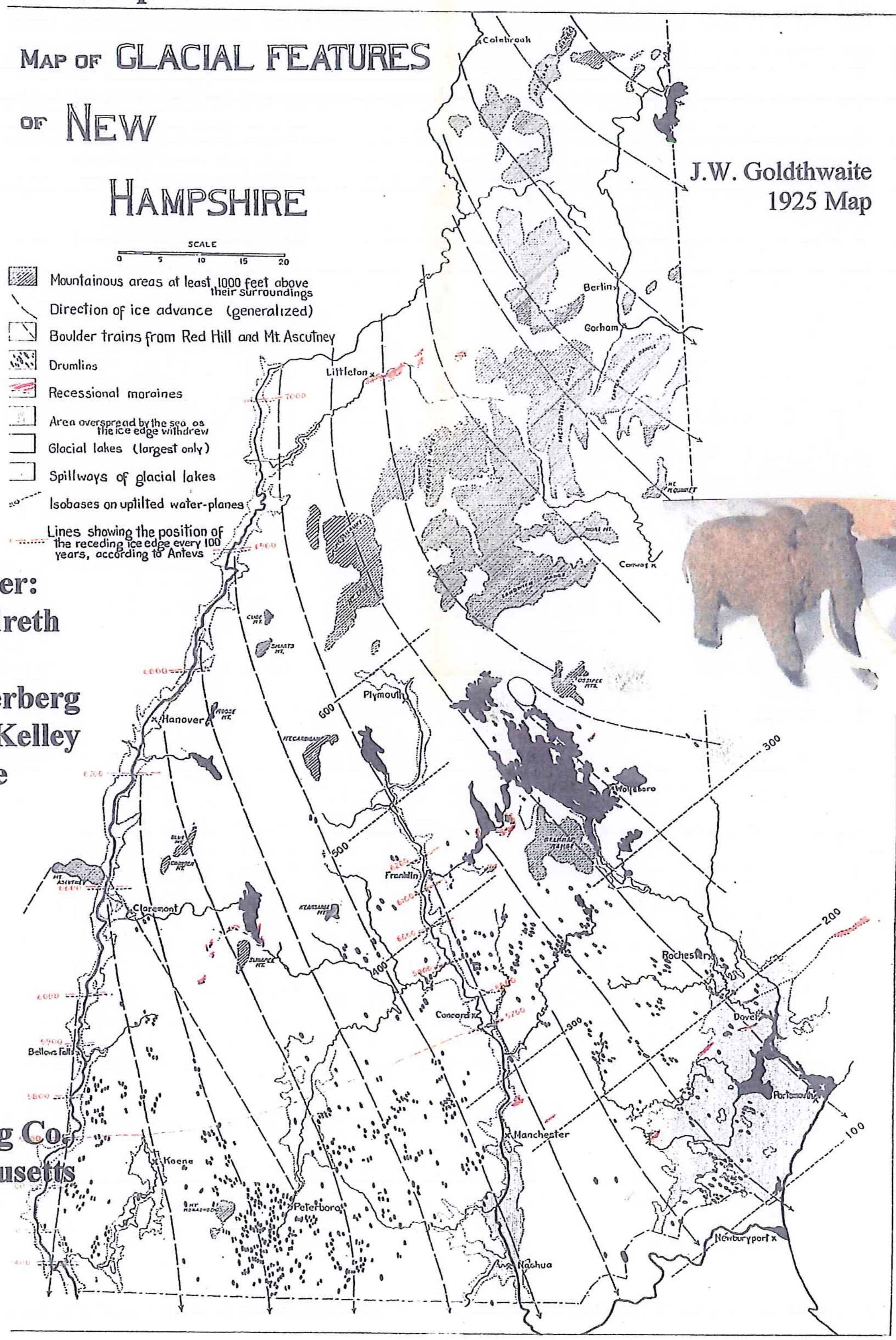
Glaciation of the Connecticut River Valley-- Hanover, Lebanon, Enfield, Cornish and Claremont, New Hampshire

Guidebook for field trips held June 4-6, 2010
For the 73d Reunion of the Friends of the Pleistocene-Northeast Section
West Lebanon, New Hampshire



J.W. Goldthwaite
1925 Map

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Jack C. Ridge

TarnRow Publbshing Co.
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June 4, 2010

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We especially thank Woody Thompson for being the unofficial "Secretary" of this non-organization "The Friends of the Pleistocene (Northeast Section)" in this its 73d Annual Reunion, in particular, finding one of our lot to host next year's reunion, and managing the FOP Website and FOP mailing list.

Finally, we heartily thank Dartmouth College for providing use of their DOC facility during the fieldtrip.

INTRODUCTION

During the last (late Wisconsinan) glaciation, about 25-20 thousand years ago (ka), part of the Laurentide ice sheet of northeastern North America spread southward over New England as far as Long Island, New York. We can measure the ice movement directions using glacial striations and grooves on bedrock, drumlin axes, and by the positions of ice margins during retreat. Initial ice movement in the Hanover-Claremont study area was predominantly from north-northwest to south-southeast. However, southerly and even in places, somewhat southwesterly trends have been measured in the center and western side of the Connecticut Valley here and to the south. Nearly all the glacial meltwater deposits in the area are inferred to have been deposited during retreat of the late Wisconsinan ice sheet. However, several localities in the Connecticut Valley contain meltwater deposits beneath till that are inferred to have been deposited during advance of the late Wisconsinan ice sheet (see Stop 12 in Sugar River Valley).

GLACIAL ICE-LAID DEPOSITS

Till Deposits

Two glacial tills are present in the Connecticut Valley area. They are not shown as separate map units on the Surficial Geologic Maps of the Enfield and Hanover quadrangles (Hildreth, 2009, 2010) because the lower, older till (also called "drumlin till") occurs almost entirely in the subsurface; generally, the lower till is at the surface today only in narrow stream cuts or the floors of artificial excavations that are too small to show at this map scale. It is not clear yet whether the till exposed in the landslide deposits in the Mascoma Gorge expose lower or upper till. The upper younger till (also known as "surface till") is generally less than 5 m (15 ft) thick and makes up most of the surficial material in areas mapped as thin till. Denney (1958, table 1) mapped surficial materials in the Canaan area to the east. He classifies two tills, "loose till" and "compact till," which may not necessarily correspond to the aforementioned upper and lower tills of others. He measured a 48-foot section of till exposed in the valley of Stony Brook in the Enfield quadrangle, though he doesn't indicate whether that section is compact or loose till (See Appendix A)/

Figure 1 . Photo of 2003 landslide of till in the Mascoma River gorge (mapped as Qls) The toe of this landslide reached the nearby riverbed, but was removed by workers from the gravel road surface at the bottom of the photo. The stump diameter in the foreground is about 25 cm (10 in.) Photo by C.T. Hildreth.

No major recessional end moraines have been identified in the study area, though there are some that have been identified to the north. The Littleton-/Bethlehem moraine has been identified as one. In the Hanover-Enfield area, only minor moraine ridges at the margin of Great Hollow in the Enfield quadrangle have been interpreted as such (Hildreth, 2009).

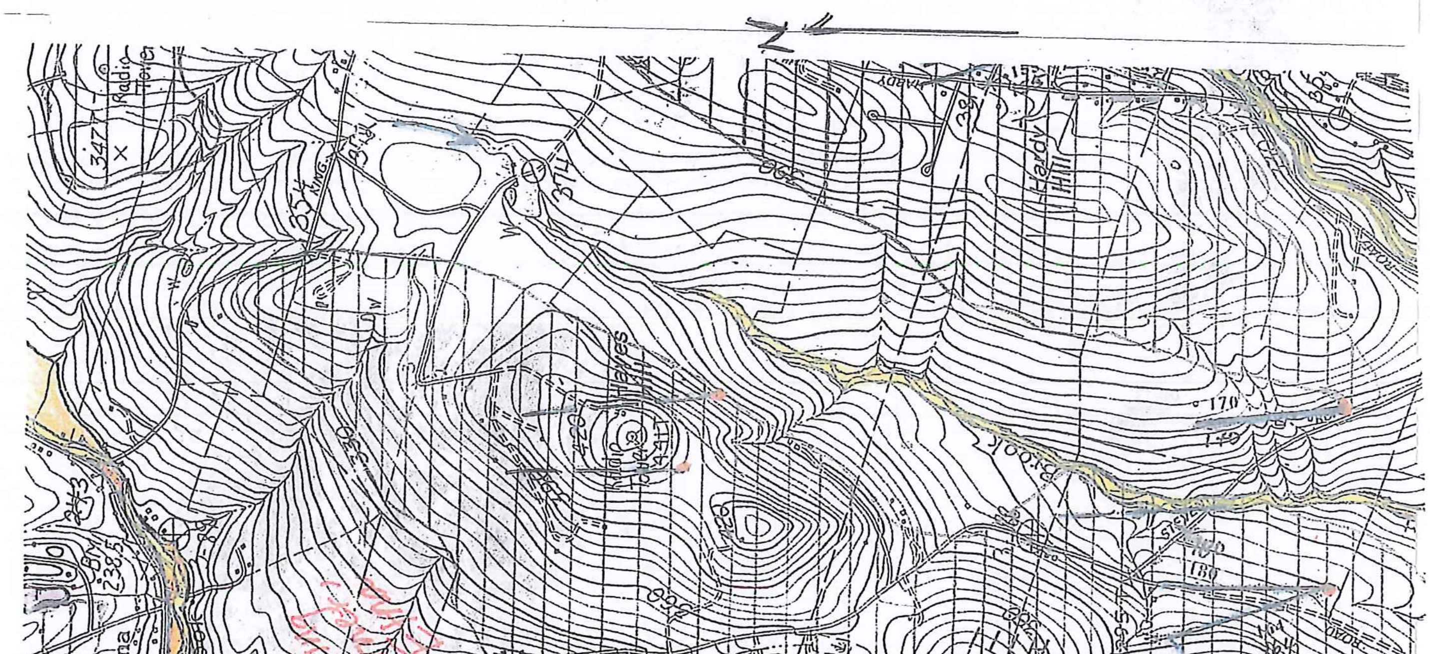
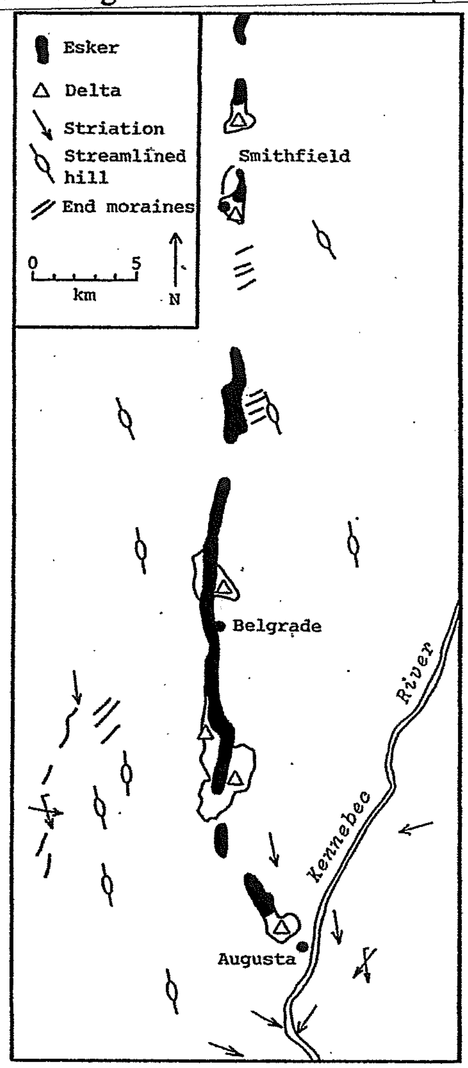


Figure 2 . Great Hollow moraine ridge, Enfield quadrangle. Several marginal ridges littered with boulders, some of which ridges also have directly down-valley, associated meltwater channels. Note also the Lake Hitchcock 197 m (657 ft) Glacial Lake Hitchcock Delta and the possible lower level 185 m (609 ft) delta about midway down Great Hollow (mapped by Hildreth, 2009)

The retreat northward of the late Wisconsinan ice sheet produced huge volumes of meltwater that picked up rock debris eroded and carried by the ice sheet and deposited most of it shortly beyond or in contact with the ice sheet. These deposits are sorted, stratified layers of gravel, sand, silt and clay that accumulated in streams and lakes of all sizes. Most of the meltwater sediments in the area were deposited in or graded to large or small lakes, including one notable large esker that extends from Lyme, N.H. and Thetford, VT, 24 miles south to Windsor, VT. We will visit on gravel pit in this esker in Vermont (Stop 4) and walk over it along Occom Ridge (Stop 6).

Esker Deposits

This esker is likely the same as the DeGeer esker system mapped in the Belgrade-Augusta, Maine, area (Caldwell and others, 1985, Fig. 3). It likely has the associated sandy gravelly fan deposits found in the Maine esker systems, but here in the Connecticut Valley, all those landforms, even the esker itself, are masked with thick drape deposits of varves; so only perhaps where these landforms are exhumed by human excavation or stream erosion, can we begin to delineate by their internal composition and structures where they belong in the environment of deposition. The pit on River Road in Cornish (Stop 11) exposes faulted sand, gravel and varves that may be an ice-marginal fan deposit. Among the most useful diagrams of the sedimentary facies and morphosequences of glacial meltwater deposits in New England are given in Stone and others (1998, Fig. 6) which is appended here (See Appendix B).



(From Caldwell and others, 1985)

Figure 3. Map showing the DeGeer esker, associated glaciomarine deltas, and indicators of ice-flow patterns in the Augusta-Smithfield area [Flagged striations are older.]

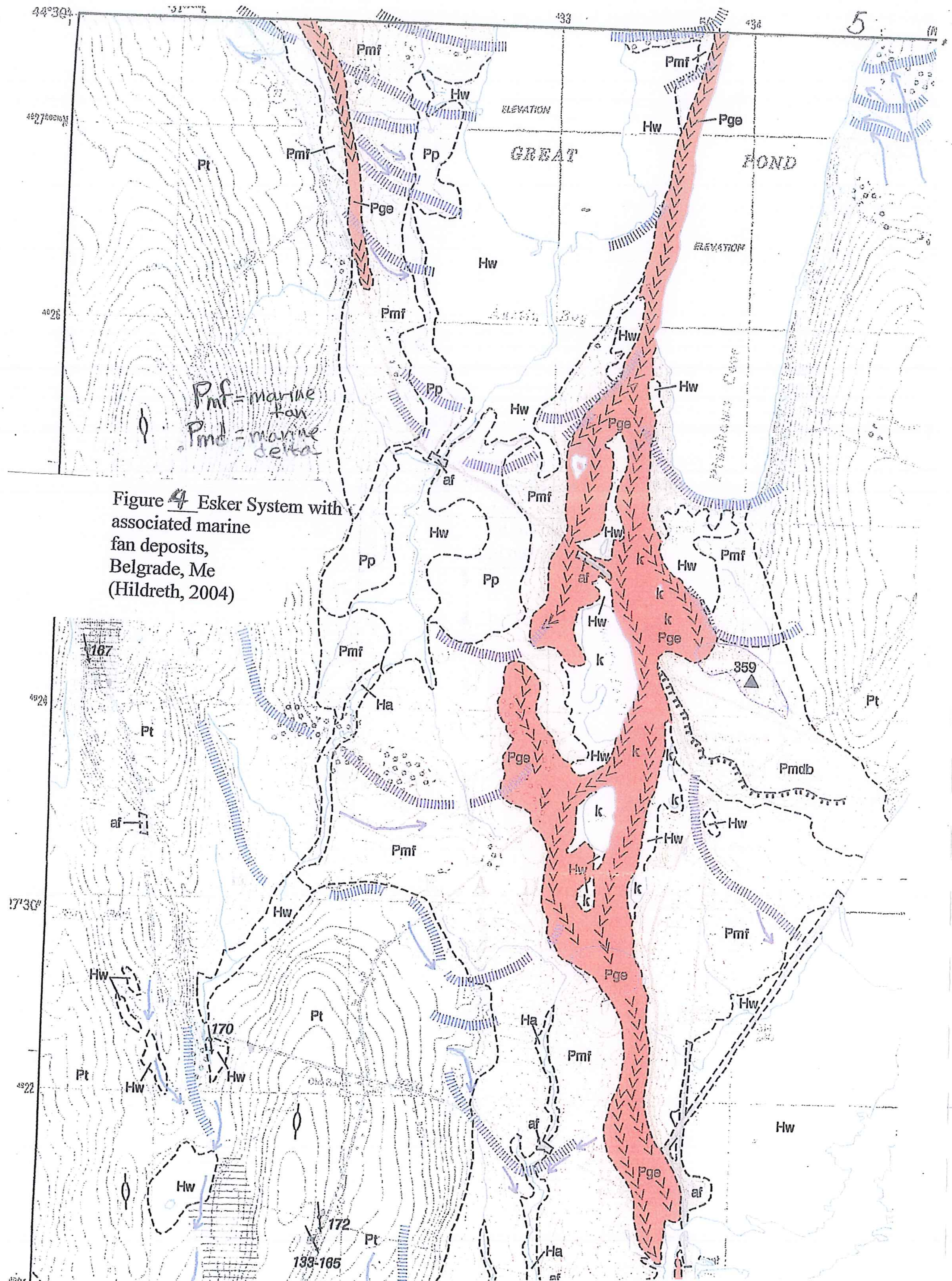


Figure 4 Esker System with associated marine fan deposits, Belgrade, Me (Hildreth, 2004)

Glacial Lacustrine Deposits

There is evidence for two large glacial lakes in the area—

Glacial Lake Hitchcock, which occupied the Central Connecticut Valley lowland, has been the subject of much investigation and on-going debate since before Lougee (1939) named it for Massachusetts' first State Geologist, Dr. Edward Hitchcock. It extended from the New Britain, CT spillway (stable elevation of 82 ft [25 m]) northward up the valley to the vicinity of Burke, VT (Fig. 5). It lasted from about 15.5 ka to about 11.5 ka, with a long-lasting "Stable Phase" that ended about 13.7 ka when the ice front was north of Hanover. A "Stable Phase" delta topset/foreset contact of 657 ft (197 m) was measured at Etna in the Enfield quad (Koteff and Larsen, 1989) and a lower "Post-stable Phase" 565- ft delta were identified in the Sand Hill section of Hanover, near Storrs Rd. Another possible lower delta (609-ft [185-m] surface elevation) occurs about midway on Great Hollow Road in the Enfield quadrangle (Fig. 2). The delta t/f contact measurements throughout the basin (Fig. 5 and 6; Koteff and Larsen, 1989) indicate that post-glacial uplift in the area was not begun until after the "Stable Phase" ended as these elevations define a water plane that tilts up to the N.21°W. in the amount of 0.9 m/km (4.74 ft/mi) that is graded to the stable 25 m (82 ft) New Britain, CT, spillway level.

Glacial Lake Hitchcock (GLH) lasted about 4000 years based on Antevs (1922) New England varve measurements. The amount of measurements Antevs made and analyzed is phenomenal and very reliable, based on recent studies by Ridge and Larsen (1990) and other works that have refined Antevs (1922) work; **Appendix C**, here, contains copies of select data from the 1922 publication, especially as it relates to the very thick (12 ft thick) sandy varve found in Mink Brook claypit by himself and Lougee and Goldthwaite, later, in 1926, where they reported a 21-foot thick varve—though the sandy bed in the 1926 photo (Figure 7) (Lougee, 1958?) does not appear to be anywhere near that thick. (The claypit is now thickly overgrown and slumped). Lougee interpreted this sandy varve to have formed when GLH's water level subsided and Mink Brook spread sandy layers of material over the lake floor here.

Figure 8 from Lougee (1958?) shows a section of 72 varves of Lake Hitchcock at West Lebanon, which first gave the clue to the subsidence of Glacial Lake Hitchcock These varves match those under the thick sand "subsidence" varve 4 miles North in the Mink Brook claypit in Hanover. Emergence here of the lake floor ended varve formation. [Note the recumbent folds in the thin varves beneath the sandy bed.] Lougee (1958?) felt that GLH drained when the ice front reached Lyme, NH, 10 mi. north of Hanover. In a dozen sections measured within 20 mi of Hanover, the varves of the "Hitchcock Period," as he termed it, are suddenly stopped all in the same year, either by no further sediment or they are capped by a thick sand bed. His interpretation included a postulated drop of 90 ft, initiating a lower level lake in the valley, which he named Glacial Lake Upham. Further studies since his time have refined the lake history following the GLH "Stable Phase," which no longer invokes the concept of a Glacial Lake Upham as configured by Lougee.

Lougee (1958?) also felt that the drainage of GLH probably caused the collapse of the esker ice tube which stops near Lyme, NH, and Thetford, VT.

In the 1933 varve exposure in the Beta House cellar (Fig. 9), Lougee appears to be pointing to the base of a thick varve that may be the "Sandy Subsidence Varve," in that it is fairly close to the surface. Any further excavation on the Hanover Plain could provide significant data relating to the GLH drainage history.

Glacial Lake Mascoma is one of a series of temporary upland glacial lakes East of the Connecticut River Valley in New Hampshire (See **Appendix D**, Selected data from Flanagan, 1996) Previous workers (Lougee, 1939; Denney, 1958) identified the successively lower spillways in this large drainage basin. In its early stages, when the lake was controlled by a spillway at Orange Summit with associated potholes (that were blasted away for railroad construction), Glacial Lake Mascoma was 300 feet higher than at present (Fig. 10), the lowest of which were southward over Bass Hill, finally draining into the Connecticut Valley, forming deltas into Lake Hitchcock. Over time, the Mascoma River cut a deeper and deeper gorge through the till hills west of the lake; it left an abandoned channel and waterfalls through and over bedrock about 60 ft above the present channel of the river. J.W. Goldthwaite (1925) and his students produced a 5-foot contour map of the feature, which we will visit as part of stop 10 (Fig. 11); along the walk to the abandoned channel site, we shall pass some exposures of till in modern landslide scars, both new and vegetated over. Could there be slippery lake-bottom sediments beneath the till that facilitate the landsliding or is the consistency of the till more prone to landslide formation, or is the slope too great to sustain the till, or is the undercutting of the slope by the gravel roadway more of a factor than any of the others?

Very little if any lake-bottom sediments of Glacial Lake Mascoma (GLM) are exposed at the land surface in the Enfield quad, and generally they are only discovered in deep wells and test holes (See selected samples in **Appendix D**). Why so little at the surface? Did high current velocities in GLM flush out all the fine sediment except in the deepest parts of the basin? Or could those deep lake-bottom sediments get deposited during the glacial advance, as in the Claremont basin? Digging in the active landslide to check does not seem to be a wise option, especially since the heads of several modern active landslide scarps are at the edge of Route 4, above. The present report includes investigations only in the Enfield quadrangle. A detailed study of the stratigraphy and structures in the entire Glacial Lake Mascoma drainage is necessary to answer these questions.

GEOHYDROLOGY

Flanagan (1996) gives a comprehensive assessment of the Geohydrology in the area of the fieldtrip, so selected parts of her work are included here as **Appendix D**.

ARCHAEOLOGY

Richard Boisvert, New Hampshire State Archaeologist (personal communication), provided the sparse available information in Figure 12, with regard to pre-European habitation in the area of the fieldtrip.

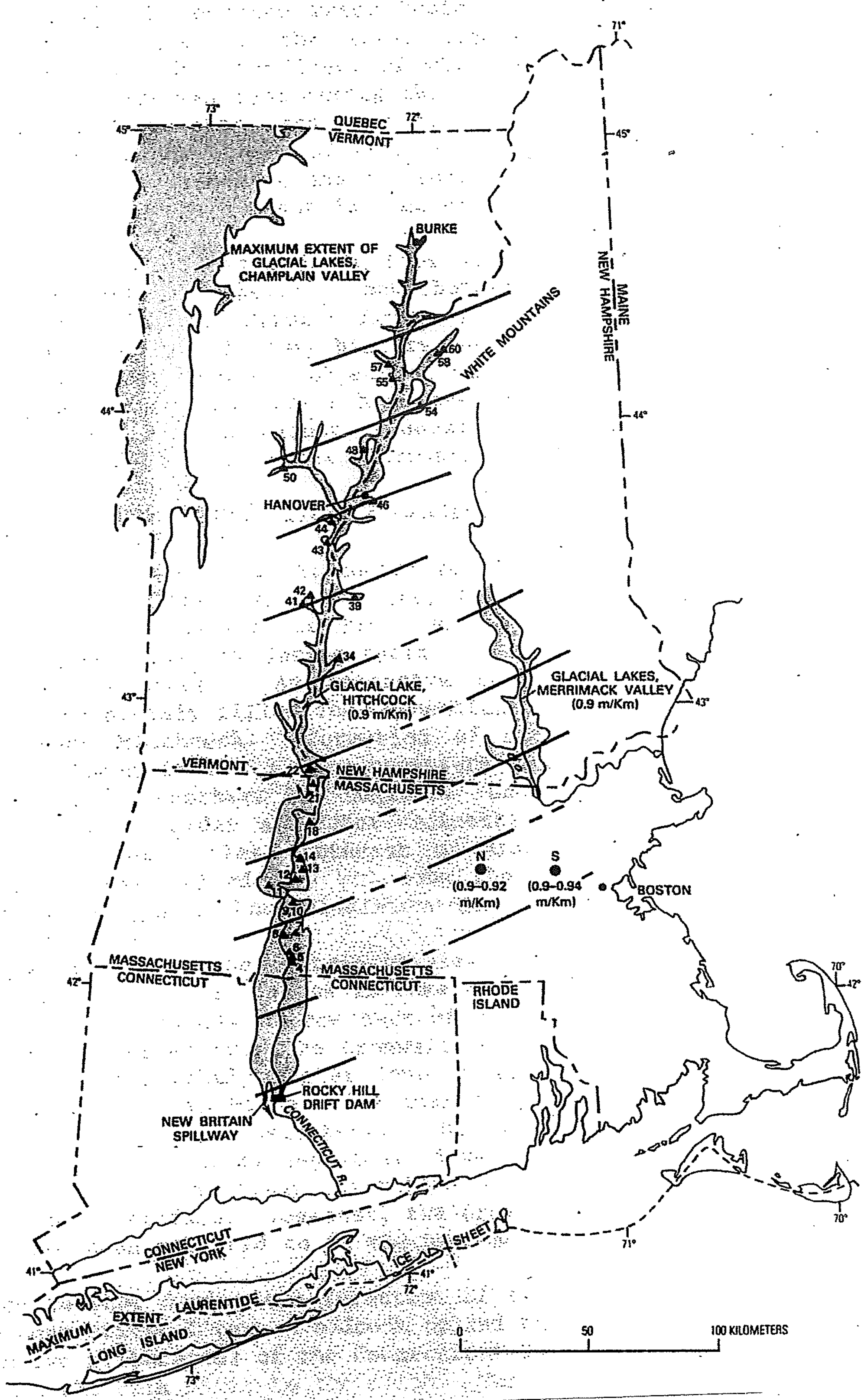


Figure 5. General outline of Glacial Lake Hitchcock and selected lakes in New England. (N) is Glacial Lake Nashua; (S) glacial Lake Sudbury. Triangles are deltas. Uplift isobase interval 25 m. Figure taken from Koteff et al. (1989).

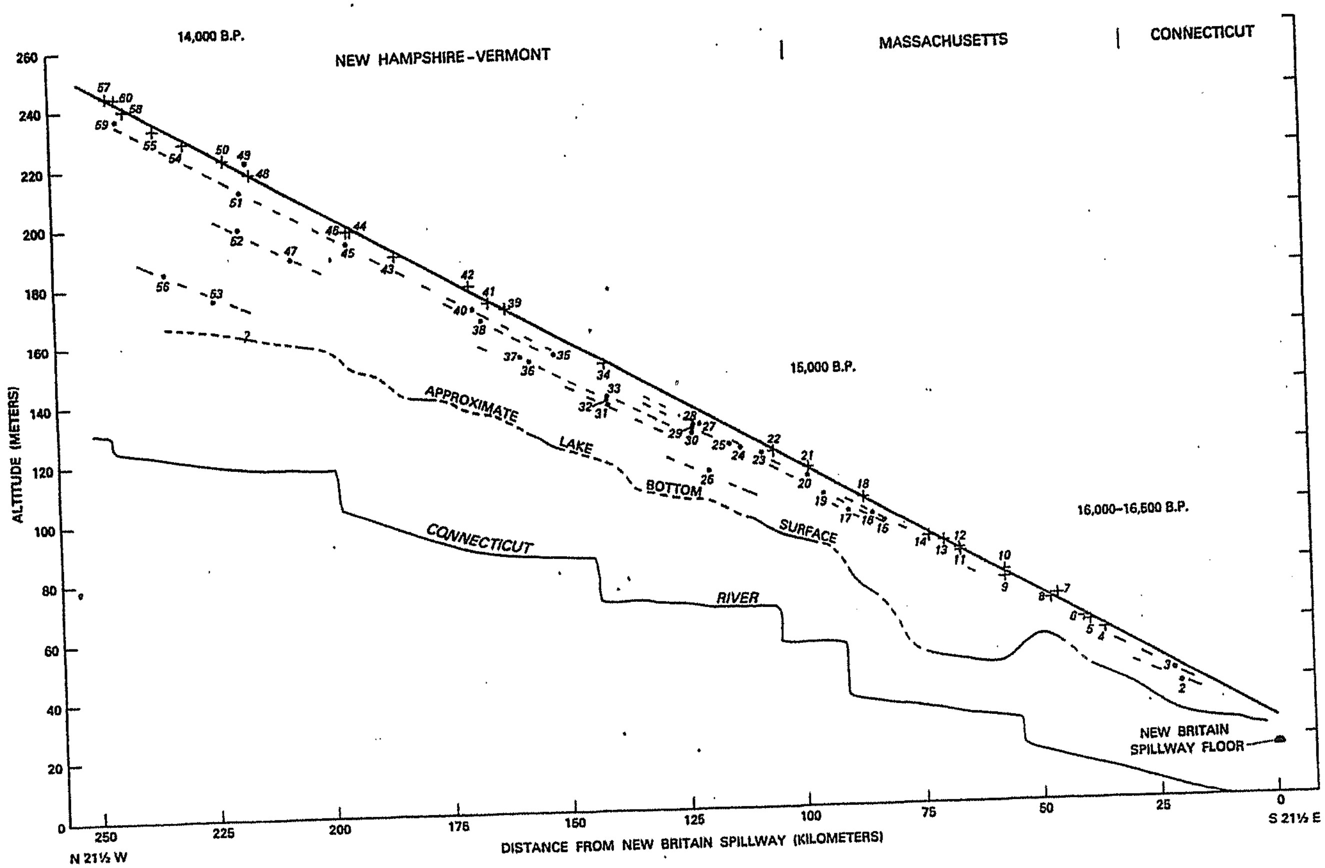
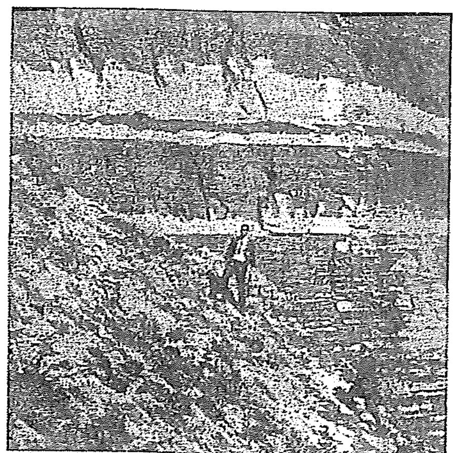
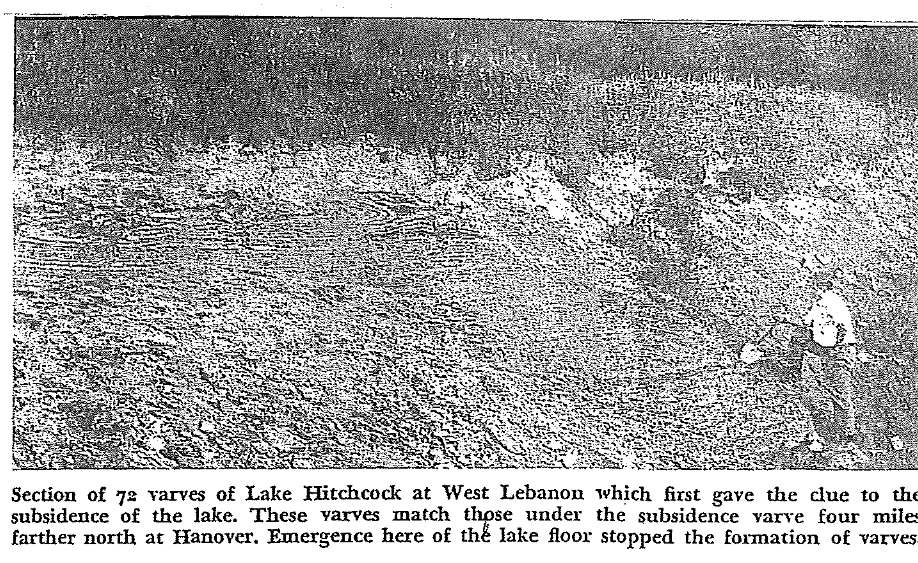


Figure 6. Ordinary least squares regression profile based on altitudes of topset/foreset contacts of 28 unmodified, ice-marginal or meltwater-derived deltas (+) in glacial Lake Hitchcock. (·) other altitudinal data. Dashed profiles <u>diagrammatic only</u>. Lake-bottom profile estimated from previous publications and topograhic maps; lake bottom may be higher at delta localities 7 and 8 (STOP 5 discussion). Figure from Koteff and Larsen (1989).

Figures 7 and 8 are from Lougee's (1958?) Dartmouth Alumni Magazine article entitled "Hanover in the Ice Age." Figure 7 is at Mink Brook, south of downtown Hanover. Figure 8 is somewhere in West Lebanon, perhaps near Stop 2 on our fieldtrip.



Prof. Goldthwait and Mr. Lougee in 1926, examining the sandy subsidence varve, 21 feet thick, in the bluff at Mink Brook, Hanover. When Lake Hitchcock subsided the brook spread sandy material over the lake floor.



Section of 72 varves of Lake Hitchcock at West Lebanon which first gave the clue to the subsidence of the lake. These varves match those under the subsidence varve four miles farther north at Hanover. Emergence here of the lake floor stopped the formation of varves.

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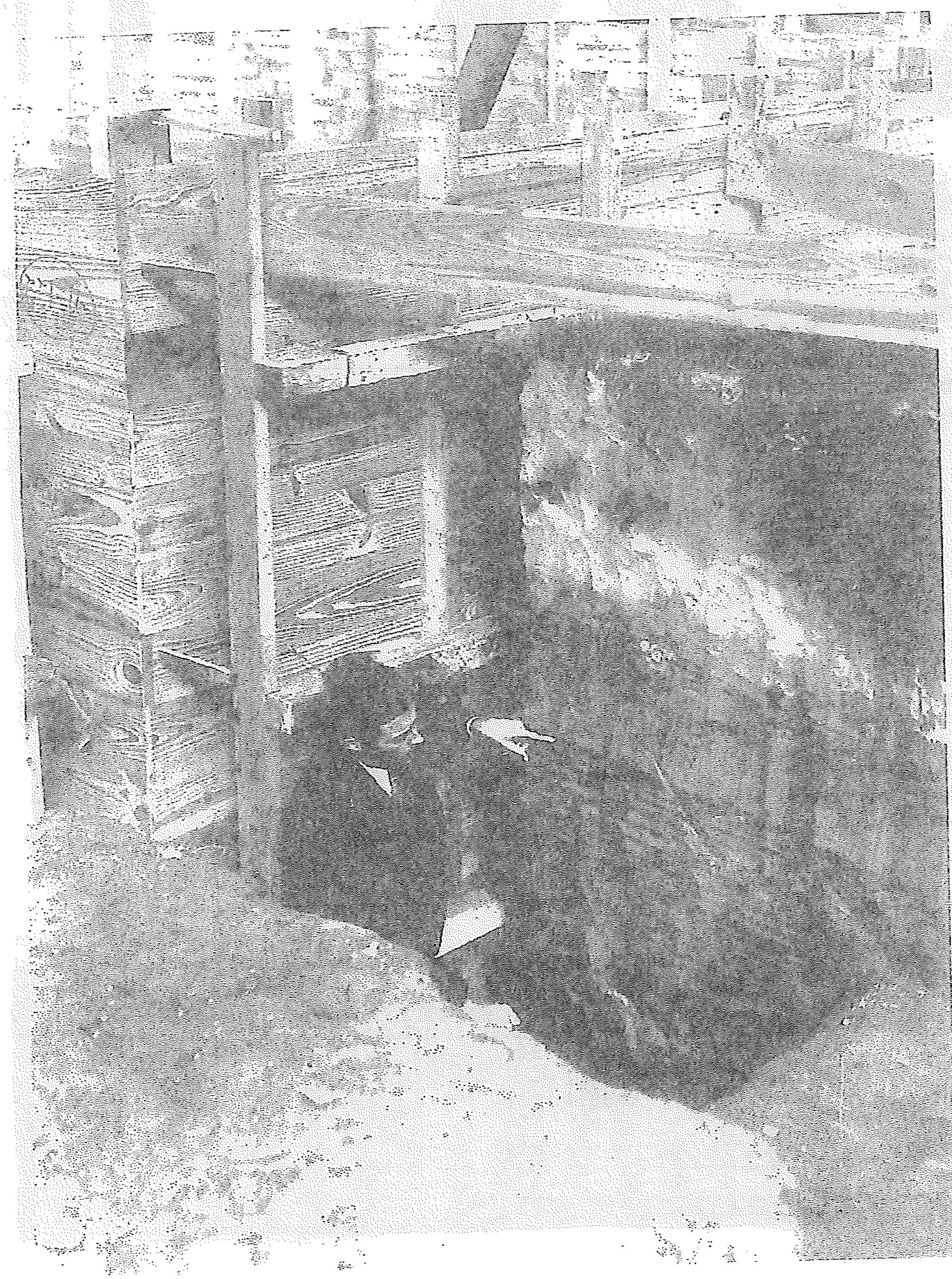
NOTE: THIS REPORT IS UNEDITED and PRELIMINARY. Carol T. Hildreth



Varve exposure on Dartmouth campus (Figure 9)

From: Woodrow.B.Thompson@maine.gov

I managed to obtain a good scan of the glass plate negative from Brian Fowler. See attached photo.

James Goldthwait most likely took the photo, with Richard Lougee pointing to the varves. Brian, does that interpretation sound right? Is that Lougee in the hole?

Goldthwait's writing on the negative sleeve has the caption "Varved Clays, Beta House cellar, 1933, Dick Lougee". The negative was passed down to John Lyons and then to Brian.

Glacial Lake Mascoma Outlets and Extent

It was about 300 feet higher than present.

Finally drained thru channels on Bass Hill 2 miles SE of Lebanon, some of which are in the Enfield Quad.

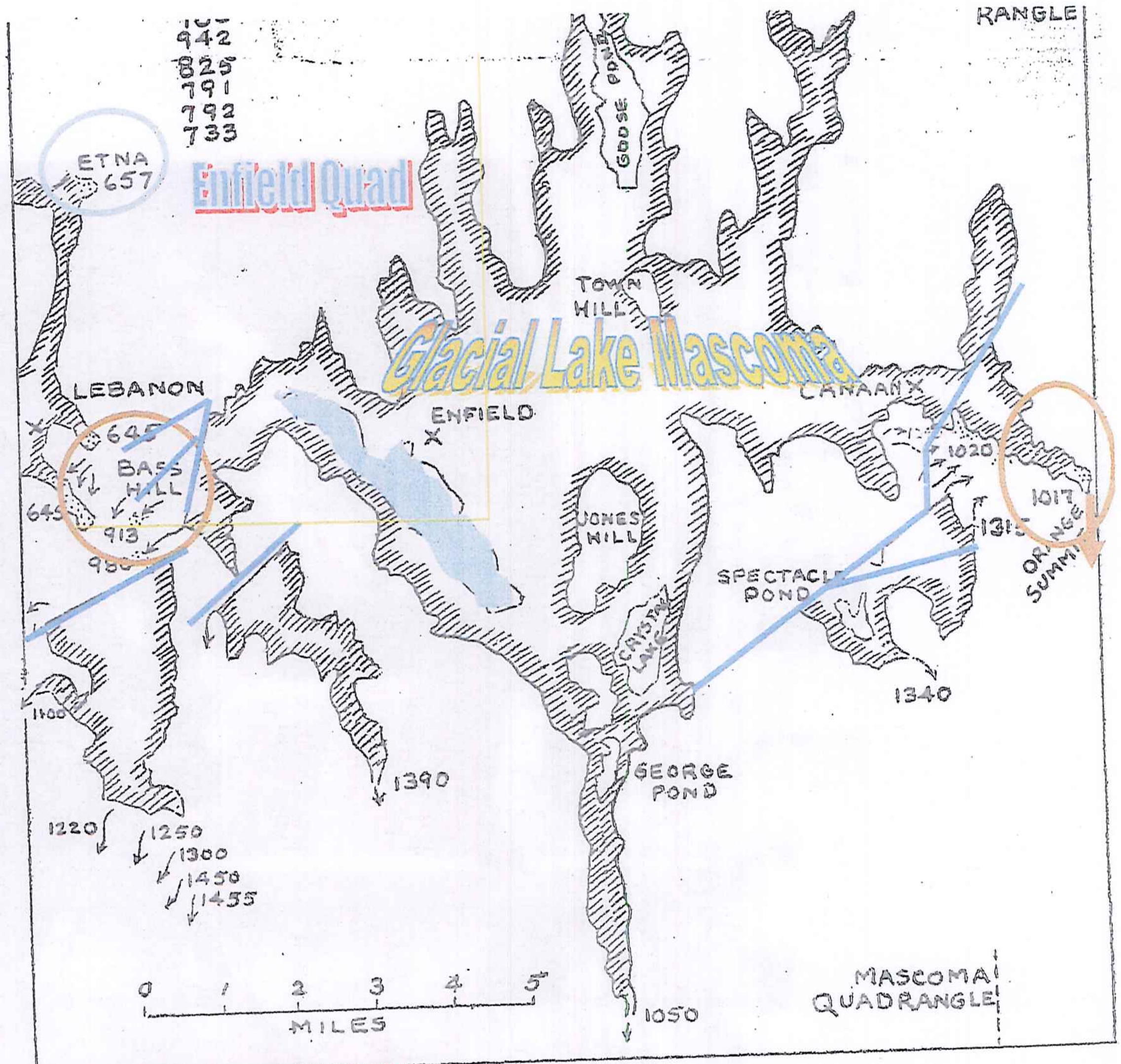


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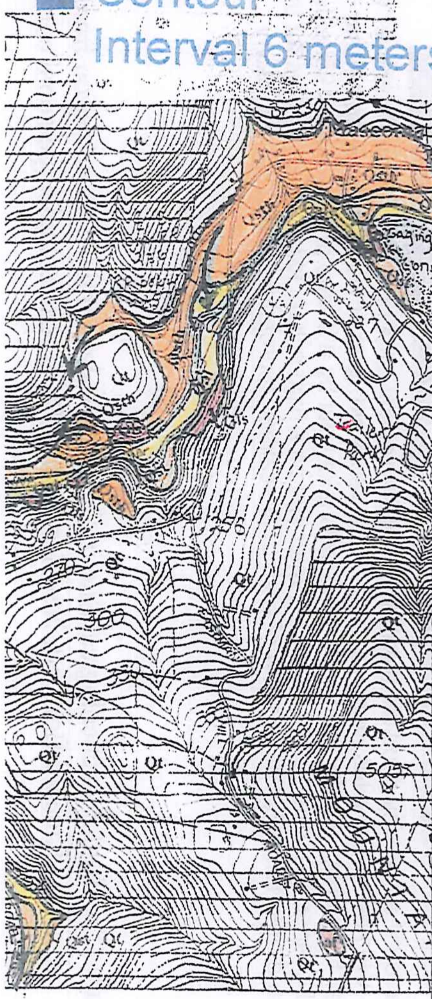
Figure 10. (From Lougee, 1939)

"....the headwater area of Mascoma River was controlled early

Abandoned Stream Terrace, Gorge, and Waterfall, Mascoma River, from Goldthwaite (1925), compared to present map

Contour Interval 6 meters



Contour Interval 5 feet

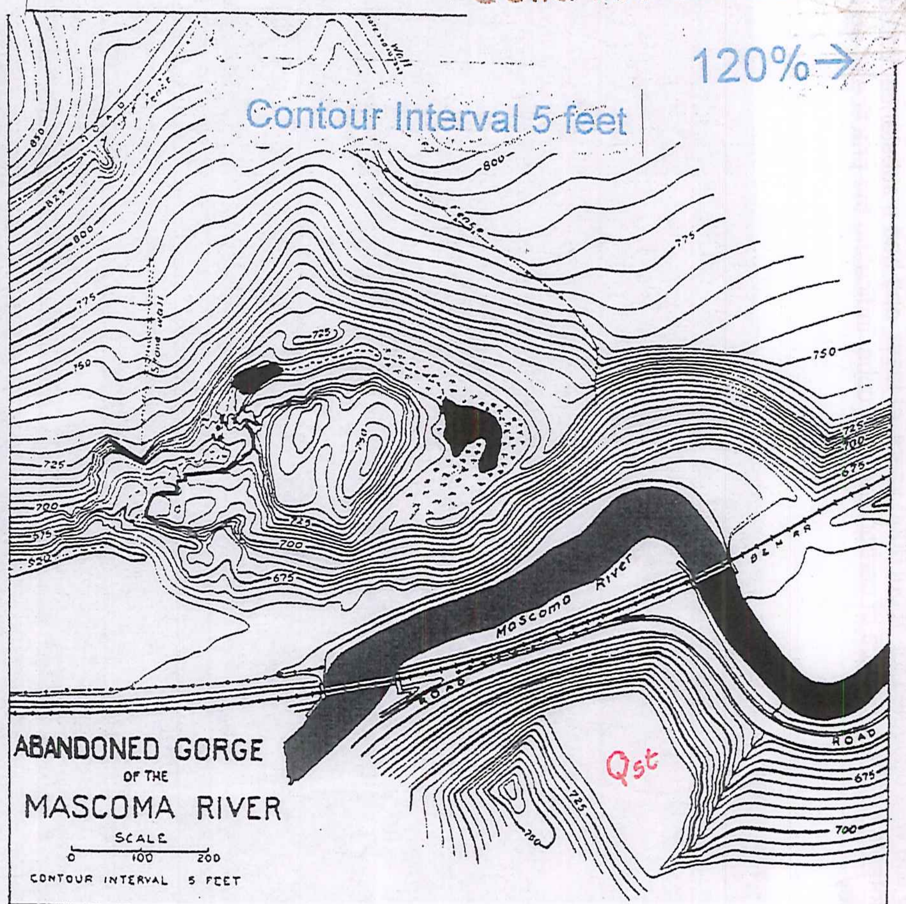
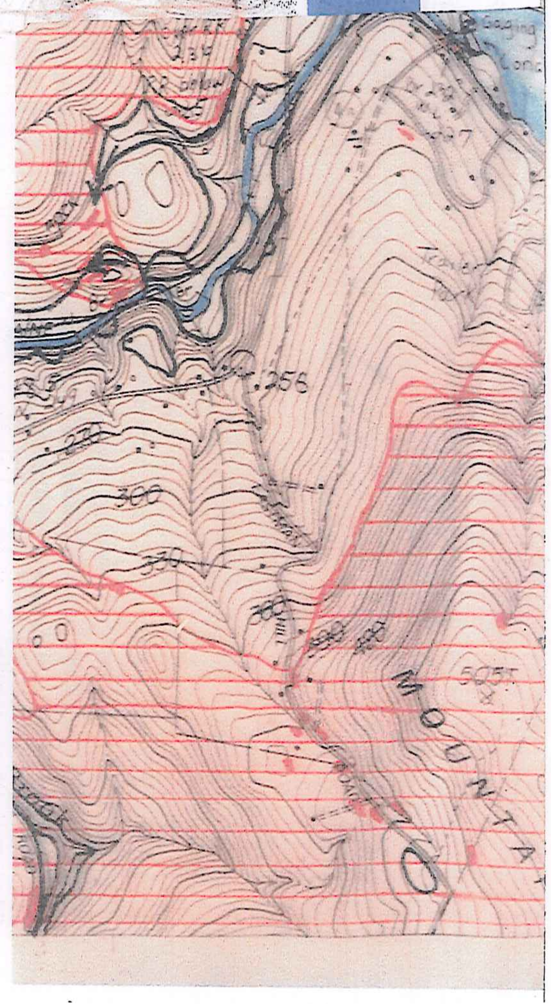


FIGURE 11. Map of the abandoned gorge and waterfall of the Mascoma River east of Lebanon, mentioned by Belknap in 1792. (From Goldthwaite, 1925)

Red Hachure = shallow bedrock
Solid red areas = bedrock outcrop

120%→



The Hunter site was never written up, the excavator (Howard Sargent) never got to it before he died in 1994. The site is known in NH archaeological oral history, but that is about it. Attached is the location of where the site was. The bridge construction got it.

The site was occupied for about 6000 years, at least, and had a substantial Woodland period occupation. It is notable for the presence of carbonized corn cobs, indicating the practice of agriculture in the Connecticut valley.

There really aren't any good candidates for archaeological sites on the NH side of the river within the target zone. We have a few sites, generally late (1000 years old, give or take) but nothing striking. The best of the lot was the Hunter Site in Claremont, but it was taken out by a bridge project in the 1960s. Ironically I come from Lebanon and even worked at the Hunter site as a high school kid. I have run trips for the FOP in the past and unfortunately I don't know of sites of the caliber appropriate to such a tour. Sorry.

Figure 12a. Hunter Archeological Site in Claremont--location and information from Richard Boisvert, New Hampshire State Archeologist (personal communication).

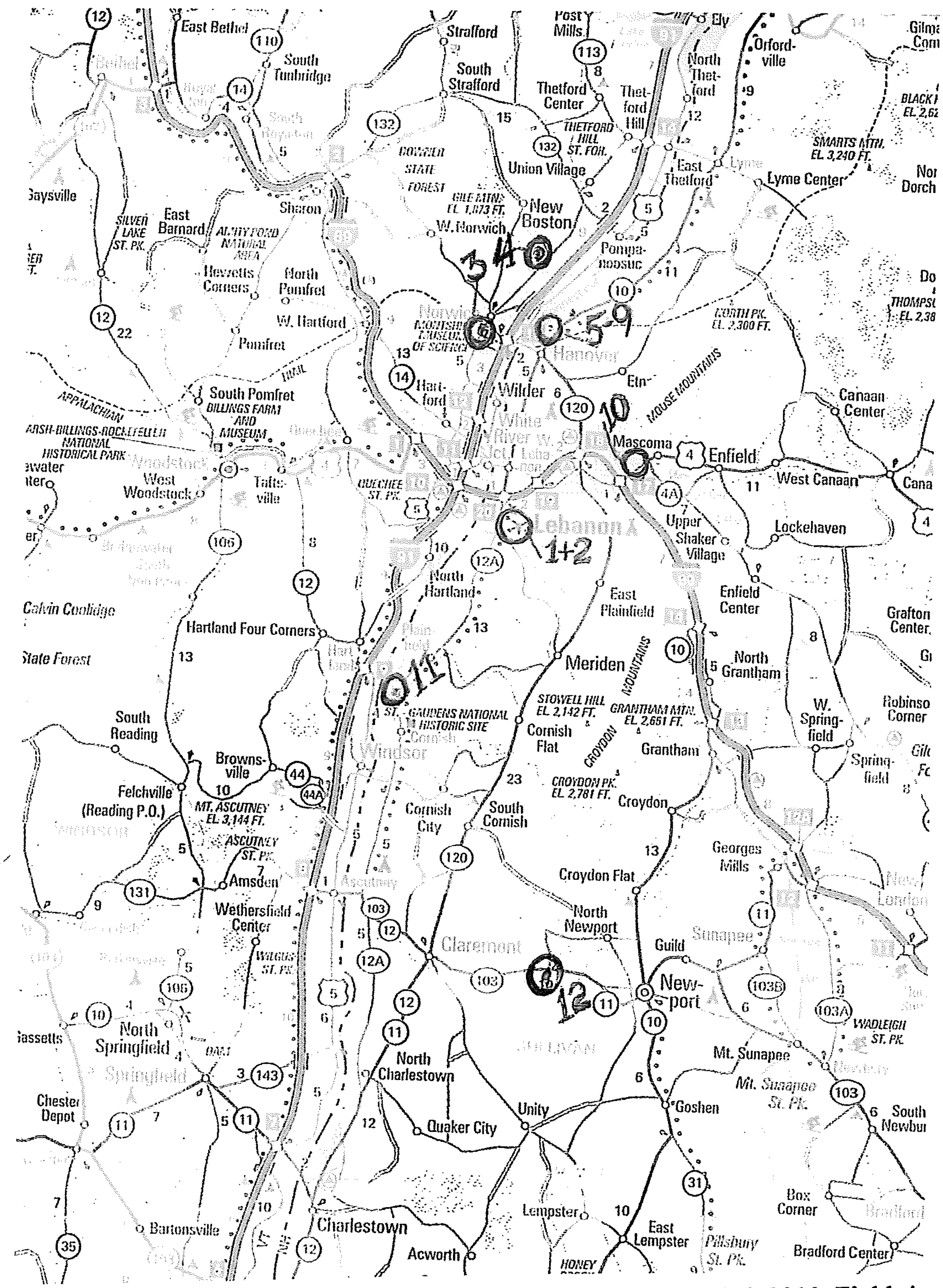
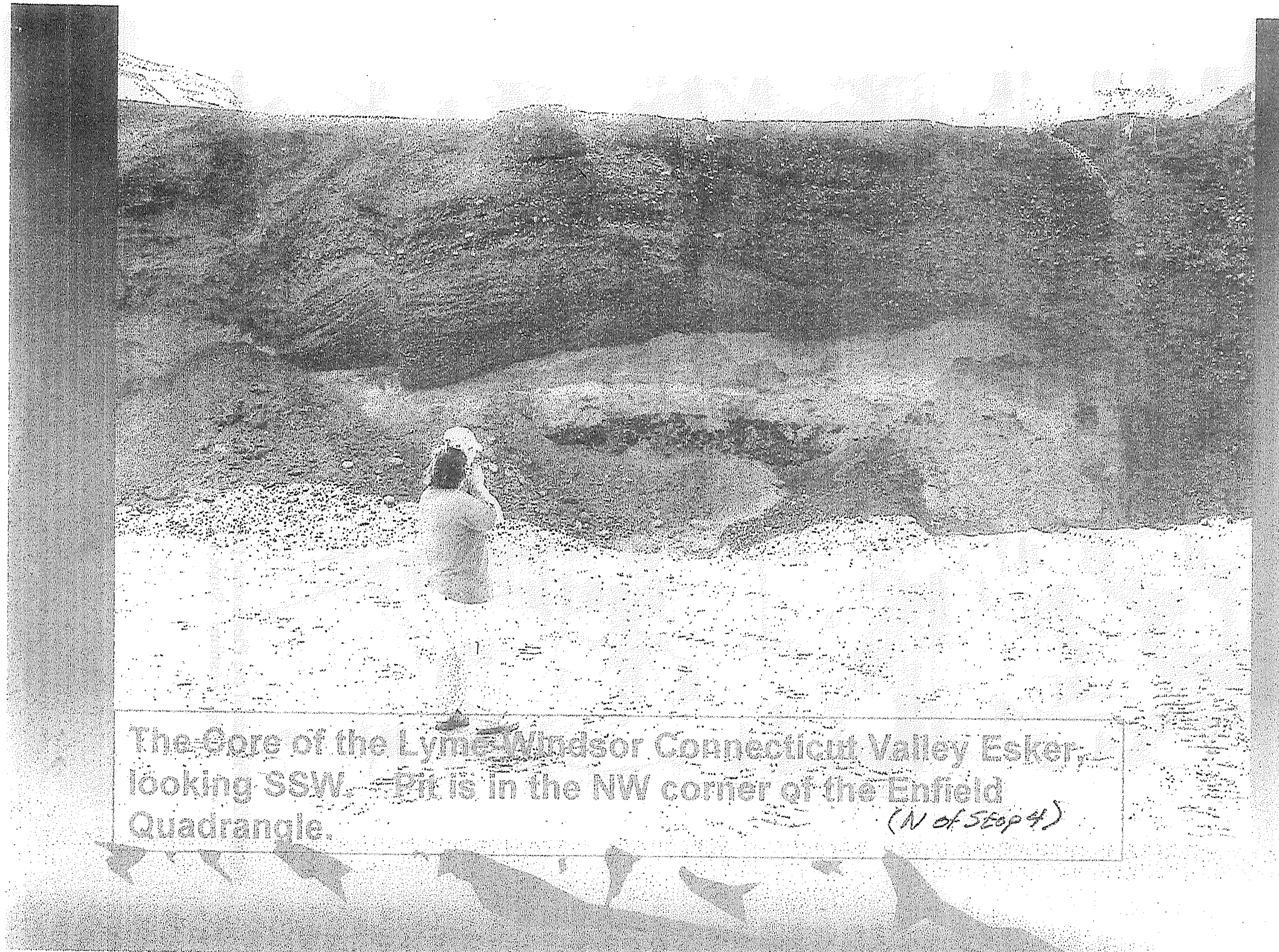
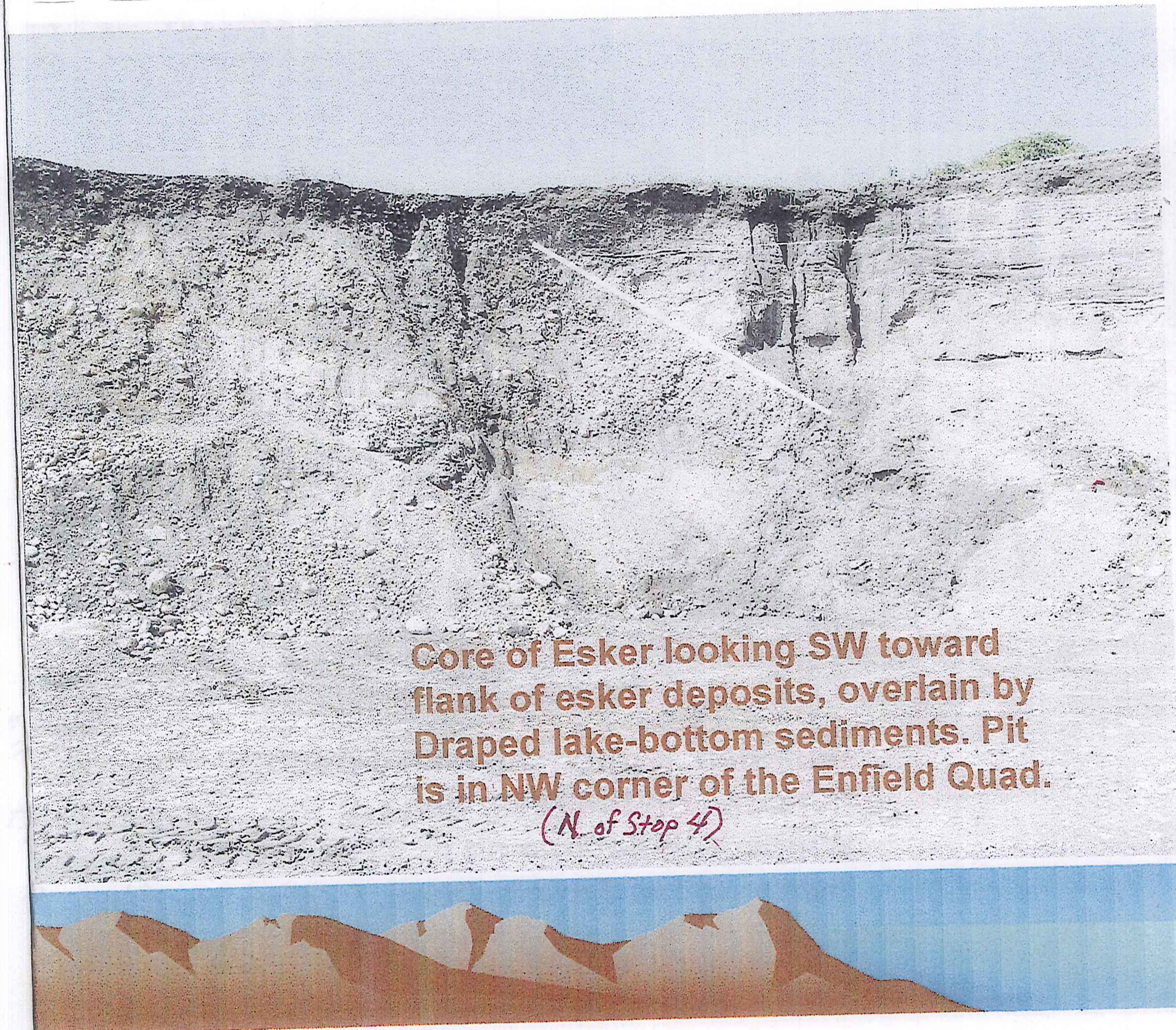


Figure 12.-- Friends of the Pleistocene (Northeast Section) 73 Reunion, June 4-6, 2010, Fieldtrip. Stop Locations. Stops 1-9 are on Saturday and Stops 10-12 are on Sunday.


The Core of the Lyme-Windsor Connecticut Valley Esker, looking SSW. Pit is in the NW corner of the Enfield Quadrangle.
(N of Stop 4)


Core of Esker looking SW toward
flank of esker deposits, overlain by
Draped lake-bottom sediments. Pit
is in NW corner of the Enfield Quad.
(N. of Stop 4)

P.16 Fig. 16

Slumped, faulted thick lake-bottom deposits on the West flank of the Lyme-Windsor Esker in a pit in VT in the NW corner of the Enfield Quad. (N of Stop 4)