODUCTION

The surficial geology of the Champlain lowland and bordering Green Mountains of west-central Vermont has been generally known for many years. However, the results of a recent, comprehensive, state-wide study in Vermont and studies in the upper Hudson Valley of New York have led to the definition of one major problem and the reinterpretation of two significant aspects of deglaciation; the physical characteristics of the waning glacier and the extent of proglacial lakes impounded by the retreating ice margin.

At least two tills are present in the Champlain Valley in western Vermont and one in the Connecticut Valley in eastern Vermont. The problem is whether the eastern till correlates with the upper or the lower Champlain Valley till.

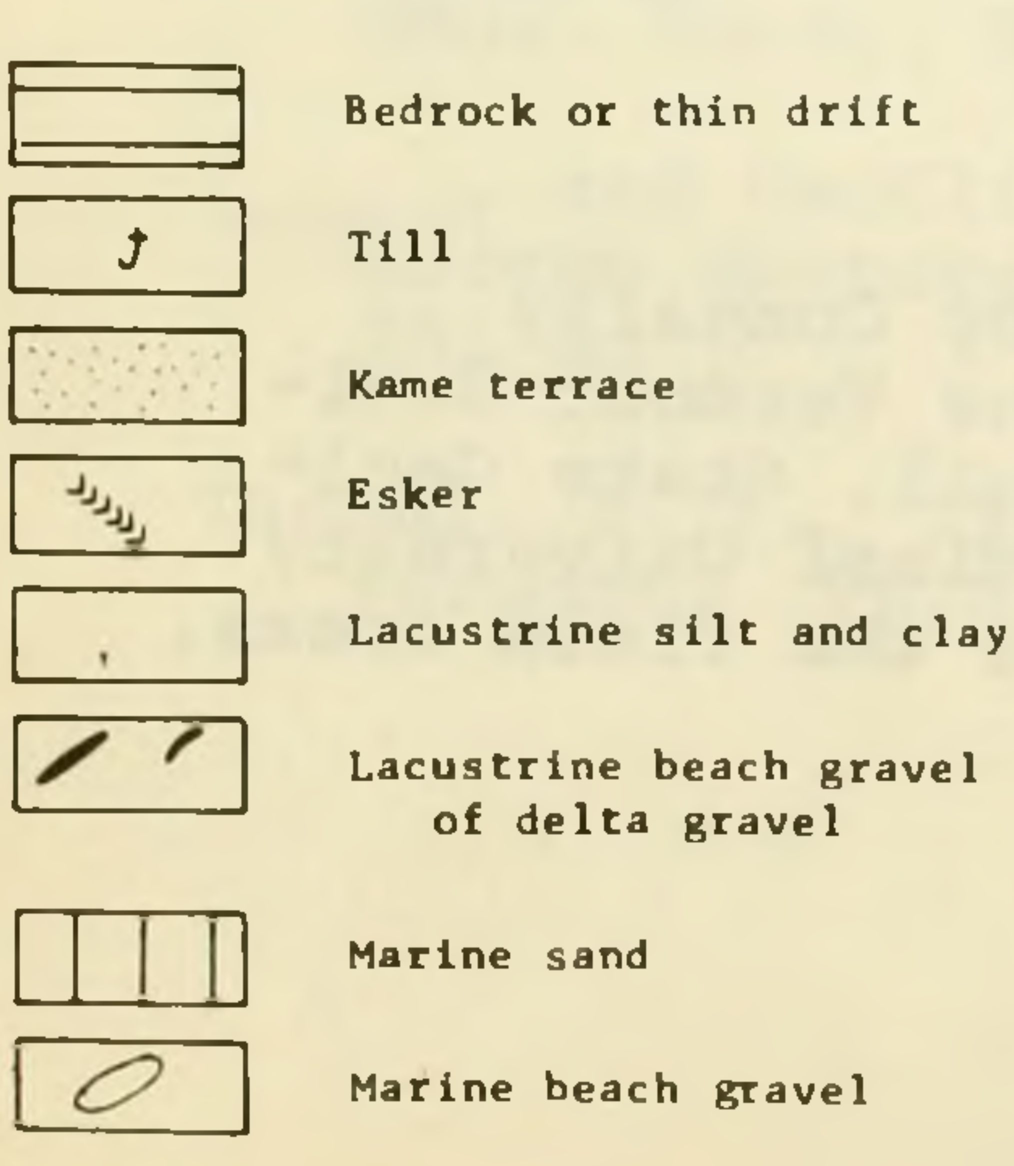
The many kame terraces which flank the Green Mountain front throughout the Champlain Valley were incorrectly correlated by early workers. This led to the conclusion that the last glacier had stagnated and downwasted in place. However, it has now been shown that each kame terrace belongs to a discrete south-sloping sequence of ice-contact and outwash deposits. The sequences formed successively during recession of the margin of a still-active glacier.

Early workers correctly concluded that the clays, sands, beaches, and deltas flanking the Green Mountains were results of proglacial lakes. They inferred that these lakes were confined to the Champlain Valley. It has now been shown that the highest levels in the Champlain Valley were coextensive with similar lakes in the Hudson Valley which has led to an updating of terminology.

ACKNOWLEDGEMENTS

Field study by Calkin (Middlebury Quad.) and by Connally (Brandon and Ticonderoga Quads.) was supported by the Vermont Geological Survey. We are indebted to Dr. Charles G. Doll, State Geologist for his help, and to Dr. David P. Stewart of Miami University for many stimulating discussions and introduction to the field areas.

Fig. 1. Generalized glacial geologic map of the Champlain Lowland from Burlington to Brandon, Vermont.



THE BURLINGTON-SHELBURNE PROBLEM

The Champlain lowland and bordering Green Mountains have been overridden at least twice and probably three or more times by continental ice sheets during the Pleistocene. McDonald and Shilts (1971) record at least three distinct glaciations in Quebec, to the north, while Borns and Calkin (1970) distinguish at least two in northwestern Maine, to the east. Local evidence includes multiple-till sections, differences in till fabric orientations, and striations on scoured bedrock surfaces, all reported by Stewart and MacClintock (1969).

In four well exposed, multiple-till sections (Shelburne, Lewis Creek, Little Creek and West Bridport sites (see stops 1, 3 and 7, Figure 1) between Burlington and Brandon, lodgement tills with northwest fabrics are underlain by similarly compact tills with slightly different lithologies and northeast fabrics. At the Lewis Creek and Little Otter Creek sites varved clay records an ice recession between deposition of the contrasting tills. The observations of a northwest-derived surface till over a northeast-derived till is supported at several places in the Middlebury, Brandon, and Ticonderoga quadrangles where weak but definite northeast striae are cut by northwest striae. Supporting evidence from fabrics and striae is reported by Stewart and MacClintock (1969) for the bordering mountainous areas of northwestern Vermont . Although the division unfortunately has been based almost entirely on till fabrics, and there are occurrences of apparently contradictory till fabrics; the evidence for two till sheets in west-central Vermont is convincing.

Stewart and MacClintock (1969) defined the lower, northeast-derived till as the Shelburne till and the upper, northwest-derived till as the Burlington till. Some workers have questioned the interpretation of two tills at the type section of the Shelburne till, but a more important Burlington-Shelburne problem, discussed by Stewart and MacClintock (1969, p. 190), arises relative to the definition of the boundary between these tills and the correlation of the lower, northeast-derived lodgement till of the Champlain Valley with an ablation till with northeast fabric in eastern Vermont. The sandy ablation deposits of southeastern Vermont may well be the result of normal reorganization and lobation of a thinning ice mass in the north-northeast-trending Connecticut Valley; therefore, these could have been laid down by the same continental glacier that deposited the Burlington till in northwestern Vermont as suggested by Shilts and Behling (1967) and postulated by Stewart and MacClintock (1969, p. 80) as their Alternate Hypothesis III.

However, the Burlington-Shelburne problem is resolved, the Burlington appears to be a lithologically correlatable till sheet in northwestern Vermont. The Burlington till may represent the late

Woodfordian Luzerne readvance; the underlying Shelburne till deposited by the ice sheet that receded from the main Woodfordian Ronkonkoma Moraine on Long Island about 18,000 yrs. B. P. (Connally and Sirkin, 1972). Alternately, the Burlington drift may be a western facies of a much more extensive drift sheet that represents the entire Woodfordian. In either case it is possible that at least some of the lower tills of multiple till sites in the Champlain Valley record pre-Woodfordian glaciation. However, Connally (1970) postulated that both lodgement tills at the West Bridport section are from the last Woodfordian glaciation because of the orientation of striae on the smoothly polished bedrock surface beneath the till.

ACTIVE ICE RETREAT

Recession from the Burlington glaciation involved stagnation and downwasting in the Green Mountains while backwasting of an active, calving, ice margin occurred in the Champlain lowland where the terminus fronted a series of expanding glacial lakes. The wide, and apparently continuous series of kame terraces depicted in Figure 1 can be separated into discrete sequences. Each sequence grades southward from ice-contact deposits, through kame moraines, and onto outwash aprons. Connally (1970) describes five separate sequences in the Brandon quadrangle, each of which includes one or more kame terraces. Elsewhere, the presence of interbedded tills and lacustrine deposits in numerous subsurface exposures indicates that the recession of the Burlington glacier involved frequent frontal oscillations (Calkin, 1965).

Calkin (1965) demonstrated that large remnants of stagnant ice downwasted in depressions in the Green Mountains producing an abundance and variety of dead-ice deposits while continental ice was still actively receding in the Champlain Valley. These upland remnants shed outwash down the major valleys from high mountain divides and onto the retreating ice sheet. The outwash forms the bulk of the ice-contact drift in many of the kame terraces adjacent to the Green Mountains.

Connally and Sirkin (1970) suggest that the Burlington drift of Vermont is equivalent to the till of the Luzerne readvance near Glens Falls, New York and is therefore about 13,200 years old. Recession from the Luzerne readvance was underway by 13,150 yrs. B.P. The ice sheet retreated steadily northward through the Champlain Valley interrupted only by the Bridport readvance (Connally, 1970). This readvance extended from the vicinity of Burlington to near Bridport about 12,800 yrs. B.P. (Connally and Sirkin, 1972). No moraine marks the terminus of this readvance; glacial lake waters apparently prevented formation of any distinct recessional moraines in the lowland. Overriding of lacustrine deposits and calving of the active ice margin of the Bridport readvance probably caused the ubiquitous bouldery clay shown by Stewart and MacClintock (1970) between Burlington and Bridport.

GLACIAL LAKE HISTORY

Chapman (1937, 1942) made an exhaustive study of lacustrine and marine strandlines in the Champlain Valley. Chapman combined the marine levels as The Champlain Sea. He defined an upper, Coveville Stage and a lower, Fort Ann Stage comprising Lake Vermont. Stewart (1961) added an even higher Quaker Springs Stage. LaFleur (1965) working in the Hudson Valley, suggested that the lowest levels of Lake Albany in the Hudson Valley were coextensive with the upper levels of Lake Vermont in the Champlain Valley. Connally (1968) working in the uplands between the Hudson and Champlain Valleys confirmed LaFleur's suggestion. Connally and Sirkin (1971) altered existing terminology by restricting the name Lake Albany to the highest lake in the Hudson Valley, dropping the provincial name Lake Vermont, extending the names Lake Quaker Springs and Lake Coveville to the coextensive lakes, and using the name Lake Fort Ann for the lowest freshwater lake in the Champlain Valley. Lakes Albany, Quaker Springs, and probably Coveville extended all the way south to the Harbor Hill Moraine across Staten Island, New York.

The Woodfordian glacier, in its northward recession up the Hudson Valley, fronted an expanding Lake Albany. The Luzerne readvance took place during the existence of this lake and presumably the deposition of the Burlington till. With retreat of the Burlington ice margin into the Champlain Valley, the land to the south rebounded differentially causing a relative lowering of the lake level and formation of Lake Quaker Springs. Stewart and MacClintock (1969, 1970) projected Lake Quaker Springs northward to the Lamoille River, 15 miles north of Burlington. They state (1969, p. 163) that in this general area "the shore line features are so well developed that they seem to indicate that the Quaker Springs Lake was in existence for an interval as long as the later lake stages". However, good evidence for this lake is lacking north of Brandon in the Brandon and Middlebury quadrangles and Connally and Sirkin (1972) and Connally (1972) place the ice margin in the vicinity of Brandon, and Ticonderoga, New York, during Lake Quaker Springs.

As the ice margin retreated northward the land continued to rebound and the outlet shared by Lakes Albany and Quaker Springs was evidently breached forming Lake Coveville at a lower elevation. The ice retreated to near Burlington, readvanced to Bridport, and then retreated at least as far as the Lamoille Valley; all during the existence of Lake Coveville. Finally, the ice retreated to the north end of the Champlain Valley, the land continued to rebound, and a probable dam near Fort Ann, New York, formed Lake Fort Ann. Lake Fort Ann was most likely dammed to the north by the glacier as it stood at the Highland Front Moraine about 12,600 yrs. B.P.

Retreat of the Burlington ice north of the St. Lawrence Valley allowed Lake Fort Ann to drain northward down to lower levels (see Wagner, 1969). Following a short erosional interval (Stewart and MacClintock, 1969, p. 178) the Champlain Valley was invaded by marine waters to form the Champlain Sea. Coldwater marine molluscs in clays and sands between Vergennes and Burlington document at least one stage of the Champlain Sea in the field trip area.

FIELD TRIP STOP DESCRIPTIONS

Topographic 15 minute quadrangles covered: Burlington
Middlebury
Ticonderoga
Brandon

STOP 1. SHELBURNE VILLAGE SECTION: This is the type locality for the Shelburne drift described by Stewart (1961, p. 102) as "a small stream valley, one and one-quarter miles south-southwest of Shelburne Village. The Valley walls ... expose a layer of dark gray till over bedrock ... overlain by fifteen feet of red-brown sandy till that is covered by four to eight feet of bouldery lacustrine clay. ... The orientation of pebbles in the gray till show a fabric with maximum approximately north 30° east. The fabric of the overlying till is north 15° west." The lower till was later named the Shelburne till. Many workers have subsequently visited this section; some have supported the two-till interpretation while others have challenged it.

STOP 2. LEWIS CREEK DELTA: A gully exposure in this marine delta, 1500' south of Lewis Creek off Rt. 7 displayed the following section in 1965:

2'	Sand, pebbly, probably marine; at 200' elevation.
15'	Clay, gray, with scattered shells of marine clams.
8'	Clay, brown, bouldery, probably lacustrine.
5'	Till, gray lodgement; boulder pavement at top.
1'	Sand, brown, stratified.

A very well formed beach ridge nearby at 250' may mark the high stage of the Champlain Sea or a post Lake Fort Ann stage, called "Lake New York" by Wagner (1969).

STOP 3. LITTLE OTTER CREEK SECTION: The composite section along the creek two miles north of New Haven shows the following:

2-10'	Clay, bouldery, with stratified lenses of silt and sand; lateral gradation to till.

3-10' Till, clay-rich with boulders of varved clay; fabrics are N 4°W, N 6°W, and N 35°W.

3' Varved clay in situ.

14' Till, brown, bouldery, lodgement; fabrics are N 35° E and N 19° E.

15' Sand, pebbly, poorly stratified and interbedded till.

The upper till may be assigned to the Burlington Stade, the lower to the Shelburne (Calkin, 1965). Interbedded tills and lacustrine deposits suggest an active oscillating ice margin.

STOP 4. BRISTOL KAME TERRACE - DELTA: The ice contact deposits as first described by Chapman (1942) appear to be topped by a deltaic surface (village and airport) of Lake Coveville at 570'. Wave erosion at this level may have carried gravel out over the ice contact gravels to form the foreset-like beds seen at the outer edge (Stewart and MacClintock, 1969). Weak bars at the Lake Fort Ann level (420' here) occur nearby.

STOP 5. THE COBBLE AND KETTLED KAME TERRACE: Five miles south of Bristol off Rt. 116 is the Cobble, a bedrock outliner which has controlled the great width of the kame terrace here. Two kettle holes over 40' deep in the surface at 540-580' are below the level projected for Lake Quaker Springs. Do these kettles preclude the existence of Lake Quaker Springs here ?

STOP 6. CHIPMAN HILL, MIDDLEBURY AND LUNCH. This hill has more than 400' of relief, has exposures of bedrock near the base at the north, but only till is found at the surface within the upper 300'. Is it a drumlin ?

STOP 7. WEST BRIDPORT SECTION: This section was described by Connally (1970, p. 11). In 1964 the exposure showed:

0-2' Silty-clay containing ice-rafted(?) pebbles and boulders.

16' Silt and sand, laminated to thin-bedded, lacustrine.

5 1/2' Clay-loam till, dark gray (N3), with a lower 12-18" gray-black (N2) till overlain by 12-18" of oxidized gravel at the base.

3' Sandy-loam till, light olive-gray (5y 5/2), calcareous sandy-loam till.

Bedrock with striae oriented N 10° E.

Till fabric maxima are N 50° E for the olive-gray till and N 30° W for the overlying dark gray till. This agrees with the definition of NE Shelburne overlain by NW Burlington as seen at Stop 1. However, Connally (1970, Table 2) attributes the striae and both tills to the Burlington advance. The upper, bouldery, silty-clay is inferred to represent the Bridport readvance.

STOP 8. BRANDON-FORESTDALE DELTA: This delta was deposited by the Neshobe River. Chapman (1937, p. 59) inferred the Coveville level at 430' at Brandon but Connally (1970, p. 21) placed it at 405' farther south where Chapman's projection is 420'. Chapman attributed higher levels to local lakes but Connally correlated the well developed 500' level with Lake Quaker Springs. If time permits the 405', 500', and a higher 565' level related to the Lake Dunmore kame moraine will be visited.

STOP 9. LAKE DUNMORE KAME MORAINE: The kame moraine is part of a full deglacial sequence that consists of kame terraces surrounding Lake Dunmore, the moraine, outwash at Forestdale, and the eastern channel of the Brandon-Forestdale delta that is graded to a local lake level at 565'. We will drive through this sequence and stop if time permits.

STOP 10. COVEVILLE BEACH: Reworking of a kame terrace belonging to a sequence higher and earlier than the Lake Dunmore moraine is present north of the Middlebury River. This kame terrace has been reworked to form a sandy apron, probably a beach, at the base of the terrace at 480'. This is only about 20' below Chapman's projection for Lake Coveville. Because there is no beach between the pre-Lake Quaker Springs kame terrace and the Coveville level beach, the northern boundary of Lake Quaker Springs is inferred to be south of the Middlebury River, near Brandon.

REFERENCES CITED

Borns, H. W., and Calkin, P. E., 1970, Quaternary history of northwestern Maine; <u>in</u> Boone, G. M. (Editor), Guidebook, N.E.I.G.C., 62nd Ann. Mtg., p. E-2, 1-6.

Calkin, P. E., 1965, Glacial Geology of the Middlebury fifteen minute quadrangle; Open-file Rept. to Vermont State Geologist, 23 p.

Chapman, D. E., 1937, Late-glacial and post-glacial history of the Champlain Valley: American Jour. of Sci., v. 34, p. 89-124.

______, 1942, Late-glacial and post-glacial history of the Champlain Valley, Vermont: Vermont State Geologist, 23rd Rept., p. 48-83.

Connally, G. G., 1968, Surficial resources of the Champlain Basin: Ms. to New York State Office of Planning Coordination, 111 p.

_____, 1970, Surficial geology of the Brandon-Ticonderoga 15-minute quadrangles, Vermont: Vermont Geol. Survey, Studies in Vt. Geol., No. 2, 32 p.

_____, 1972, Major proglacial lakes in the Hudson Valley and their rebound history (Abs.): Geol. Soc. America, Abstracts with Programs, Pt. 1, p. 11.

_____, and Sirkin, L. A., 1970, Late glacial history of the upper Wallkill Valley, New York: Geol. Soc. America Bull., v. 81, p. 3797-3306.

_____, and _____, 1971, The Luzerne readvance near Glens Falls, New York: Geol. Soc. America Bull., v. 82, p. 989-1008.

_____, and _____, 1972, The Wisconsinan history of the Hudson-Champlain lobe: Geol. Soc. America, Spec. Paper (in press).

LaFleur, R. G., 1965, Glacial geology of the Troy, New York quadrangle: New York State Museum, Map and Chart Series 7, 22 p.

MacDonald, B. C., and Shilts, W. W., 1971, Quaternary stratigraphy and events in southeastern Quebec: Geol. Soc. America Bull., v. 82, p. 683-698.

Shilts, W. W., and Behling, R. E., 1967, Deglaciation of the Vermont Valley and adjacent highlands (Abs.): Geol. Soc. America, Abstracts Ann. Mtg., p. 203.

Stewart, D. P., 1961, Glacial history of Vermont: Vermont Geol. Survey Bull., No. 31, 124 p.

_____, and MacClintock, P., 1964, The Wisconsin stratigraphy of northern Vermont: American Jour. Sci., v. 262, p. 1089-1097.

_____, and _____, 1969, The surficial geology and Pleistocene history of Vermont: Vermont Geol. Survey Bull., No. 31, 251 p.

_____, and _____, 1970, Surficial geologic map of Vermont: Doll, C. G. (Editor), Vermont Geol. Survey.

Wagner, W. P., 1969, The late Pleistocene of the Champlain Valley, Vermont: in Barnett, S. G. (Editor) Guidebook, New York State Geol. Assoc., 40th Ann. Mtg., p. 65-80.

____, 1970, Surficial geology of the Brandon-Ticonderoga 15-minute quadrangles, Vermont: Vermont Geol. Survey, Studies in Vt. Geol., No. 1, 32 p.

____, 1972, Pro-glacial lakes in the Hudson Valley and their recorded history (Abs.): Geol. Soc. America, Abstracts with Programs, Pt. 1, p. 11.

____, and Sirkin, L. A., 1970, Late glacial history of the upper Wallkill Valley, New York: Geol. Soc. America Bull., v. 81, p. 3297-3306.

____, and ____, 1971, The Luzerne readvance near Glens Falls, New York: Geol. Soc. America Bull., v. 82, p. 989-1008.

____, and ____, 1973, The Wisconsinan history of the Hudson-Champlain lobe: Geol. Soc. America, Memoir 136.

LaFleur, R. G., 1965, Glacial geology of the Troy, New York quadrangle: New York State Museum, Map and Chart Series 7, 22 p.

MacDonald, B. C., and Shilts, W. W., 1971, Quaternary stratigraphy and events in southeastern Quebec: Geol. Soc. America Bull., v. 82, p. 683-698.

Shilts, W. W., and Behling, R. E., 1967, Deglaciation of the Vermont Valley and adjacent highlands (Abs.): Geol. Soc. America, Abstracts Ann. Mtg., p. 204.

Stewart, D. P., 1961, Glacial history of Vermont: Vermont Geol. Survey Bull., No. 19, 124 p.

____, and MacClintock, P., 1964, The Wisconsin stratigraphy of northern Vermont: American Jour. Sci., v. 262, p. 1089-1097.

____, and ____, 1969, The surficial geology and Pleistocene history of Vermont: Vermont Geol. Survey Bull., No. 31, 251 p.

____, and ____, 1970, Surficial geologic map of Vermont: Doll, C. G. (Editor), Vermont Geol. Survey.

Wagner, W. P., 1969, The late Pleistocene of the Champlain Valley, Vermont: in Barnett, S. G. (Editor) Guidebook, New York State Geol. Assoc., 41st Ann. Mtg., p. 65-80.