Surficial Geology from the Hudson Valley to the Massachusetts Coast

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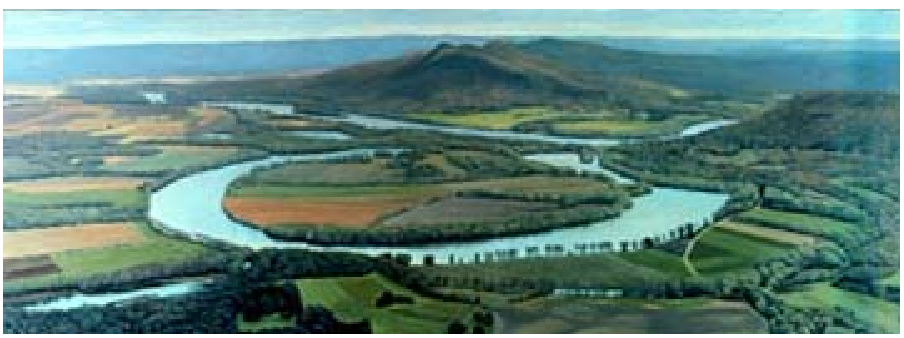
This first in a series of articles on the landforms and tectonics of New England and New York, by member Steve Daukas, begins with a closer look at the Connecticut River Valley. We start with a broad overview of the forces that combined to form the topography of the region, the geomorphology of the Connecticut Valley, its relationship to Glacial Lake Hitchcock, and the evolution of the Connecticut River's course and drainage patterns from the Pleistocene through the Holocene.

Connecticut River Valley & Glacial Lake Hitchcock

The Connecticut River Valley is a prominent feature of the Massachusetts landscape. The "valley", as it is known to those who live there, was a good place to farm and locate industry because of good soils and access to markets via the Connecticut River. Those who live in the valley are familiar with the river's banks and coves, as well as the annual spring flooding along the flood plane. This is also the location of Glacial Lake Hitchcock, a lake formed by ice melting during the Pleistocene that occupied the valley prior to the present-day river.

One of the best ways to see the Massachusetts part of the Connecticut Valley is from the top of Mt. Tom, a 2000+ acre State Reservation with amazing views, or from the top of Mt. Holyoke from the porch of the Summit House providing exceptional views of the CT River and the Pioneer Valley. The now famous *Oxbow Lake* was painted from atop Mt. Holyoke by Thomas Cole in 1836.

Introduction

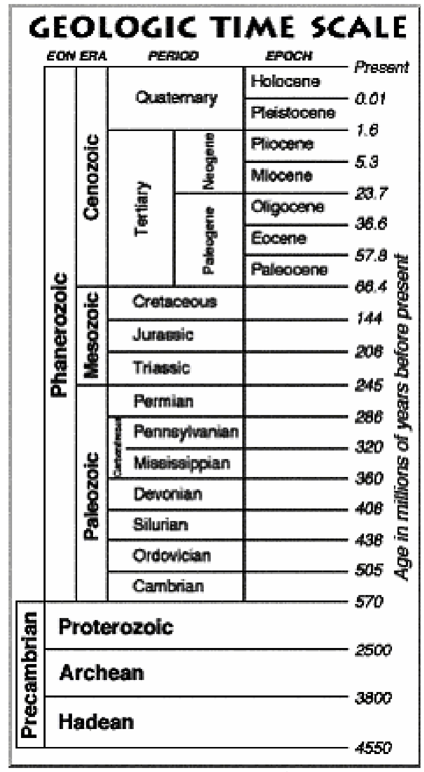


Oxbow Lake, Connecticut River, Northampton Massachusetts
From Amherst College's Museum of Natural History Web Site

Central New England in general, and the Connecticut Valley in particular, represents an area both familiar and unknown to many of its tourists and inhabitants alike. The familiar include well-known views, indeed some famous, from the area's summits, and many of the town centers and local farms do, in fact, appear on post cards and calendars. Tourists triple their numbers during fall’s colorful display and apple-picking season, and everyone enjoys the fairs, festivals, and parades throughout the year. What isn't known to many is the region's relationship to ancient events - continental collisions, mountain building, volcanoes, the creation of a new ocean, and the weathering away of much of the evidence - that is often met with fascination and disbelief once brought to light. Even those who visit the several dinosaur parks in the valley are not fully aware of the opportunity for learning of Earth's history that the valley represents.

Events Leading to the Pleistocene

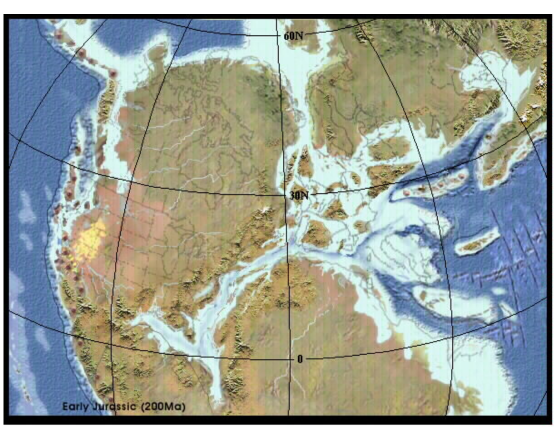
Central New England & Massachusetts



From Geological Society of America

The Connecticut River Valley occupies a lowland area (ancient syncline - graben) located between two higher elevations (ancient anticlines - horsts); the Berkshire Highlands (to the west) and the Bronson Hill Upland, also known as the Worcester Plateau (to the East). This valley is in the center of a larger region, extending from eastern New York State eastward to the Atlantic Ocean, formed where the supercontinents Laurentia and Gondwana began their collision during the final formation of Pangaea, about 417 million years ago. Crystalline basement rocks were formed during the late Devonian through the Carboniferous with metamorphic activity continuing into the early Permian and are the eroded remains of the late Silurian's and early Devonian's Acadian Orogony, a mountain building event whose peaks were once as imposing as the Alps are today.

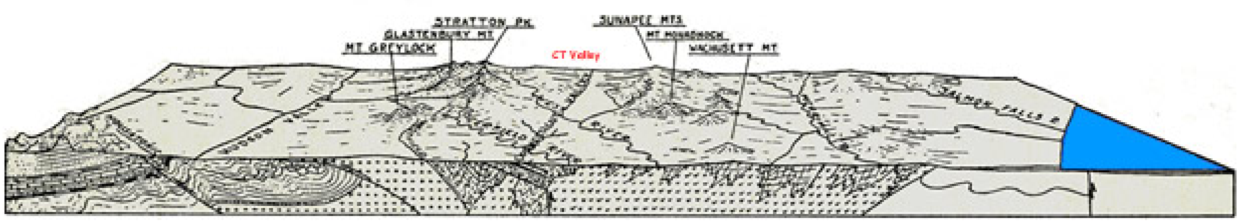
The formation of Pangaea involved several terranes at the margins of both Gondwana and Laurentia (separated by the closing Iapetus Ocean) that formed as early as 550 millions years ago after the break up of Rodinia, the previous supercontinent. These terranes started to become sutured to the continent during the earlier Taconic Orogony of the Ordovician. The Bronson Hill Upland (or Worcester Plateau) is one of the Laurentain terranes that began as a volcanic island arc. Other volcanic and plutonic terranes begun in the Ordovician include those thought to be of Gondwanan origin: the Meguma (SE portion of Cape Cod), the Avalon (SE MA inclusive of Boston), the Nashoba (a thin wedge trending SW to NE east of Worcester) and the Merrimack (Worcester west to the Bronson Hill volcanic belt). The makeup of the general area is actually more complex than described, with five of the six Laurentian terranes omitted, as well as all of the various belts making up these terranes.



The Continents Rift Apart During the Jurassic, 200 MYA
From Prof. Blakey, Ron, 2005, Northern Arizona University, Paleogeographic Views of Earth's History - Web Site

By the end of the Permian, about 250 million years ago, the Iapetus Ocean had completely disappeared and the final assembly of Pangaea was complete. Fifty million years later during the Jurassic (see image at left), the Connecticut Valley region was among the sites where Pangaea began rifting apart giving rise to volcanism and igneous formations that dot the area today. This newly forming basin was only part of a larger mountainous region resembling the Basin and Range region in Nevada. The Connecticut Valley Border normal fault forms the eastern boundary of this particular basin, and marks a drop of thousands of feet to the valley floor to the west (filled with thousands of feet of sediment since that time). Farther to the east, another rift valley had formed and continued to open, eventually giving birth to the Atlantic Ocean (lower left of center). The location of this new ocean left parts of the old Gondwana continent behind - the terranes mentioned above - as part of New England. Given the rather involved history of the area, the geology is quite complex and difficult to interpret.

The Connecticut Valley area is underlain by a collection of metamorphic and intrusive rocks from the formation of Pangaea, and continental sedimentary rocks, extrusives, and intrusives from the Mesozoic. Metamorphism is estimated to have been as deep as 25 km (15 miles). By the late Cretaceous, the area is thought to have been eroded to a peneplain with the "ancient" Connecticut River flowing through the basin formed during Mesozoic rifting. Many of the domes in the Connecticut Valley, such as the Shelburne Falls, Pelham, Monson, and Warwick, are eroded remains of the earlier fault-block mountains and associated volcanism.

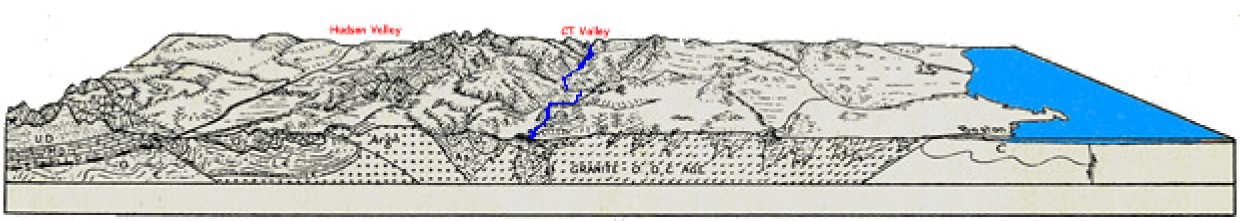


Block diagram showing the main features of central New England at the opening of the Cenozoic era.
Modified From: *Bain, George William, 1942, The flow of time in the Connecticut Valley, Fig 19, p 45*

The Pleistocene Forward

Massachusetts and the Connecticut Valley

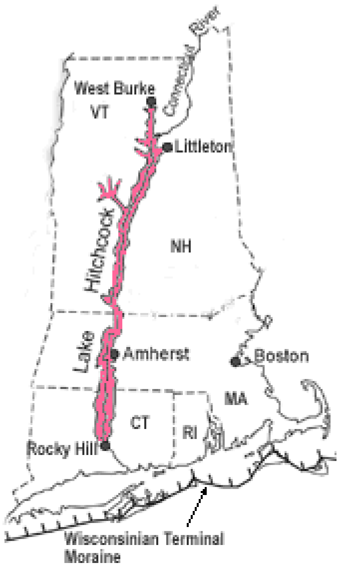
Glacial and interglacial periods have left their mark on the general area. Deposition of sands and gravels from receding glaciers cover much of eastern Massachusetts, and till from the Illionian ice sheet (140,000 years ago) has been identified. Marine sediments were deposited during the Sangamon interglacial period, about 125,000 years ago, followed by the Wisconsinian glacial period about 80,000 years ago. Much of the topography we see today is a result of this latter ice sheet's modification of preexisting features.



Block diagram showing the main features of central New England at the present time.
Modified From: *Bain, George William, 1942, The flow of time in the Connecticut Valley, Fig 20, p 45*

Sometime between 25,000 and 15,000 years ago, the Wisconsinian ice sheet began its retreat. As the ice sheet retreated, higher elevations melted first, leaving the ice-filled valley to become a constantly changing mix of ice, melt-water and sediment eroded from the uplands.

The Connecticut Valley - *Glacial Lake Hitchcock*



Glacial Lake Hitchcock
After Skehan, 2001; Roadside Geology of Massachusetts

Melting glacial ice often forms proglacial lakes, lakes between the retreating glacier and natural barriers that block the meltwater's course downstream. New England had many glacial lakes, but the largest of these was Glacial Lake Hitchcock. At its largest, the lake extended from Rocky Hill, Connecticut, northward approximately 220 miles into Vermont and reached a maximum width of 20 miles. The lake included long islands (ridges) of volcanic origin. The dam at Rocky Hill was approximately 1 mile wide, blocking the entire valley, and consisted of stratified drift deposited as coalescent deltas in a glacial lake at 135 feet above sea level. As the water flowed over the dam, a shallow outlet was incised and the lake's elevation stabilized for a short time. This channel is known as the Dividend Brook outlet. The present day Dividend Brook is located in the southern part of Rocky Hill adjacent to the Industrial Park and the Town's Fire Headquarters, and has two ponds (Upper & Lower Dividend Pond). The New Britian spillway, just west of Rock Hill, eventually took over as the outlet of the lake.

Streams draining the watershed deposited sediment into the lake from both the surrounding highlands and the glacier itself. Deposits consist of sand and gravel (deposited at the mouths of tributaries as the streams' competence diminished) as well as finer sediment from suspended loads that settled into clay layers farther from their source. Varved clay layers record the annual freeze-thaw cycle of the glacial lake. In addition, large erratics entombed by ice calved from the retreating glacier were deposited as the ice-rafts melted.

Differing clay colors show changes in erosion sources. Reddish-brown indicate Triassic sedimentary sources while blue-gray to grey-brown indicate predominantly igneous and metamorphic sources from the uplands. The reddish-brown deposits indicate sediment coming from the glacier that occupied the Triassic lowland. However, sediment showing colors of an olive-brown could be attributed to a rind or cement formed from iron-rich leachate introduced into sediment layers not originating from Triassic sources. Once the glacier retreated as far north as the Chicopee and Westfield Rivers, sediment from the igneous uplands was able to flow directly into the glacial lake forming familiar fluvial landforms.

The basins and valleys in the uplands show terraces, ridges, and knob-and-kettle topography giving evidence of eskers, filled crevasses, kames, and other ice-contact deposits. As waters drained off these higher elevations, they encountered ice blocks and deposits of till at lower elevations. The drainage patterns were chaotic as numerous local base-levels were formed, destroyed, and formed again. It was these streams that contributed large quantities of sediment in the form of deltas that prograded into the glacial lake.

Studies of the varved clay layers throughout the valley in 1927 (by Ernst Antevs) suggested the lake existed for about 4000 years and later radiometric dating gave an age of 3,700 years. 12,700 years ago, the Rocky Hill dam failed draining the lake as far north as the Holyoke Range. 300 years after the Rocky Hill failure, the remainder of the lake drained when the sediment dam located at the Holyoke Range also failed.

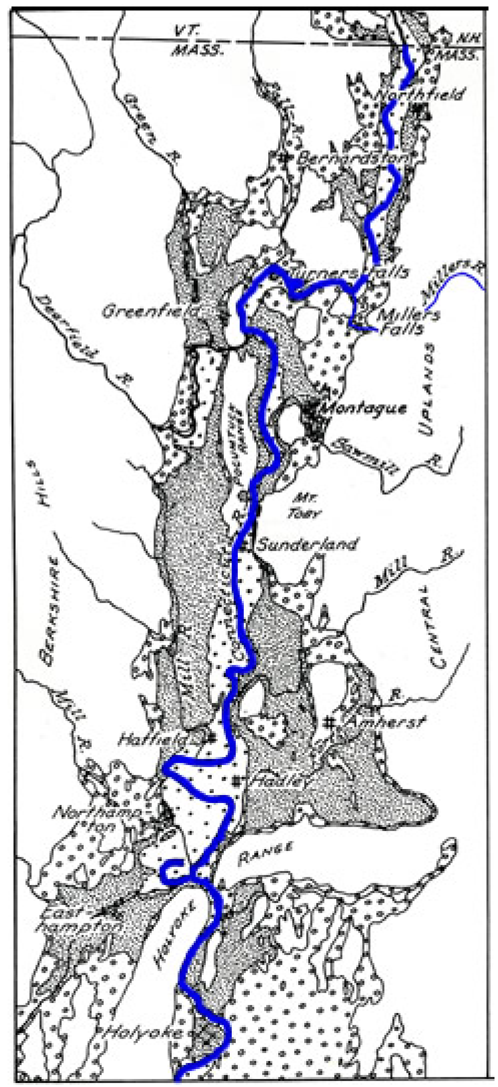
The Connecticut Valley - *The Connecticut River*

Once the weight of the Wisconsinian Ice Sheet had been unloaded via melting, the northern region of the valley rebounded. Uplift has been calculated at roughly 4.2 feet per mile (northward) based on vertical displacement of shoreline features (wave-cut benches, beaches, topset and foreset beds, etc.) in Western Massachusetts, with similar rates calculated for the Connecticut portion of the basin.

After the lake water had drained, the Connecticut River essentially followed the same pre-glacial course through the ancient Jurassic rift valley, incising itself some 160 feet through the former lake bottom sediments and passing through several pre-existing gaps cut across sedimentary and basement rock (consequent channels) formed as a result of uplift during the Miocene (24 million years earlier).

As a result of deltas prograding into the now drained glacial lake from tributaries such as the Deerfield and Millers River, the river's course detoured around these obstacles. In the case of the confluence of the Connecticut with Millers River at Millers Falls, MA (visible from Route 2), the Connecticut River diverted to the west towards Greenfield, then followed a path south along the western edge of Rocky Mountain (through present day Greenfield), eventually heading eastward through the Deerfield Gap to its original course. This path has also subsequently been abandoned with the river now following along the eastern side of Rocky Mountain (the western edge of the ancient delta).

The southern wall of Barton's Cove (just west of the Millers confluence) is a result of the Connecticut River cutting across a narrow ridge of Triassic sandstone and shale (the Lily Pond Barrier) forming a large fall. More than one nick point existed along this detour, some migrating upstream while others remained stationary, leaving a series of cut terraces. Construction of the current dam across a nick point down-stream formed Barton's Cove by flooding, previous to which plunge pools were visible at the base of the ancient waterfall.



Major Quaternary Deposits, CT Valley, MA
Modified From: *Richard Jahna, 1967, The Late Pleistocene of the CT Valley in Northern MA:*
In *New England Intercollegiate Geological Conference 59th Annual Meeting, p.166*

These plunge pools were called "lily ponds" and the name was adopted to describe features in the area. The Lily Pond Barrier was responsible for the formation of proglacial Lake Upham that extended northward approximately to the Canadian border until such time as the Connecticut cut its way through weaker formations at Turners Falls thus draining the lake. The current path of the Connecticut River is located where basal infiltration weakened that portion of the waterfall allowing a collapse where a third plunge pool was probably located.

As the Connecticut River continued to incise the ancient lake bed, it also meandered cutting (non paired) erosional terraces at ever lower elevations, eventually establishing a flood plain widening southward (less resistant rock) reaching some 3 to 4 miles in width. Erosion and deposition continues across the active flood plain today, which bears witness to regular flooding.

In the Spring of 1840, the Connecticut River was swollen and in a high flood stage. Anticipating a change in the river's course, Professor Edward Hitchcock (pioneering geologist, president of Amherst College, and for whom the glacial lake was named) led a contingent of students to the top of Mt. Holyoke where they there witnessed the river cut across a meander neck forming the *Oxbow Lake* at Northampton MA.

1936 saw similar extensive flooding in the valley allowing the Connecticut River to cover the majority of the ancient floor of glacial Lake Hitchcock. Reports of the day indicate that Hadley, MA, located 3 miles north of the oxbow formed in 1840, was in danger of being destroyed by the river cutting through the town forming another meander cutoff. Fortunately, the flood abated and Hadley was spared. A quick view of the river's present course shows other possible locations where new cutoffs might form, including Vernon, VT, Glastonbury and Rocky Hill, CT.

Summary

As noted in the introduction, the Connecticut Valley is a scenic region that has much to offer those who live and visit there today. With the overview of valley's long history presented above, it is easy to see that the valley has quite a bit to offer those interested in how and why the landscape got to be the way it is today. The complexities of the valley attest to its long history of involvement with all the "big stories" we have heard about - continental drift, plate tectonics, super continents, volcanoes, dinosaurs - and represent an amazing opportunity to observe evidence of those stories first-hand.

The next installment will take us to the French King bridge, along the Montague Delta, to Baton's Cover, and finally to Poets Seat tower atop Rocky Mountain – a Jurassic-age volcanic ridge overlooking Greenfield to the West and the CT River to the East.