SURFICIAL GEOLOGY OF THE LINCOLN MOUNTAIN QUADRANGLE, VERMONT

by Parker E. Calkin and Paul MacClintock

(A Report to the State Geologist of Vermont)

INTRODUCTION

Location

The Lincoln Mountain quadrangle, covering an area of approximately 215 square miles, is defined by latitudes 44° 00' and 44° 15' north and longitudes 72° 45' and 73° 00' west in central Vermont (fig. 1). The area lies within parts of Addison, Washington, and Chittenden Counties. In this areaare the principal villages of Lincoln, Moretown, Irasville, Waitsfield, and Warren, as well as the lavish ski resorts of Sugarbush Valley.

Physiographic and Geologic Setting

The Lincoln Mountain quadrangle lies at the eastern edge of the Green Mountain physiographic province. In addition to the north-south oriented Green Mountain range proper, the quadrangle includes the Northfield Mountain ridge along the eastern edge, which is considered part of the Vermont Piedmont province.

Peaks of the latter average between 2,400 and 3,000 feet while along the Green Mountains, the elevation reaches up to 4,013 feet above sea level at Lincoln Peak (fig. 2).

Although the whole area has been covered by the continental ice sheet during the Pleistocene, the principal and most interesting glacial features

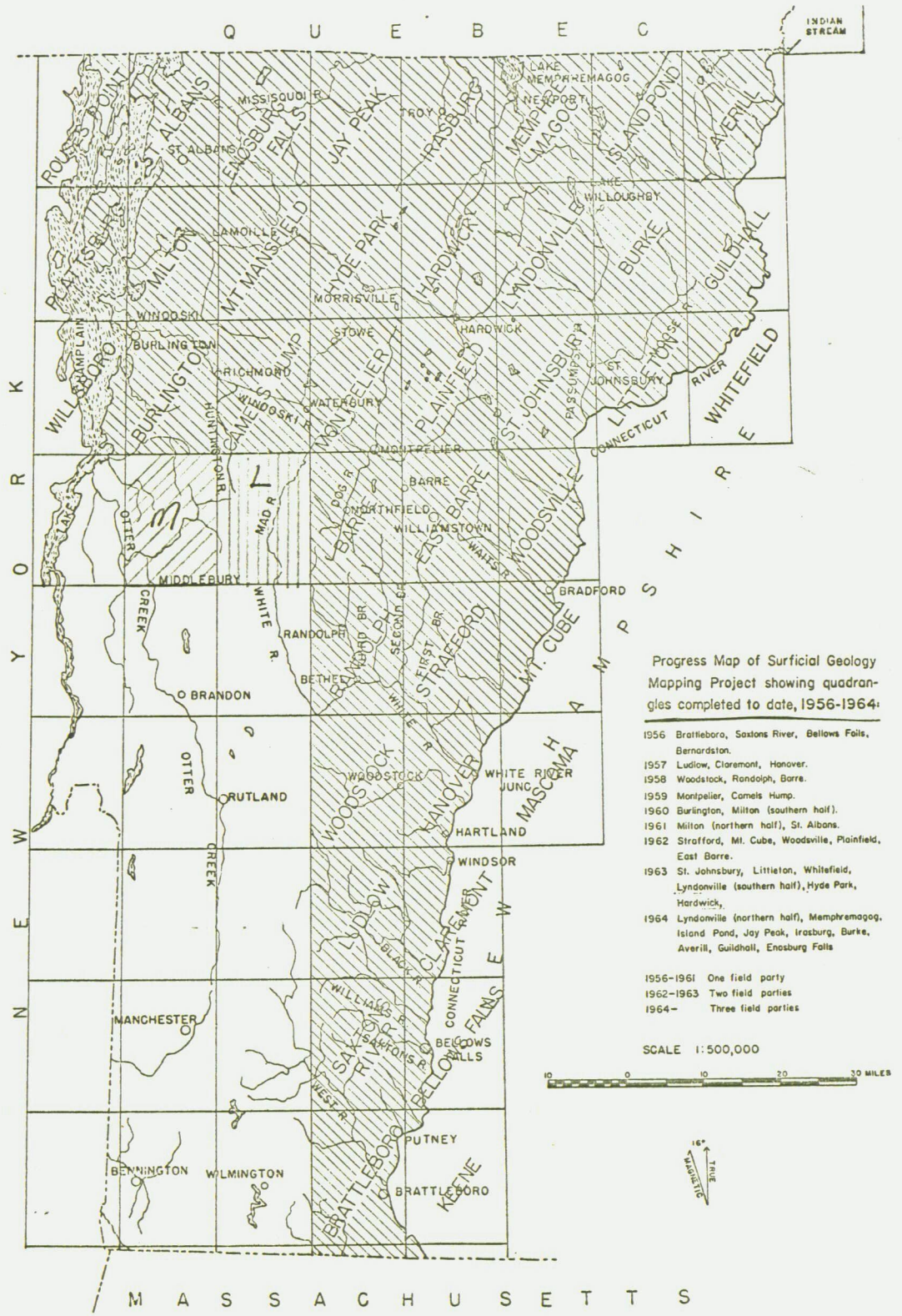
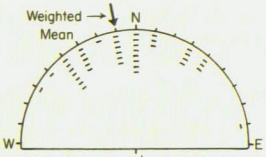
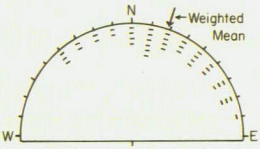


Figure 1. Map showing location of the Lincoln Mountain quadrangle (L) and the Middlebury quadrangle (M).

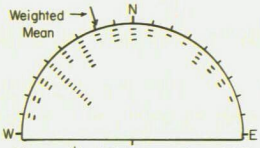
Figure 2. View looking west southwest across the Mad River Valley from below Burnt Mountain toward Lincoln Mountain.



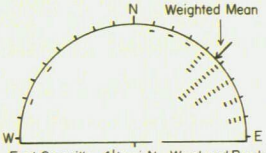
Waitsfield Common, ½mi. E.N.E.
Lincoln Mt. Q.



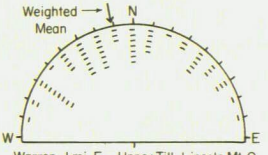
Waitsfield Common, Valley 1 mi. N. E.
Lincoln Mt. Q.



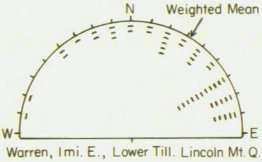
Warren, 1½ mi. E., Upland. Lincoln Mt. Q.



East Granville, 4½ mi. N., Woodward Brook
Lincoln Mt. Q.



Warren, 1 mi. E., Upper Till. Lincoln Mt. Q.



Warren, 1 mi. E., Lower Till. Lincoln Mt. Q.

of deposition lie in the two major valleys, i.e., that on the west side of the Green Mountain ridge occupied by the villages of South Lincoln, Lincoln, and Jerusalem, and in the Mad River Valley between the two mountain ridges to the east. The latter river flows north from a divide near Granville Notch at 1382 feet and leaves the northeast corner of the quadrangle at Moretown about 640 feet above sea level.

The area is predominantly underlain by a typical eugeosynclinal assemblage of Lower Cambrian phyllite, schist, and gneiss ((fig. 3). Some Precambrian gneisses of the basement complex crop out at the core of the north trending Lincoln Anticlinorium (southwestern corner of the quadrangle). The Lower Cambrian beds strike north-south and dip with moderate to steep inclination off two north-south trending anticlines (see Cady et. al., 196).

Acknowledgements

The fieldwork for this report was undertaken during August and early September of 1965. Parker Calkin was ably assisted by James Lehmann and received guidance in the field from David P. Stewart. The southwestern third of the area was completed by Paul MacClintock assisted by Joseph Jackimovicz.

Previous Work

The bedrock geology is well displayed in the Centennial Geologic Map of Vermont (Doll, 1961) and a detailed bedrock map of the area was made by Cady and others (196). A general background of the glaciation of Vermont is given by Stewart (1961) and surrounding quadrangle maps of the surficial geology are on file in the offices of the Vermont Geological Survey.

Figure 3. Map showing trends of bedrock and contacts in the Lincoln Mountain quadrangle. Є - Cambrian, pЄ - Precambrian, OC - Ordovician/ Cambrian.

PLEISTOCENE GLACIAL FEATURES

Glacial Sculpture

During the Pleistocene time, glaciers advanced southward into New England several times, leaving this area for the last time about 12,000 years ago (see Stewart, 1961; Stewart and MacClintock, 1964; Schafer and Hartshorn, 1965). Results of this activity are displayed by the glacially rounded peaks and hills typical of the massive crystalline rock outcrops in New England. In addition, the two main valleys are broad U-shaped valleys, being modified by through-moving continental ice (fig. 4).

Striations and Grooves

Glacial striations and grooves were only rarely found over the quadrangle. The coarse grained or foliated bedrock either was not stratified or it was weathered too rapidly to preserve these marks and the short time in the field did not permit extensive search for preserved marks in the scattered bedrock exposures of the mountains. However, gneiss, freshly exposed northwest of Irasville village, shows northeast striae crossed by northwest striae, a phenomena also displayed in the Camels Hump quadrangle to the north and in the Middlebury quadrangle to the east.

Till

Unstratified and moderately to poorly sorted deposits laid down from basal ice during an advance (lodgement till) and let down from within, or from the surface of, melting ice on recession (ablation till) are shown on the map. Most of this till is thin and lacks morainal topography. In the mountains this deposit is largely ablation till, being very sandy or

Figure 4. View looking east southeast across the Mad River Valley. Northfield Mountains (a) in distance, with till covered uplands (b), kame terrace (c) above floodplain of the Mad River (d). Uplands and kame terrace are dissected here by Charles Folsom Brook.

gravelly, frequently partially sorted, and in places very poorly stratified. Except for its general lack of stratification, such deposits are similar to some glaciofluvial deposits.

Such thin deposits and partial sorting is to be expected in mountainous areas where glacial erosion was predominent over deposition and eroded material was washed by outwash streams to the lowlands. Here too, down-wasting of the ice sheet was predominant and slow slipping and sliding of debris off stagnant ice blocks probably was a significant factor in sorting. Such a process has been observed in operation at the terminae of present glaciers where pebbles and sand are separated over inclined ice surfaces due to varying thresholds of movement and wind action.

Till of the Mad River Valley

Most of the surface till of the Mad River Valley and adjoining uplands to the east, between the villages of Warren and Moretown, is extremely rich in clay-silt and noticably low in boulder and pebble content. Because of its fine texture and apparent compaction, it is probably of lodgement origin. However, the unusually fine texture in this area is also probably due to the incorporation of underlying, fine, lacustrine deposits. The origin for the lacustrine deposits is considered in another section.

Stratigraphy and Till Fabric

Due to the lack of sufficient time spent in the area, coupled with complexity and interest generated by the stratified drift, only six exposures of till were examined in any detail. Measured sections, till fabrics, and samples are tabulated below by locality.

Western Valley Area

1. Basement excavation northwest of Jerusalem corners, adjacent to Hollock Brook at west central border of quadrangle.

   Till, sandy ablation, with lenses of stratified drift; 20' plus; weighted mean fabric 15W. Sample 204

Mad River Valley Area

1. Road/stream cut 1.5 miles west of Rt. 100 (near Moretown) on Shepard Brook road. Elevation approx. 780' above sea level.

   (5) Till, very silty, noticable paucity of stones; horizontal platy structure (lodgement?); slope former; 15'; weighted mean fabric 19W. Sample 207

   (4) Till, sandy (ablation), many boulders in upper portion; forms steep slope; 13'; weighted mean fabric 24W. Sample 206

   (3) Sand, coarse - medium grained, moderately bedded; 3'.

   (2) Till, sandy and bouldery; forms cliff; rests on boulder pavement of till below; 6'; weighted mean fabric 14E.

   (1) Till, pebbly - cobbly, lodgement; 6' plus; weighted mean fabric N-S. Sample 205

2. Basement cut one mile northeast of Waitsfield Common (uplands above the Mad River Valley).

   Till, silty/clayey with rare boulders and unusually few pebbles; weighted mean fabric N-S. Sample 208

3. Gully one to two miles northeast of Waitsfield Common.

   Till; weighted mean fabric 10W.

4. Roadcut one mile east of Warren village.

   Till; weighted mean fabric 11W.

   Silt, lacustrine, 10'.

   Till; weighted mean fabric 32E.

5. Cut on upland farther east beyond #4 above.

   Till; weighted mean fabric 19W.

6. Cut at southeast corner of Lincoln Mountain quadrangle, east base of Northfield Mountain.

Till, weighted mean fabric 17E, although preference poorly displayed.

Multiple Wisconsin Glaciation

The meager data from striations together with that from the till sections considered above, suggests that the Lincoln Mountain quadrangle has been overridden during the Wisconsin by at least Two distinct glacial advances. The earlier advance was from the northeast while the latter was from the northwest as indicated by the stratigraphic sections at Shepard Brook and east of Warren. In both these areas, the two tills are separated by lacustrine sediments. Elsewhere surface tills show unquestionable derivation from southeastward moving ice and indeed the fine texture of the "northwest" tills in the Mad River Valley area suggest incorporation of lacustrine sediments. This history is well shown at Shepard Brrok by the upper 15 feet of till (unite 5, sec. 1). Boulder pavements on the top of the third till (unite 4, sec. 1) and between the lower two tills (units 2 & 3) at this location also support intervening lacustrine phases.

The lack of weathering profiles in the lower till or in the interbedded lacustrine deposits suggests that both advances probably occurred during the Wisconsin time and were not separated by significant time periods. Therefore, it seems reasonable to correlate the upper till with the Burlington tills (NW fabric) and the lower with the Shelburne till (NE fabric) of Stewart (1961) and Stewart and MacClintock (1964).

Stratified Drift

Kame Terraces

Kame terraces are very widely scattered in the Lincoln Mountain quadrangle and have been mapped at many elevations from 800 feet up to 2300 feet. It is likely that, could more time be spent traversing the Green Mountains, terraces and gravel deposits would be found on the flanks of the highest peaks. Such a distribution of kame terraces as this quadrangle displays leaves little doubt that the ice down-wasted in these mountains, leaving stagnant ice blocks detached from the active ice front.

Display of kame terraces is particularly good in the vicinity of Lincoln and South Lincoln villages. East of the New Haven River the Lincoln Gap road crosses a two-story terrace system with levels at 1020 feet and at about 1100 feet above sea level. Two miles south of South Lincoln, along the New Haven River, at 1530 feet, a terrace remnant between creek branches reveals over 100 feet of bedded sand and gravel. Most of the large accumulations are presently used, or have been used in the past, for construction materials. The locations of these pits are displayed on the map.

In the Mad River Valley and adjoining uplands, the kame terraces frequently contain a few lenses or beds of nearly pure clay up to two feet in thickness. A portion of the Mad River kame terrace is shown in figure 4.

Kame Moraine

Hummocky masses of collapsed stratified gravel and sand occur on flat uplands or within valleys of this area. Particularly large hummocky areas were mapped 0.5 to 1.5 miles south of Jerusalem and across the mountains to the east, at Waitsfield Common and at Moretown.

Although mapped as kame moraine for project continuity, most of these deposits lack obvious linearity and may perhaps be better termed kame fields. An exception, is the pronounced loop-ridge fromed of stratified gravel, lacustrine silt-clay and spotty till at Moretown village. This feature may represent a stand of the ice front while glacial Lake Moretown was formed and/or it may represent a position of the ice front when the Mad River Valley train was deposited.

Eskers

Two narrow ridges stand on the kame terrace along the east bank of the New Haven River, southeast of South Lincoln village. Each of these gravel ridges stand above the surrounding terrace with some 30 to 50 feet of constructional relief.

Outwash

Paired terrace remnants of a valley train deposit were mapped at heights of 40 to 60 feet above the flood plain of the Mad River in the northeastern part of the quadrangle. Numerous exposures in these terraces show sands and gravels, much coarser than the present bed material of the river and lacking ice-contact deformational structures.

The terraces between Irasville and Moretown have an upper surface averaging near 700 feet with higher elevations at the southern end. The northward slope of the terrace may possibly be attributed to either erosion of the post-glacial, north flowing Mad River before it cut down to its present surface, or less likely, to the piecemeal deposition of successively lower segments in front of the northward-retreating ice edge. Mill Brook, Shepard Brook, Charles Folsom Brook, Freeman Brook, and numerous other

tributaries have barbed junction with the Mad River and thus have been captured and diverted from southward to northward flow in post-glacial time.

Lacustrine Deposits and Glacial Lake Moretown

Lacustrine sand and gravel have not been shown on the map; however, extensive silts and clays of lacustrine origin were found up to 1000 feet elevation along Shepard Brook and along the Mad River near Moretown village. Local proglacial lakes must have accompanied recessions of the ice front in the area as the land slope is now strongly northward in the valley and probably was also in glacial time.

Indication of extensive deposits of clay and silt and some sand below the upper till sheet (Burlington) in the Mad River Valley area is suggested by: 1) narrow (not mappable) clay slopes along the Mad River Valley; 2) silts or clays encountered below surface tills with northwest fabrics and above tills with northeast fabrics at Shepard Brook and in the area of East Warren; 3) reports of thick "blue clays" below clayey till; one and one half miles north of Scrap Mountain Peak a resident reported drilling through 5 to 10 feet of "blue clay" after passing through 10 feet of till at the surface; at the road fork 0.5 miles southeast of Waitsfield, at about 760 feet, another resident reported drilling through more than 80 feet of "blue clay" after passing through the surface till; and 4) the silty and clayey nature of tills in Shepard Brook and Mad River Valleys, and in the upland to the east below Scrag Mountain.

Much more detailed work is needed in this area but preliminary work suggests that the above-mentioned deposits may have been related to: 1) a 1000 foot level in the Connecticut Valley lake (see Stewart, 1961) previous to the last glacial advance over the quadrangle; or 2) a local, glacially dammed lake, "Lake Moretown", in the Mad River Valley north of Warren village. No evidence for a level of the Connecticut Valley lake above about 695 feet has been found and it seems probable that the silt and clay deposits represent deposition in a local lake probably dammed either by the advancing Burlington ice or by the retreating front of the Shelburne ice front as it stood at or near Moretown. This lake probably had levels above 1000 feet and perhaps initially had levels above 1400 feet near East Warren, draining southward over the divide at Granville Notch.

CONCLUSIONS WITH REGARD TO THE PLEISTOCENE HISTORY

1. The few glacial striations observed suggest that the most recent glacial advance into this area came from the northwest, possibly following an earlier advance from the northeast. This conclusion agrees with observations in the Camels Hump and Middlebury quadrangles to the north and west respectively.

2. Till fabrics measured at five locations (most in Mad River Valley area) also suggest that the last glacial advance came from the northwest, with a preceeding advance from the northeast.

3. Lacustrine silts and clays beneath the surface drifts at several locations and the high proportion of fines and lack of stones in the surface till

itself, suggest the former presense of a relatively extensive proglacial lake, "Lake Moretown". This lake was dammed either by the waning Shelburne ice front or by the suceeding, advancing Burlington ice. This lake may have been dammed for some time by ice in the narrow gorge of the Mad River at Moretown.

4. With the down-wasting and recession of the last ice in the quadrangle, large extensive kame terraces were formed followed by thick valley train deposition in the Mad River Valley near Irasville and Moretown.

5. With glacial recession from Moretown, a small proglacial lake probably accompanied the ice front in the northeastern corner of the quadrangle until the outlet to the Winooski River was opened. At this time the drainage of the Mad River Valley turned northward again from its temporary southward diversion.

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