

GLACIAL HISTORY OF THE BLACK RIVER AND NORTH BRANCH VALLEYS, WEATHERSFIELD, VERMONT

VERMONT

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Introduction

Weathersfield, located in southeastern Vermont, lies on the Connecticut River, which is the border between Vermont and New Hampshire. Weathersfield has an area of 44.2 square miles, and a population of 2,825 from 2010 census. Our field group surveyed the town's surficial material to better understand the record of glaciation and surficial processes in the area. During our fieldwork, we identified and analyzed various types of surficial materials in an effort to understand how the Laurentide Ice Sheet influenced the topography and surficial geology of Weathersfield. We constructed GIS maps of surficial materials and glacial landforms (Figure 7) using these gathered

Major objectives of this fieldwork were to make a surficial geology map and to generate a cross section of a river valley. Water well logs were used to gather data about depths of surficial units in the valleys. We also searched for, analyzed, and recorded glacial ice flow indicators such as striations, chatter marks, and roche moutonnées (Figures 1 and 2). Using these glacial motion indicators, as well as the distribution of glacial, glaciofluvial, and subglacial sediments, we modeled the history of the Laurentide glacial retreat that is preserved in the Black River and North Branch Valleys (Figure 8).

Methods

- Soil Characterization
- Soil probes, augers, and sediment grain size cards were used to identify and classify surficial materials and to determine contacts between units. Contacts between differing surficial units and landforms were marked and
- recorded with the smartphone app, Fulcrum.
- Glacial Identifiers & Landforms
- Glacial movement indicators such as striations, grooves, and roche moutonneés were identified and their trends were measured using a compass and recorded in Fulcrum.
- The locations of potential glacially produced landforms, such as eskers, kames, and kettles were marked or outlined with Fulcrum.
- Cross Section
- Water well ID tags were recorded in the field.
- Water well logs and additional well locations from the Vermont Agency of Natural Resources (ANR) were used to generate a cross section of the Black River valley.

Data

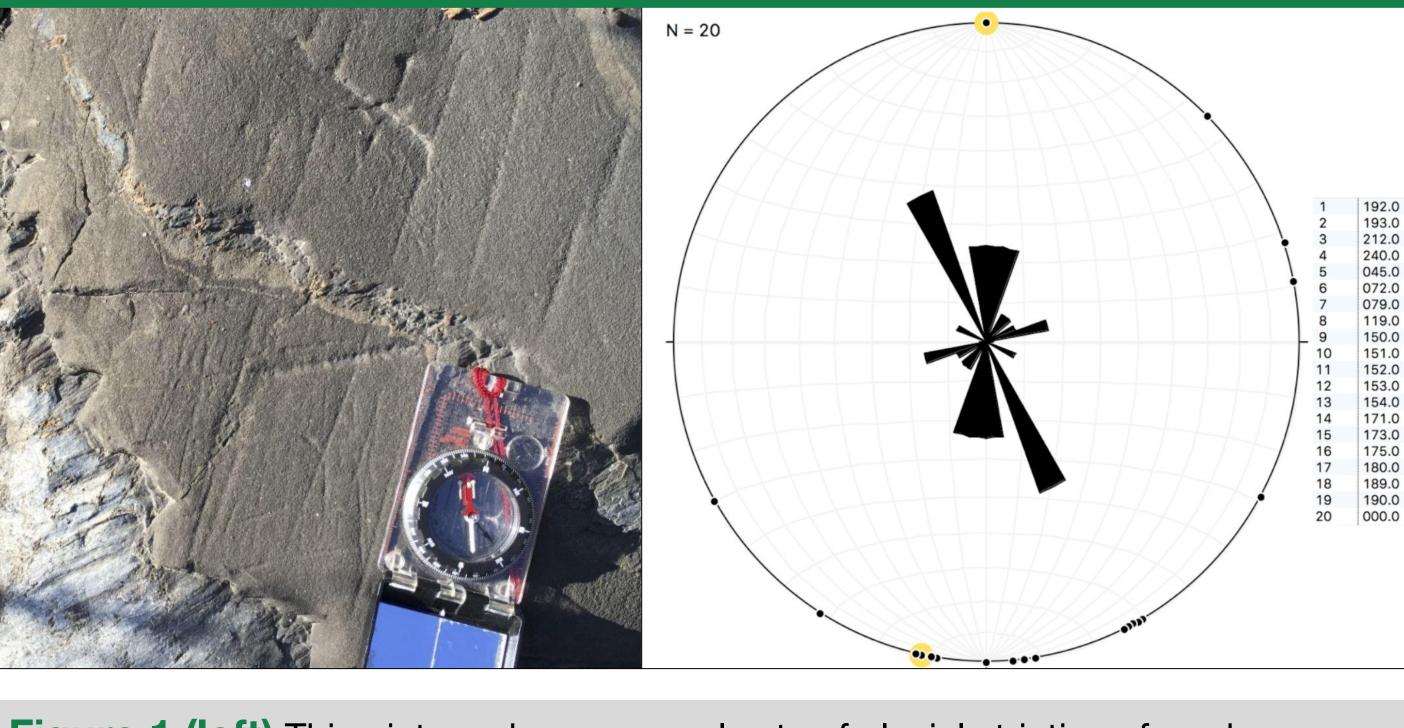


Figure 1 (left) This picture shows several sets of glacial striations found on a bedrock outcrop in Weathersfield. Cross-cutting striations indicate a flow direction change from a trend of 163° (SE) to ~175-189° (S). This change may be caused by increased ice ablation, leading to ice sheet marginal thinning.

Figure 2 (right) The rose diagram shows the trend of glacial flow directions recorded in Weathersfield. This visualization of flow indicators combines data from striations, glacial grooves, and roche moutonnées. The two dominant trends are 150°-160° SE and 170°-190° S. These two significant trends show a change in the trend of glacial flow across the landscape.



Figure 3 shows a small channel about 4 meters wide in Amsden Gravel Pit. This channel cuts through poorly sorted sand with cobbles and pebbles, and is infilled by fine grained sand after channel abandonment. These sediments were discovered at ~600 ft in elevation, similar to the elevation of deltaic foreset/topset bed contacts (Koteff & Larsen 1989). Large grained deposits are scoured by the channel, which is subsequently infilled by small grained, well sorted sand. We infer this event sequence shows the periodic aerial exposure of a deltaic environment, along with channel migration.

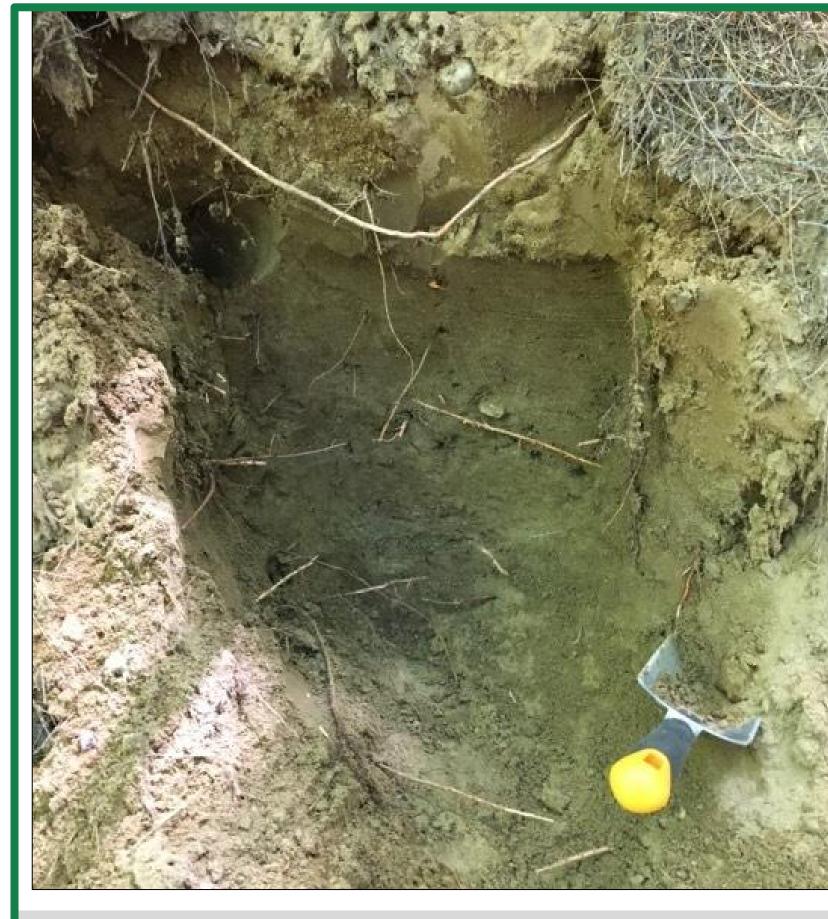
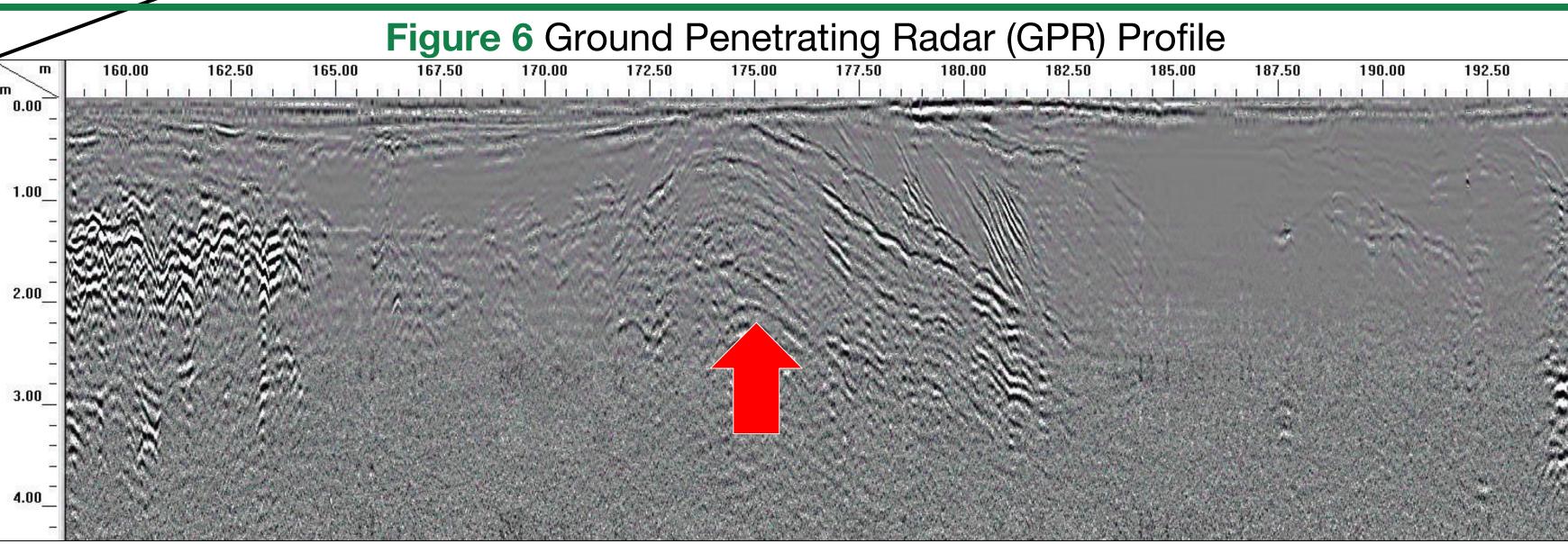


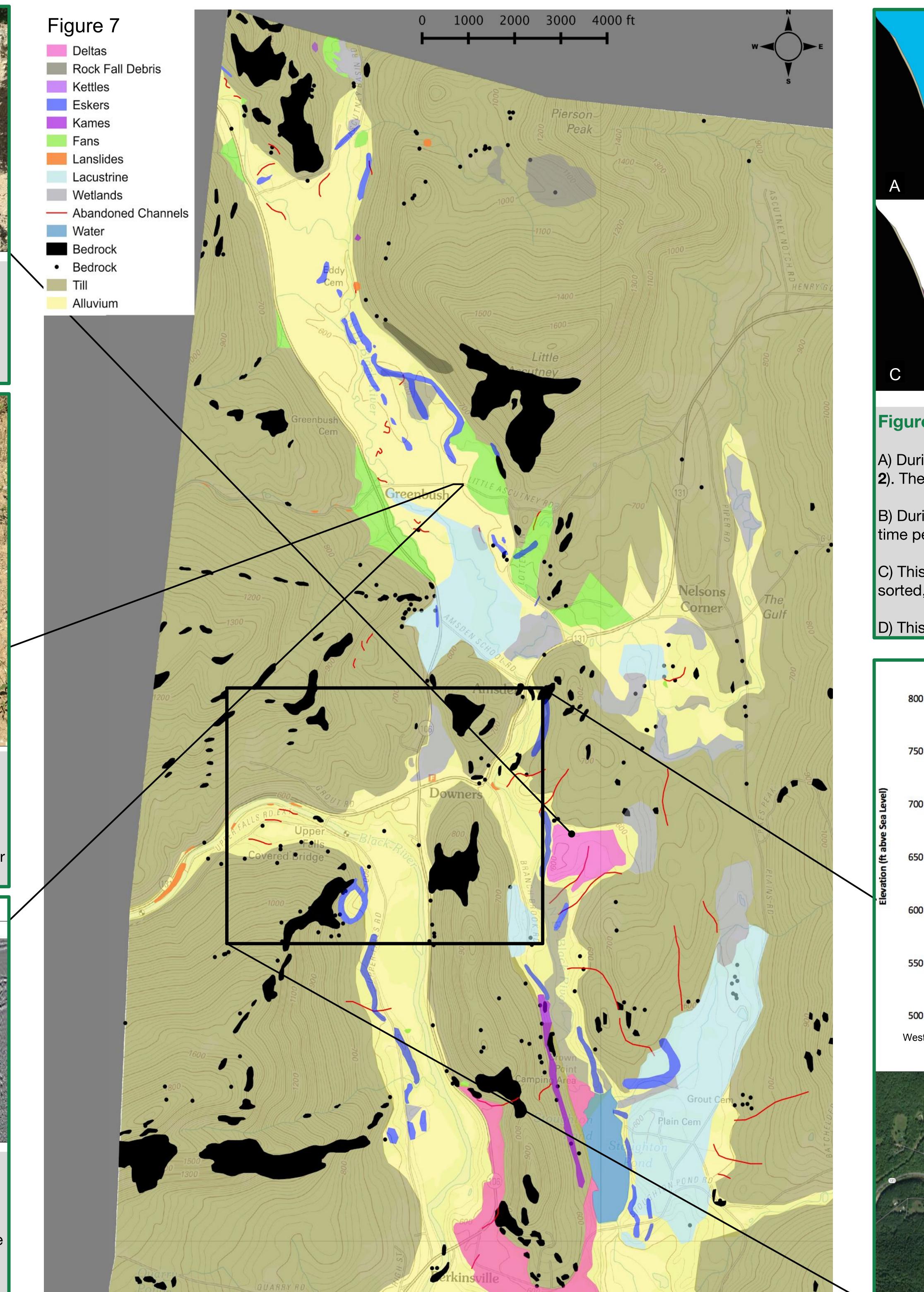
Figure 4 shows relatively large clasts in layered very fine and fine sand. These clasts are ice rafts melt, causing stones ranging in size from pebbles to boulders to be deposited in fine grained, well sorted lacustrine sediment.

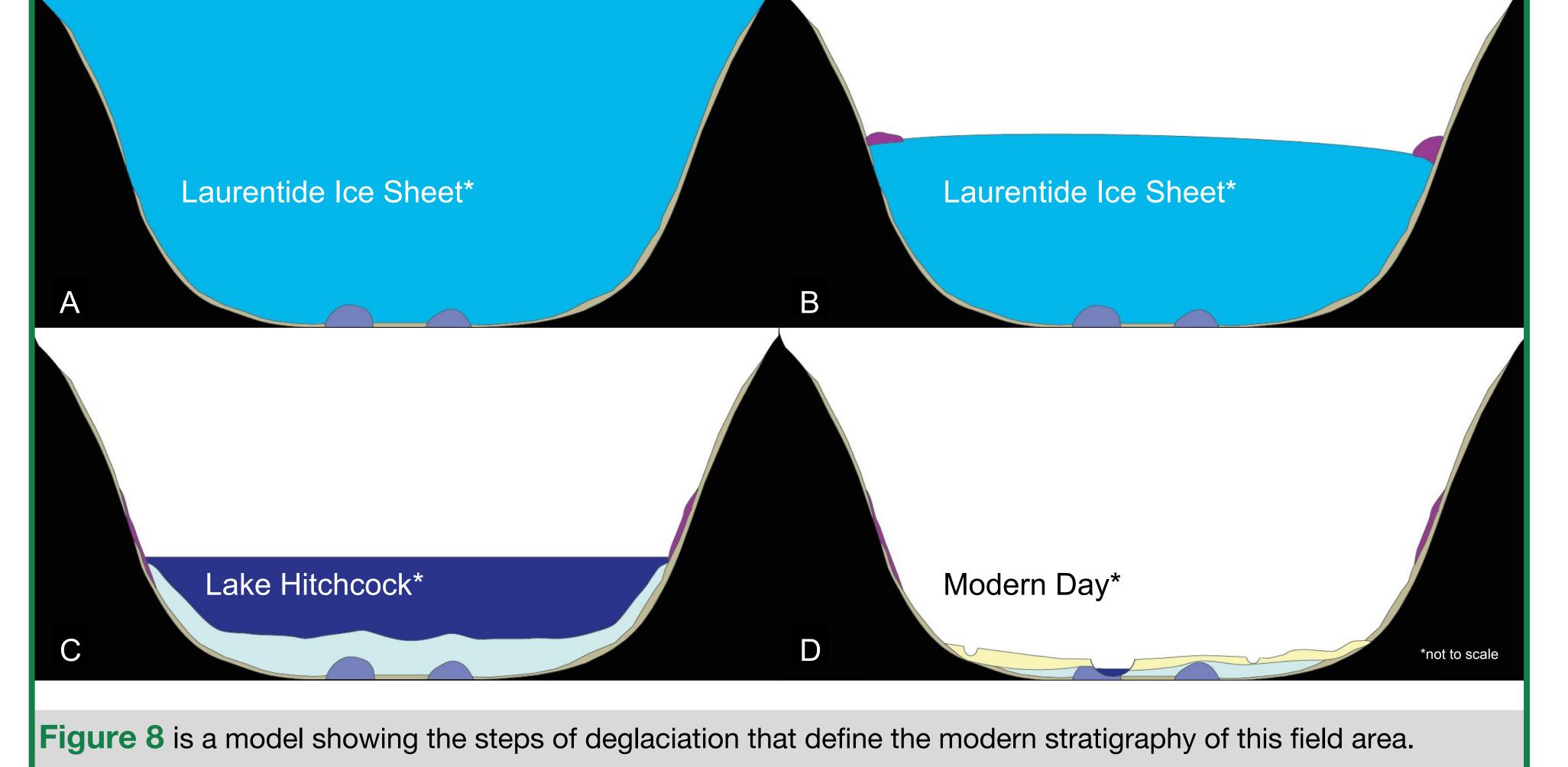


Laurentide Ice Sheet. Till is found mostly at elevations greater than 700 ft asl. It is very poorly sorted and contains sediments ranging in size from fine sand to boulders. Farm land underlain by till often has human made cobble walls for increasing farmable land area or for marking old or current property borders.



GPR is a type of reflection seismology, and uses radio waves to generate images of subsurface sedimentary layering and stratigraphy. This image used a 400 MHz GPR unit and shows horizontal distance and two-way reflection time rendered as depth. In the middle of this image above the red arrow, the profile shows shallowly dipping layers. Due to the location of this landform in a valley bottom, and its reflective profile, we interpret this to be part of a buried esker. Eskers are subglacial drainage tunnels since filled with with sand and gravel. This esker is found further north in the North Branch valley, and is overlain by Glacial Lake Hitchcock lacustrine sediments, (Ridge et al., 2012) and by modern alluvium in other parts



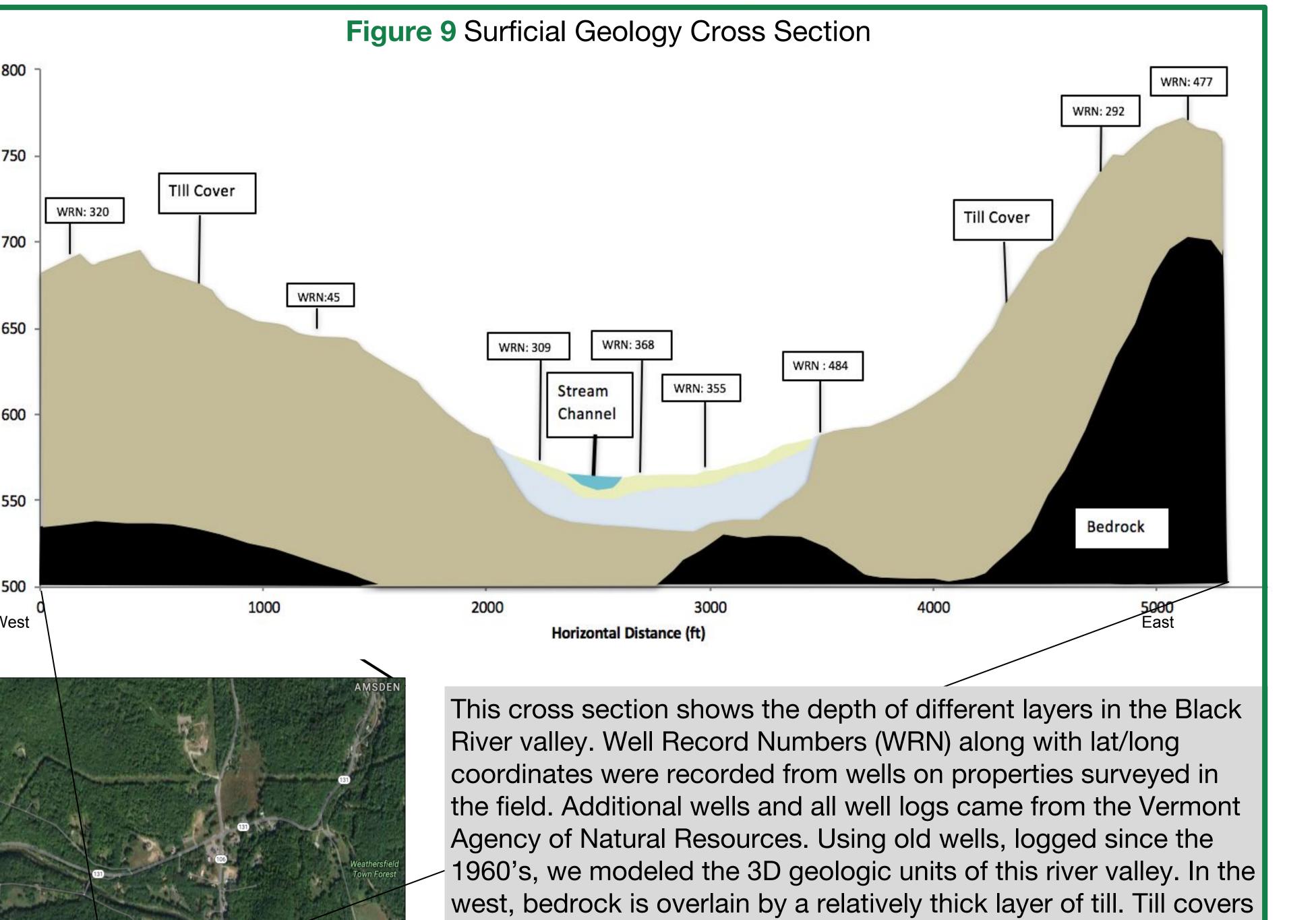


A) During the Last Glacial Maximum, we interpret regional ice flow to trend to the SE due to flow indicators (Figure 2). The Laurentide Ice Sheet reached its maximum ~26 kya, and deglaciation began ~19 kya.

B) During marginal thinning of the glaciers, flow was restricted by bedrock topography. Striations formed during this time period have trends roughly parallel to N-S local mountain ridges, and are strongly related to local topography.

C) This image shows Lake Hitchcock and the deposition of glacial lake sediments. These sediments are very well sorted, and transition from fine sand to clay as the glacial margin moves further north.

D) This image shows a representation of modern stratigraphy within river valleys.



most of the field area, and was the most common glacially derived

sediment type found during mapping. In the river valley, modern

and old alluvial landforms (terraces, cut-banks, point bars) were

deposited above Lake Hitchcock clays and sand. (Figure 4)

Conclusions

- The Laurentide Ice Sheet has sourced most of the surficial material in Weathersfield.
- The Laurentide Ice Sheet deposited thick deposits of till at elevations greater than 700 ft asl.
- The ice sheet left behind esker and deltaic deposits throughout the valleys that have been utilized for their well sorted sand and gravel.
- Esker deposits have been eroded and modern alluvium has been deposited overtop of esker deposits, as shown by GPR.
- Glacial flow indicators discovered in the field reveal that the ice sheet travelled in both SE and S trends. This directional shift from SE to S occurred when the ice sheet thinned and began flowing parallel to the Black River and North Branch valleys.
- Ice sheet recession facilitated the formation of a narrow proglacial lake, Glacial Lake Hitchcock, which extended up the Connecticut River valley into the Black River and North Branch valleys. The shallow lake in these valleys rapidly filled with deltaic sediments that prograded southwards until the lake drained.
- During the transition between Figure 8B and 8C, a glaciolacustrine delta occupied the Black River and North Branch valleys (Koteff & Larsen 1989).
- After the ice sheet margin retreated to the north, Glacial Lake Hitchcock occupied the Connecticut River valley, and an arm of the lake extended into the Black River and North Branch valleys.
- Lacustrine sediments overlay till and any glaciofluvial sediments from glaciation.
- Modern and old alluvium is deposited in a film overtop of lacustrine, glaciofluvial sediments, and till.

Other Work

- The Vermont Agency of Natural Resources is currently collecting and analyzing LIDAR data that will include the town of Weathersfield. LIDAR will greatly increase our understandings of how the Laurentide Ice Sheet affected Weathersfield topography and surficial materials.
- Analysis of (GPR) data is currently being performed by faculty at the University of Vermont. This data will increase the understanding of the stratigraphic layering of sediments within the Black River and North Branch valleys.

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References

- Clark, P. U., Dvke, A. S., Shakun, J. D., Carlson, A. E., Clark, J., Wohlfarth, B., . . . McCabe, A. M. (2009), The Last Glacial Maximum [Abstract]. Science, 325, 710-714. doi:10.1126/science.1172873 Gale, Mariorie., Anderson, Ginger, "Geology of Vermont Lands," Educational Leaflet No. 2, 1998, VTDE0
- rebound. In "Earthquakes at North Atlantic Passive Margins: Neotectonics and Postglacial Rebound" (S. Gregersen and P.W. Basham, Eds.) pp. 105-123. Kluwer Academic, Amsterdam
- Koteff. C., Robinson, G.R., Goldsmith, R., and Thompson, W.B., 1993. Delayed postglacial uplift and synglacial sea levels in coastal central New England:Quaternary Research, v. 40, p. 46-54.
- Little, Richard. "The Rise and Fall of Lake Hitchcock New England's Greatest Glacial Lake". 2000. ISBI
- Ratcliffe. N.M., Stanley, R.S., Gale, M.H., Thompson, P.J., and Walsh, G.J., 2011, Bedrock geologic map of Ridge, J.C., Balco, G., Bavless, R.L., Beck, C.C., Carter, L.B., Dean, J.L., Vovtek, E.B., Wei, J.H., 2012. The new
- Roger LeBaron Hooke, John Charles Ridge, Glacial lake deltas in New England record continuous, not delayed postglacial rebound, Quaternary Research, Volume 85, Issue 3, May 2016, Pages 399-408, ISSN 0033-5894
- http://dx.doi.org/10.1016/j.ygres.2016.02.006. • Wright, S.F. "Glacial Geology of the Burlington and Colchester 7.5' Quadrangles, Northern Vermont." Glacial
- Geology of the Burlington/Colchester Quadrangles. 2009.