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THE PLEISTOCENE GEOLOGY OF THE BENNINGTON AREA, VERMONT

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The Bennington Map Area includes the Bennington 15 minute quadrangle and the Vermont portions of the Hoosic Falls, North Pownal, Berlin, Williamstown, and North Adams 7½ minute quadrangles.

The writer studied this area during June and July of the summer of 1966 as a part of the surficial geology mapping program of the Vermont Geological Survey. He was assisted in the field by Kenneth Beem.

The surficial geology of this area has been examined and discussed in a cursory manner by several geologists. Hitckcock at al. (1861) noted the southeast movement of "drift" across the Green Mountains. They inferred this from observations of southeasterly displacement of Cheshire Quartzite and Stamford Granite Gneiss (part of the Mount Holly Complex) from the areas of outcrop of these formations. They also postulated that the quartzite found west of the outcrop area of the Cheshire was actually Potsdam Sandstone from New York.

Taylor (1903) studied the southern half of the area and described morainic systems which he felt were correlative from valley to valley. Taylor (1916) described the deposits of glacial Lake Bascom in the Hoosic Rivdr Valley. The highest water plane of Lake Bascom was at an altitude of 1125-1130 feet. Taylor suggested that there were later, lower stages of this lake with water planes at unspecified altitudes.

Burt (1932 a,b) felt that erosion in the Vermont Valley was minimal because of the preservation of soft "Miocene" kaolin deposits beneath the drift. He felt that the tills and gravels of the valley had been "let down" after melting of a stagnant block of ice. C.E. Gordon (1941, 1942) suggested that the ice occupying the Vermont Valley during deglaciation down wasted in stages leaving definite terrace levels along the valley sides. MacFadyen (1956) stated that the extensive gravels of the Vermont Valley were deposited as coarse lake sediments in a pro-glacial lake. The Glacial Map of the United States (1957) outlines the outwash deposit at Bennington and another "outwash" deposit in the Vermont portion of the Hoosic River valley. The source of this information is not indicated.

PHYSIOGRAPHY

The physiography of the Bennington area consists of three distinct provinces (Jacobs, 1950). The Vermont Valley forms a prominent topographic low, bounded on the west by the Taconic Mountains and on the east by the Green Mountains. To the south, the Vermont Valley dies out near Pownal where the Taconic and Green Mountains merge into a continuous highland. The Green Mountain front rises as an abrupt scarp on the east side of the valley. The Taconics rise more gently on the west side to somewhat lower altitudes. In the southeastern quarter of the Bennington 15 minute quadrangle the North Branch of the Hoosic River cuts a deep valley which separates the Green Mountains from their structural extension, the Hoosac Mountains. The maximum relief of the area of interest is 3248 feet.

The present major drainage of the area is by way of the Walloomsac and Hoosic Rivers. The Walloomsac flows almost east-west, cutting a gorge across the structure of the Green Mountains. After leaving the mountains, it flows west through a broad trough in the Taconics and into the lowlands of the Hudson River Valley. The Hoosic flows northwestward through a gap in the Taconics and joins the Walloomsac in the Hudson lowlands. Both streams are transverse across the structure of the Green and Taconic Mountains. Minor streams generally flow parallel to the strike of the structure, about north 10^0 to 20^0 east.

The Bennington area is lightly populated. The major "industries" are tourism and logging. Iron was mined from the ochre deposits in the late 18th and early 19th centuries. Ceramics and brick manufacturers utilized the kaolin and lacustrine clay deposits of the Valley until the 1930's when these activities were largely abandoned.

The bedrock geology of the Bennington area has been studied by MacFadyen (1956) and Skehan (1961). Three very distinctive bedrock terranes exist in the region. These correspond closely to the three physiographic divisions mentioned above.

The Taconic Mountains are underlain by the Walloomsac Slate and the Mount Anthony Formation. The Walloomsac Slate is typically a carbonaceous, sericitic, black phyllite. The Mount Anthony Formation is a green, chloritic-muscovitic phyllite. Both formations are cut by numerous quartz veins. Vein quartz fragments and boulders of these formations make very distinctive indicators.

The Vermont Valley is underlain by carbonate units interbedded with quartzite. Differential erosion of the predominant carbonates accounts for the relatively low altitudes of the Valley. Isolated hills in the valley are held up by Monkton or Cheshire Quartzites. The abrupt scarp of the west front of the Green Mountains is formed on the Cheshire Quartzite. The Cheshire is a firmly indurated, buff-weathering quartzite which sheds spheroidally-weathering boulders because of the closely-spaced, rectilinear joint pattern in the formation. When found as erratics or in river gravels, the Cheshire boulders commonly display crescentic fracture marks. Boulders derived from the Cheshire also make distinctive indicators.

The core of the Green Mountains consists of the Precambrian Mount Holly Complex, coarse to fine-grained granitic gneisses with pink or white feldspars and abundant biotite. Cheshire quartzite is exposed in isolated outliers on top of the gneisses of the anticlinorium, and Cheshire crops out on the east flank of the gneissic core along the west side of the valley of the North Branch of the Hoosic River, near Stamford.

The structure consists of a series of elongate anticlines and synclines with axes trending north to northeast. The major structures are the northeast trending Green Mountain Anticlinorium and the Taconic thrust sheet. The northeast trend of the structure causes the steeply-dipping beds to have a general northeast-southwest outcrop pattern. This situation affords excellent opportunities to determine ice-flow directions by tracing indicator fans developed in the lee of source areas of distinctive lithologies. The structure also imparts a northeast-southwest grain to the topography which may have had important influence on the flow directions of thin, yet active ice.

GLACIAL GEOLOGY

The most extensive type of drift in the area is glacial till. This material is disposed as a thin, discontinuous sheet on upland surfaces where it usually does not exceed 10 feet in thickness. In valleys, on the other hand, the till may attain a thickness of 30 feet or more. In the Vermont Valley, considerable thicknesses of drift have been noted, but most of the fill appears to be glacio-fluvial or glacio-lacustrine in origin. Few natural stream cuts expose till in the Vermont Valley and no exposure of greater than 30 feet of till was noted west of the Green Mountain front. A well, located 0.25 miles south of Shaftsbury Center, reportedly penetrated 146 feet of unconsolidated material which, judging from the position of the well at the crest of a hill, may be largely till.

Two types of till occurring in the Bennington area are a silty-clayey, dense "basal" till and a sandy, compact or loose till with a low silt-clay content. The latter deposit has been called "ablation" till by Stewart and MacClintock (personal communication, 1964, 1966). The present writer feels that sandy till is a better name and one that avoids unwarranted genetic implications. The degree of compaction and marked fissility (even in upland areas) of these tills indicates an englacial or subglacial mode of deposition. The sandy texture of the till seems to be characteristic of areas of high relief. The relative coarseness of the till also may result from derivation from crystalline material and/or coarse-grained or highly indurated metamorphic formations. Water played only a limited role in till deposition.

The Walloomsac Slate is the only formation in the Bennington region capable of producing a clay-silt-rich till. Dense, silty basal till is found only in valley bottoms, and even areas underlain by fine-grained phyllites or limestones are often mantled by sandy till. In two localities very clayey till is exposed in close proximity to lacustrine clays. In the old Lemieux brick pits at the southeastern corner of the city of Bennington, ice has overridden lacustrine clays and deposited a dense, clayey till. One mile north of North Pownal an apparently similar process has produced a dense, clayey till.

Two types of ice contact stratified drift occur in the Bennington area: eskers and kames. Eskers are very common and well developed in the Vermont Valley. A prominent esker more than two miles in length is developed midway between Shaftsbury Center and Trumble Mountain. The esker ridge is discontinuous and bifurcating. Gaps in the ridge are erosional. This esker fed the great kame complex developed at the western base of Hale Mountain when the front of the retreating ice stood across the valley, just south of Shaftsbury Center.

A short esker is developed across the valley of Furnace Brook about ½ mile south of Buck's Cobble. The esker deposits blocked the brook after retreat of the last ice and ponded a small lake behind it until a gap could be cut in the barrier. The lake stood at about 1180 feet and drained southward around the western end of the plug.

The South Stream Esker begins about two miles south of Bennington and is traceable for 3½ miles in the valley of South Stream to the vicinity of Barber Pond. It is associated with hummocky kame material along its length and appears to have had several tributaries flowing into it from the western slopes of the Green Mountains. Another esker complex is developed along Ladd Brook and its tributaries one mile NNW of Pownal. In the valley of the North Branch of the Hoosic River two small eskers are developed 0.25 miles southwest of Stamford and two miles north-northwest of Stamford (Taylor, 1903).

Kames are mapped in three phases: isolated kames, kame moraine complexes, and kame terraces. The criteria for recognizing these deposits varied. Presence of slump structures combined with constructional topography, geometry of the body, gross sorting, presence of striated pebbles, and topographic position were considered when mapping any gravel body. Constructional topography and gross sorting were the most commonly used criteria in this area because of poor exposures or lack of evidence of slumping.

Hummocky kame complexes are common in the Vermont Valley. A large, elongate mass of gravel fills the valley of South Stream from one mile south of Bennington to approximately six miles south of the city. The surface of the mass is hummocky and it is associated with the South Stream esker, as noted above. Few indicators of current direction were noted, but the general trend seems southerly, in the sense opposite to that of the present drainage. Limited areas of outwash gravel and lacustrine sand are probably included in this deposit. The presence of the esker and continuous disposition of ice contact gravels on the valley floor suggest that the valley of South Stream was occupied by a tongue of stagnant ice after the hills surrounding the valley had been deglaciated. Since the valley of Jewett Brook, which parallels South Stream one mile to the west, contains very little ice contact debris and is in large part a clean bedrock gorge, the ice block must have been confined to the South Stream valley. The ice in the zone of stagnation could not have exceeded 100-200 feet in thickness and would have formed a body roughly five miles by one mile by 200 feet.

Local thickening of the gravel at Bushnell School and in the vicinity of Barber Pond might support the concept of sporadic slowing of northward retreat of an active ice tongue as visualized by Taylor (1903). Taylor correlated such drift thickenings from valley to valley assuming that the ice retreated at similar rates in adjoining valleys and formed correlative recessional moraines. Although Taylor recognized features of this type in the Bennington area, the evidence for retreat and periodic slowing of an active ice tongue south of Bennington is weak.

North of the Walloomsac River, the deglaciation of the Vermont Valley has quite a different aspect from that of the valley to the south. Two main bands of kame moraine complex can be traced more or less continuously in an east-west direction across the valley.

The more southerly system, the Harwood Hill moraine, appears to mark the position of an ice front of a lobe of active or actively-retreating ice confined to the Vermont Valley. It is arcuate in plan and is traceable from near White Chapel on White Chapel Road, westward, around the eastern and southern flanks of Harwood Hill to a point on the south slope of Bingham Hill in North Bennington. The moraine is a hummocky gravel mass which averages less than a half-mile in width. The composition of the gravel is very closely related to the underlying bedrock units that the moraine crosses. This indicates movement of the depositing ice along the bedrock (and topographic) strike. A movement from 10^0-20^0 east of north is inferred because there is little lateral transport of material across strike. The best exposures of ice contact gravels are at present in the extensive pits on the east side of Harwood Hill. It is here that the moraine has its strongest development.

The Hale Mountain cross-valley morainic system is developed one mile north of South Shaftsbury. The material is mostly ice contact gravel of either kamic or ice contact deltaic origin. The mass occupies a one mile wide depression a few hundred feet west of Trumbull Mountain. The moraine extends from the vicinity of Trumbull Mountain southward to its best development on the west slope of Hale Mountain. One mile west of Hale Mountain on the southeast slope of West Mountain is a morainic, gravelly mass which seems to form the west side of the "loop" in the moraine. Topography developed between the two areas suggests a thickening of drift which may be till or gravel. As in the Harwood Hill moraine, there is a strong influence of local bedrock in the deposits. The east part of the moraine is primarily quartzite-limestone-dolomite gravel, and the west part is a dirty shingle gravel derived from the Taconic phyllites of West Mountain.

The two cross-valley or "loop" moraines described above are very similar to those occurring in the trough now occupied by Lake Memphremagog in northern Vermont and southern Quebec. In the Vermont Valley and in the Memphremagog basin the style of deglaciation appears to have been northward back-wasting of an active ice tongue.

Other occurrences of kame material are spotty in the Bennington area. There may be some ice contact gravel along the western slopes of the Green Mountains. Topography on the lower slopes in many locations appears constructional up to altitudes of 1500 feet. The heavy tree cover on the slopes may obscure considerable kame terrace and esker deposits.

From an area one mile east of Glastenbury Mountain south to Mud Pond on the Stamford-Woodford town line a topographic low is developed on the gneisses of the core of the Green Mountains. Within this depression, the topography is hummocky with many small, undrained depressions. It appears that most of this topography is constructional and that the drift here was deposited from a block of stagnant ice which occupied the depression after the surrounding highlands had been deglaciated.

The few exposures of drift examined in the basin showed either sandy till or sands and gravels of ice contact origin. There may be a great deal of gravel in this area as kames are commonly found in areas of widespread stagnation elsewhere in the state.

The map unit, "outwash", as used in the Bennington area embraces all gravels of demonstrably fluvial origin which, either because of elevation above the present drainage or because of gravel sizes requiring deposition by streams more competent than those existing today, are thought to have been deposited in meltwater complexes.

Two extensive areas of outwash are mapped in the Vermont Valley. The city of Bennington is built on the most southerly of these; an extensive flat extending from the vicinity of Woodford Hollow to a point directly north of Old Bennington. The flat is composed of an unknown thickness of crudely stratified, imbricated boulders which, east of Bennington, commonly reach diameters of six feet. The boulders contain a high percentage of percussion-marked Cheshire Quartzite with much gneiss from the Pre-Cambrian core of the Green Mountains. Shingling shows current direction from east to west. The coarse boulder flat disappears under younger lacustrine and alluvial sands at Old Bennington. This is the only location in the map area where noticeable amounts of material from the Pre-Cambrian outcrop area have been carried into the Vermont Valley; i.e. where east to west transport has occurred.

On the north side of Walloomsac Brook near the power sub-station east of Bennington there are a series of sections, the most westerly of which shows a coarse outwash gravel similar to that in the present flat. The gravel is imbricated and contains large, four-to-six-foot boulders. It is exposed about 20 feet above the present flat and is overlain by 20 feet of till; 3 feet of varved lacustrine sands and silts which are capped by 6-7 feet of till. Gneissic boulders are numerous in the gravel. Both tills contain a high percentage of Taconic phyllites and no gneiss. Their fabrics are strongly suggestive of deposition by ice moving from the northwest. Both tills are oxidized and calcareous and the lake sediments separating them are calcareous. These observations suggest that at least two and, if the outwash is considered, three glacial episodes affected this locality.

From one mile south of Shaftsbury Center, on the east side of Route 7, an extensive outwash plain is developed. This feature passes southward through South Shaftsbury, past Lake Paran, and forms terraces along Paran Creek south to the point where it joins the Walloomsac River. The outwash follows no major present drainage but forms a "train" $3\frac{1}{4}$ miles long by $\frac{1}{2}$ mile wide. It starts on the distal side of the moraine at Hale Mountain. In this vicinity very coarse, angular boulders overlie fine sands and clays of the proglacial lake. The gravel becomes finer southward and in the terraces above Paran Creek, just south of North Bennington, the pebbles are small with a one to two-inch maximum dimension. The outwash is largely deposited over lake sediments and forms a cap 15 to 25 feet thick over the region, but northeast of Lake Paran, the gravel rests directly on bedrock.

A discontinuous outwash train is developed from Heartwellville to Stamford in the valley of the North Branch of the Hoosic River. Its characteristics are similar to those of the flat at Bennington; large boulders form a flat valley bottom.

There is probably a good deal of outwash in the rivers and streams in the Green Mountains. Because of the normally high gradients, it is difficult to determine whether the flats in these narrow valleys are truly valley trains or modern alluvial fill.

Glaciolacustrine sediment is poorly developed in the Bennington area. Lake sands and silty clays are known to underlie the outwash complex between Hale Mountain and North Bennington. Exposures of horizontally-bedded lake sands lie under a 15 foot cap of outwash where the train heads. Elsewhere, at South Shaftsbury, lake sands and clays are buried under 25 feet of outwash. Lake sands and clays are exposed at the west end of Lake Paran. Mr. Welling and Mr. Couch of North Bennington report numerous occurrences of clay around the north side of Bingham Hill in North Bennington. Since this area is relatively densely populated, many clay exposures have been concealed by landscaping, and the true extent of the lacustrine deposits is unknown.

R. Behling (personal communication) reports that several wells in Bennington have encountered 80 feet of clay under 30 feet of outwash. The clay rests on an unknown thickness of gravel. This sequence would be suspected from the relations in the section east of Bennington as described above. Lacustrine sands and silty clays appear at the surface on the south side of the Walloomsac Valley in Paper Mill Village. Nothing is known of their stratigraphic significance, but they do not occur above 600 feet. Patches of lacustrine sands and clays were noted just west of North Bennington and north of the Walloomsac River to altitudes of 680 feet. A thorough search would probably uncover much more lacustrine sediment than has been mapped in this area.

Small patches of lacustrine or wind-blown sand occur along White Chapel Road and around the State Soldiers' Home reservoir. On the south side of Walloomsac Brook, just east of Bennington, delta gravels and lacustrine sands are developed at 900 feet. These may correlate with the large ice-contact deltaic mass at

900 feet on the west flank of Hale Mountain. If this correlation is correct, it would indicate the presence of a short-lived, proglacial lake in the Vermont Valley associated with the Hale Mountain moraine.

Taylor (1903) proposed the hypothesis that during deglaciation a large lake stood at 1100 feet in the Hoosic River Valley. He first named this Glacial Lake Hoosic and supposed that the outlet was near Pittsfield, Massachusetts. Later he adopted the name Glacial Lake Bascom. The present studies confirm the presence of an 1100-1120 foot lake level in the Hoosic Valley and in the valley of the North Branch of the Hoosic River. In Stamford, Vermont, the outwash plain of the North Branch plunges beneath lacustrine pebbly sands and silts. Beach features are well-developed at 1100 feet on the Stamford golf course, and a small delta occurs at 1100 feet on the opposite side of the valley. One half mile east of the Hoosic River on the Vermont-Massachusetts border there are well-developed gravels in the form of beach ridges at 1100 feet. They are surrounded by lacustrine sands and form crescentic-in-plan, 15-foot-thick deposits over unoxidized, blue-gray till. On the southwest flank of Mount Anthony, two miles north of North Pownal, there is an isolated delta at 1100 feet.

One quarter mile south of Barber Pond a large gravelly-sandy mass with westerly-dipping deltaic foreset bedding stands at 1200 feet. It may represent a delta built into an ice marginal lake which occupied the depression in which Barber Pond and Pownal Bog are now situated. Eight-tenths of a mile west of the delta front, on Witch Hollow Road, a deep, abandoned bedrock channel heads at 1200 feet. At this point there is an abandoned water-fall and potholes are cut deep into the valley sides. If ice rested against the northwest flank of Mann Hill and filled the valleys to the north, this gorge may have formed the outlet of the small lake into which the delta was deposited.

"Fluvial gravels", as used in this report, are gravels of uncertain origin which form terraces above the present flood plain of a river and were products of normal fluvial processes, rather than deposition by glacial meltwater streams. They are not modern but were formed sometime between the last deglaciation and the present. In the Bennington region they are mapped only along the Hoosic River (north and south of North Pownal) and along the stream in Shaftsbury Hollow in the northwest corner of the map area. In the Hoosic valley an unknown thickness of well-sorted gravel caps lacustrine sand and clay terraces. The gravel is fine with no pebbles exceeding 4" to 6" in diameter. North of North Pownal at least two of these terraces are developed, one above the other. The gravel is imbricated and indicates current direction similar to that in the modern Hoosic River. These gravels must have formed while the river was flowing over the lacustrine deposits left after the draining of the last lake to occupy this valley. The river has since cut down at least 100 feet below the highest terrace and now flows on bedrock. The erosive nature of the lacustrine sediments here indicates that only a short time would be needed for this amount of downcutting. Thus, the gravels are probably not much younger than the lake sediments they overlie. The Shaftsbury Hollow gravels form at least two terraces above the creek. They probably overlie lacustrine sediment also, but there are no exposures (in Vermont) to indicate this.

Paludal deposits are mapped as swampy areas which have been collecting organic matter due to poor drainage. Usually organic material was mapped as paludal if it exceeded the arbitrary figure of three feet in depth. Most of the paludal areas in the mountains were not checked because of their inaccessability, and some of these may only be thin alluvium deposited behind beaver dams. Near Barber Pond there is developed a 9-14 foot-deep bog referred to locally as the Pownal bog. This has been excavated for peat and displays marl layers mixed in with the peat at the base. K. Beem found some bone-like material here and it is entirely possible that, if the material is really bone, more vertebrate remains could be uncovered. Radiocarbon dates on the organic material would be of doubtful significance as the bog is developed on limestone and partially dissolved limestone pebbles were found in the base of the deposit.

Alluvium was mapped as the organic-rich sandy-silt or pebbly sand deposited on the modern flood plains of streams and rivers.

Extensive "kaolin" deposits underlie the Vermont Valley. How much of this clayey material is truly a kaolin is conjectural because there are also buried lake clays in the valley. Most of the occurrences of this material have been described by Burt (1926, 1928), and the kaolin has been considered to be of tertiary age, correlating with the Brandon lignite. Many recently-bored wells have encountered clay or "red ochre", particularly in the valley of Furnace Brook. One mile west-southwest of Harmon Hill at the White residence, a well allegedly has been drilled through 300 to 400 feet of clay. The clay is at the surface of the knob at an altitude of about 1200-1260 feet; there is no till over it. Two hundred feet west of the knob, bedrock lies at shallow depths under 0-3 feet of till. The clay is buff to white and appears to be kaolin. The lack of till cover, great thickness, and topographic position suggest that the clay may have been emplaced subsequent to the last glaciation - possibly hydrothermally along a fracture or fault zone in the Cheshire quartzite.

STRATIGRAPHY

After mapping this area, the writer has inferred at least two distinct phases of glaciation in southwestern Vermont. The data, in large part qualitative, on which this assumption is based, are primarily of three types; till fabric, striations, and indicator dispersal.

Till fabric was measured at 26 locations in the Bennington area. The majority of these were measured in the Vermont Valley. Figure 3 shows the rosettes constructed from two-dimensional pebble orientations plotted on a base map. The Harwood Hill moraine is interpreted as the terminal moraine of an ice lobe that was active in and confined to the Vermont Valley. The fabrics measured north of the moraine show a tendency to be oriented NE-SW or NNE-SSW. Fabrics taken in most other areas near Bennington are N-S, NW-SE, or E-W trending. No striae were found in the map area north of Bennington to confirm or disagree with the fabrics. Very strong (N20^{0}E) striae were found near Manchester Center by R. Behling (personal communication, 1966). These striae are precisely parallel to the valley.

Three sets of striae having azimuths of from

$N32^{0}W$ to $N50^{0}W$.were found in the valley just south and west of Bennington. The striae are very strongly developed at these three localities. Stewart (1961) shows an additional unlocated NW striation near North Pownal, Vermont.

The tracing of indicators seems to have clarified many directional problems unanswered by striations and fabrics alone. It has been noted above that the lack of gneissic material south of Bennington suggests that no ice passed south of the city after deposition of the buried outwash exposed in the power station section. This means that the present outwash flat at Bennington was associated with an ice advance which did not extend south of Bennington. On the east side of the Vermont Valley, south of Bennington, the till contains a very high content of phyllites and vein quartz. This is true north of the city, also, as far as the limits of the Harwood Hill moraine. These lithologies are typical of the Taconic sequences on the west side of the valley, and their occurrence east of the source area confirms a NW-SE movement indicated by striae and till fabrics.

The drift in the valley north of the Harwood Hill moraine is commonly composed of material derived from the underlying bedrock with little or no Taconic material except where wedges of Walloomsac slate crop out in the valley. This indicates transport along strike with little lateral displacement of material. While measuring two till fabrics 0.7 miles north of Shaftsbury Center, I encountered no Taconic material although the Walloomsac slate outcrops barely ¼ mile west of the station.

The distinctive Cheshire quartzite is common in the Vermont Valley and is spread conspicuously over the Green Mountains to the east. Its presence east of its source area on the western slopes of the Green Mountains, the Big Pond-Woodford-Hagar Hill area, and the west side of the North Branch Valley near Stamford, confirms till fabric indication that a continental ice mass advancing from the northwest once covered the whole area. (Cheshire quartzite boulders are found on the highest peaks east of the map area - at least ten miles east of the nearest Cheshire outcrop).

The Precambrian gneisses of the Mount Holly Complex have never been positively recognized in any drift of the Vermont Valley with the exception of the outwash plain at Bennington. It is logical to assume that if glacial meltwater was able to transport significant amounts of gneiss boulders up to four miles west of their exposure, as has been demonstrated, any glacier advancing from the northeast into the valley should have transported noticeable amounts of crystallines here, also. This is not the case north of south of Bennington. It can only be concluded that the drift displaying northeast fabric with no crystalline component was deposited by ice confined to the northeast-trending Vermont Valley. Figure 3 shows the locations of significant indicators.

In a gravel pit on the distal side of the Hale Mountain moraine, two rounded boulders of a kame-like conglomerate were found. These are interpreted as rounded fragments of tightly cemented ice-contact stratified drift from a deposit formed prior to the last, valley, glaciation associated with the Hale Mountain moraine. The pebbles in the boulders are exclusively Vermont Valley lithologies. The degree of induration is interpreted as evidence of subaerial exposure of a former glacial deposit in the Vermont Valley. Similar kame deposits are common in the valley, but none are so completely cemented that they could be eroded and rounded by running water or ice without disintegrating.

CONCLUSIONS

The first recorded glacial event in the Bennington map area is the complete covering of the area by a continental ice sheet advancing from the northwest. During the wasting of this ice, the stagnation features of the South Stream Valley were formed and the damming of Lake Bascom occurred. Later, during deglaciation, a readvance, or a new glaciation, a tongue of ice existed in the Vermont Valley as far south as Harwood Hill. It remained active as it backwasted and halted briefly at a point marked by the Hale Mountain moraine. A large pro-glacial lake was formed at this time with its water plane at about 900 feet. This lake will be referred to as Glacial Lake Shaftsbury. It was dammed bya contemporaneous lobe of Hudson Valley ice in the vicinity of Hoosic Falls, New York, and drained through Shingle Hollow on the south side of Potter Hill in New York. A very slight north or west recession of the Hudson Valley lobe from the Hoosic Falls position, allowing Lake Shaftsbury to drain, was accompanied by renewed backwasting of the Vermont Valley lobe. At this time an outwash train was formed on top of the exposed Lake Shaftsbury sediments from Hale Mountain to North Bennington.

The northward-retreating Vermont Valley ice halted again three miles to the north of the Hale Mountain moraine (in the Equinox quadrangle) where it constructed an impressive ice-contact delta (Bohling, personal communication, 1966) in a small, 1000-foot proglacial lake. The dam for this lake was the Hale Mountain moraine which blocked the valley of Paran Creek northwest of

Hale Mountain. Before this dam was broken considerable quantities of lacustrine sand were deposited on the northern border of the map area.

Although two glaciations are inferred here, this does not preclude the possibilities of previous glaciations nor the possibility that the valley phase is a result of reactivation of the first northwest ice observed. From brief reconnaisance of the Connecticut Valley and the Hudson Valley, I feel that there were lobes in these valleys at about the same latitude as and contemporaneous with the Vermont Valley lobe. This observation, if correct, might indicate that all three lobes were fed and controlled by a larger mass of ice of continental proportions to the north. There is no evidence in this area to indicate whether the valley lobations are peripheral features of the Burlington, Shelburne, or Pre-Shelburne glaciations. The evidence of indurated, rounded kame boulders does suggest that the Vermont Valley lobe passed over a terrain that was glaciated and uncovered for a period of time of interstadial magnitude.

Thompson's Pond in the southern part of the map area occupies a small north-south depression with steep walls on the east, west, and south sides. The pond is natural, and a small gravel-sand ridge extends from the east wall north of the pond to a point about one-third of the way across the valley. The floor of the depression is flat and, except for the ridge, composed of till. This feature is unique in the Bennington area and may represent a basin formed by a small mountain glacier which was reactivated after general retreat of the continental ice. The gravel ridge may be part of a loop moraine which dammed a larger version of Thompson's Pond and was partly washed away when the dam broke. More detailed work is needed to confirm or disprove this hypothesis. Cirque-like features are conspicuous on the northeast slopes of the Taconic Mountains southwest of the Hoosic River. The origin of these features should be investigated.

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