ALLUVIAL FAN DEPOSITION IN VERMONT AND NEW YORK

A Thesis Progress Report Presented

by

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Introduction

Alluvial fan deposition is directly linked to hillslope erosion. By examining the stratigraphy of Vermont alluvial fans in detail, I infer the timing of hillslope erosion during the Holocene. The ability or inability to correlate depositional periods between the fans I have studied will determine whether hillslope erosion is regionally synchronous (Thesis Proposal, 1998).

Reconnaissance

During August 1998, with the assistance of Anders Noren, I began my study by locating alluvial fans in Vermont. During that time, I was able to identify 30 fans in Vermont. During the autumn of 1998, I also searched for alluvial fans in the Adirondack Region of New York but had little success. Although the topography of that region is prime for alluvial fan deposition, the dense forests of the area made locating alluvial fans extremely difficult and trenching impossible. Soon after classes ended in May 1999, Anders and I traveled to the Catskill region of New York to look for alluvial fans. The Catskills not only have topography conducive to alluvial fan formation and preservation, but they are also heavily clear-cut. The lack of vegetation early in the spring also aided my search. I identified and photographed 25 fans in this region.

All of the fans I have identified in Vermont and New York are located in valleys with flat valley floors abutting very steep mountainsides (see figure 1). A drainage must be present in order to carry sediment to the alluvial fan. For example, some valleys in the Catskills seemed ideal for alluvial fan formation and preservation, yet had no alluvial fan. The only explanation for this difference was the lack of small streams coming off the surrounding hillslopes, perhaps due to differences in infiltration rates.

During June 1999, I revisited all of the alluvial fan locations I had identified in Vermont during the previous August in order to take photos of the fans and to ask for landowner permission to trench. I had been planning to choose fans for my study based on location and condition, but it became apparent that landowner permission was the limiting factor. In the end, I selected four alluvial fans for trenching. These four fans were widely spaced across the state (Bridgewater Corners, Hancock, Maidstone, and Eden Mills), thus preserving my original intention to have the fans spatially distributed over the whole of Vermont.

Because of my struggle to gain landowner permission at most fans, I continued my reconnaissance on most weekends throughout the summer. As a result, my total fan count for Vermont is 34 with 59 fans total located across New York and Vermont together. The location of these fans is shown in figures 2 and 3. The scattering of fan locations throughout the two states is biased by my inability to locate fans in forested areas, and my reconnaissance method of driving along easily accessible roads.

Methods

For each fan, a local backhoe operator was hired to dig two trenches in the alluvial fan. Typically, thetrenches would be about 13 meters long by 2 meters wide by 1.5 meters deep. The trenches were opened so that one was oriented across the apex of the fan (hereafter called the top trench) and the other was oriented from apex to toe of the fan, as close to the fan 'spine' as possible (hereafter called the stem trench). The two trenches intersected to form either a T or L shape.

A network of grids, with 1 m by 1 m boxes, was set up using fence posts, string and a hand level. Distinct stratigraphic units were pegged with colored nails and then transferred to graphed mylar using the string grid as a guide (see figure 4). Detailed geologic and soil descriptions were made of each depositional unit. Charcoal and wood samples were located on the stratigraphic logs, described in detail, and placed in individual plastic bottles. Initial carbon dating was performed by Anders Noren at Lawrence Livermore Laboratory in August, 1998.

INITIAL DATA

Common Characteristics

Although each fan that I trenched had a unique stratigraphy, all four fans shared several characteristics. First, all four fans were well stratified. The trenches revealed semi-continuous, horizontal bedding. Second, buried soil A-horizons were found in all of the trenched fans. The buried A-horizons were identified in the stratigraphy by their dark color and by their high organic content as evidenced by a greasy feel and black streaking. Buried A-horizons are semi-continuous, horizontal and can appear at multiple elevations in the trench walls. The discontinuous nature of buried soils is most likely the result of scouring on the fan surface from sheet flow or incision during large storms. These buried A-horizons represent times when fan deposition ceased for a sufficient amount of time to allow topsoil to develop (greater than 100 years). Multiple buried soil horizons thus indicate that the fan experienced multiple stable periods without sediment deposition. Other soil horizons were also sometimes present beneath the A horizon, such as B and E horizons. Datable material (organic carbon) was found in each fan, largely in the form of rotted charcoal, although rotted wood pieces were also sometimes found.

Bridgewater Corners

The first alluvial fan I trenched, located at Bridgewater Corners, was deposited on top of a small river terrace. The drainage basin that feeds the fan is still active, and a small amount of year-round flow runs through a channel on the northern side of the fan. The fan consisted of interbedded sand and gravel. Many buried A-horizons were visible in the trenches, indicating that the fan has experienced periods of little or no sediment deposition. Because these buried soils did not show a B-horizon beneath the A-horizon, these periods of depositional quiescence may have been relatively short.

In one location in the stem trench, two thin buried A-horizons in sand bracket a gravel layer that is approximately 20 cm thick (See figure 5). This bracketing is the best evidence among the four fans that a large amount of deposition can occur on a fan during a short period of time. Charcoal samples from the sand just above and just below this gravel deposit, and within the confining soil layers, would provide the perfect test to this theory. If the dates came out to be very close to the same age, it would demonstrate that the gravel deposit was rapidly deposited. Unfortunately, this fan did not preserve much datable material, and I was unable to find charcoal or wood in the appropriate sand layers. However, the buried soil layers above and below the gravel deposit have been dated as 4390 and 4960 radiocarbon years BP, respectively. It is difficult to determine whether the 600 year difference indicates that the gravel layer is more than one event because the dates may be reflecting soil residence times. Also, the 4390 date was a very small sample and has an error range of ± 760 years. Other charcoal samples were taken from this section and, when dated, will help to constrain the age of the gravel and buried soil layers.

As mentioned above, the sediment in this fan had remained quite dry due to its coarse grain size, and as a result little charcoal and wood have been preserved. However, six carbon samples were dated from the two trenches, and are indicated on the stratigraphic logs (see Plate 1, room 211 –trench log). The dates ranged from 3420 to 5810 radiocarbon years BP. Currently undated carbon samples closer to the top of the trench may be used in the future to try to constrain stratigraphically the beginning of human influence on the landscape. A seventh date came from river overbank sediments beneath the fan, providing a maximum age for the fan of 9950 ± 50 radiocarbon years BP.

Hancock

The Hancock alluvial fan is much larger fan than the others I have trenched, and is fed by a 1-2 meter wide stream that infiltrates into the ground along the southern side of the fan. The stream is perennial and, according to the neighbors, regularly overflows its channel to spread into sheetflow over the fan during the spring melt; one neighbor reported that "It looks just like a waterfall with all that water a-comin' down the hill." A logging road has also been built along the side of the stream, which appears to have captured flow from the upper reaches of the stream drainage, and is causing a new fan to form just north of the older one (figure 6). Another smaller fan lies just south of the trenched fan, fed by a separate drainage. The fans appear to be deposited on top of a river terrace.

The Hancock fan stratigraphy was difficult to interpret. The bedrock is very shallow here, and we ran into bedrock only 0.5 m below the surface in the stem trench. The bedrock outcrop noticeably interrupted the horizontal layering in the fan and made it difficult to correlate the units downfan of the outcropping. The patchy nature of the stratigraphy may also be due to the larger size of the fan. Humans had also apparently disturbed the fan, as noted by the presence of a 'slash pit,' an area that had been dug up and filled in with dense organic material. Similar to fan at Bridgewater Corners, the Hancock fan is composed of interbedded sand, gravel, and sand mixed with gravel.

Thin, buried A-horizons were present in the trench walls, and in this fan were underlain by dark red colored B horizon soils. The buried B-horizons became a useful tool to correlate units across the trenches because the B-horizon color was often present when there was no trace of an ancient A-horizon. In all cases where a buried B-horizon was present (as indicated by soil coloring) with no overlying A-horizon, the buried soil was overlain by a course gravel deposit. This stratigraphy suggests that the fan was quiet, with little or no deposition, while the A and B horizons developed (probably on the order of hundreds of years). The next depositional event on the fan was large enough to scour and wash away the topsoil on the fan (what would have been the A-horizon) and to deposit the large gravels.

This fan had an abundance of charcoal, but not many pieces large enough to date. Five samples from the trenches were dated, as indicated on the trench logs, and range in age from 2610 to 8890 radiocarbon years BP. Because the fan was underlain by bedrock, I was unable to use organic materr in terrace sediment below the fan as a dating tool. I did dig through the fan sediments at the toe of the fan to what I believed to be river overbank sediments but was unable to find any datable material.

Maidstone

The Maidstone fan is located on a river terrace of the Connecticut River, and is fed by a small gully that extends to the next river terrace (about 15 m above the fan) where the gully abruptly stops. There is no flow in the gully, and it has been filled with over a meter of sand within the past 15 years by the current landowner, who uses the gully as a cow path. A former landowner, who bought the farm in the 1930's, indicated that there has never been any water flow in the gully or on the fan for as long as anyone can remember.

The interior of the fan is composed of interbedded sand and silt layers that are laterally continuous across both trenches (figure 7). Cross-bedding is present in many of the sand layers, indicating high velocity and significant flow depth. Only two buried soil profiles appear in the stratigraphy. The higher buried soil is only faintly colored, about 5 to 10 cm below the surface, and only apparent in the top trench where it merges with the modern topsoil farther from the gully. I believe this upper buried soil was the topsoil before the farmer put the sand into the gully, which has since washed down onto the fan. The lower buried soil is about 30 cm below the surface and has a black A-horizon, underlain by a leached E-horizon, with a B-horizon beneath the E. This profile is typical of spodosols, indicating that the soil had a long time to form in an acidic environment, such as under a pine or hemlock forest. The former landowner indicated that this part of the property had not be clear-cut until very recently, leading me to believe that the buried spodosol is indicative of the pre-settlement fan surface. All of the above features lead me to believe that this fan was formed very rapidly under a high flow regime. There is an abundance of soft sediment deformation in the fan stratigraphy such as rippled beds and faulting. I am not sure what has caused these features. The fan may have been deposited rapidly enough that dewatering from the silt layers occurred, causing the soft-sediment deformation. However, several attendees of the NEIGC conference suggested that the fan may have been deposited during a winter or early spring flood, depositing the sediment on top of ice or snow that would have melted later.

Eden Mills

The Eden Mills fan is unique compared to the previous three fans in that it is located in a valley that has not been influenced by streamflow since the last glaciation. This gives the Eden Fan the potential to be as old as the glacial retreat. The fan is fed by a small but perennially active stream that drains along the south side of the fan. A logging road has been built along one side of the stream and appears to be concentrating surface runoff onto the lower portion of the road where it is causing a great deal of hillslope erosion. The fan has an obvious layer of gravel on the surface, the deposition of which is due to gullying on the logging road. After hurricane Floyd passed through the area, I returned to the Eden Mills fan and noticed that the storm event had caused further erosion of the logging road and subsequent deposition on the alluvial fan. However, hay that had been spread over the trenched areas showed no evidence of disturbance from sheet flow, and the stream did not appear to have overtopped its banks.

The fan is composed mostly of fine sand beds, which abruptly change to coarse gravel and sand in the upper meter of the fan stratigraphy. The top 0.5 meter of sediment in the fan was heavily laden with woody debris, including sawn logs ranging from 30 cm to 2 meters in length. A metal piece of a horse bridal was also found in this zone. These observations strongly suggest that the grain size change was due to clear-cutting. Residents of the area explained that the hill had been heavily logged early this century and that the logs had been dragged by horse to the valley floor where they were cut up and shipped off.

The lower meter of the fan, composed of fine sand beds, contained an abundance of very thin, buried A-horizons (see Plate 3, room 200 - trench log) separated by thin sand layers. Two sand units also preserved thin E and B-horizons beneath the A-horizon. The number of buried soil layers in this fan far exceeds any of the other fans I have examined, and suggests that this fan was experiencing cycles of small amounts of sand deposition followed by a period of stability. The two layers with A/E/B-horizon sequences have much thicker sand units below them, and indicate that although a larger deposition event occurred on the fan, it was followed by a long period of quiescence.

Future Work

Currently I am in the process of logging trenches in a fifth alluvial fan, which is located just north of Bristol, Vermont. Trenching and associated field work for this fan will be completed on October 22, 1999. Further field work for all five fans includes surveys of two fan surfaces and surveys of three of the adjacent drainage basins using the total station and GPS instrumentation (see Thesis Proposal, 1998). There is also the possibility of trenching and surveying a sixth fan, located in the Catskills, during spring of 2000. I will determine the need and benefit of using that fan in my thesis based on the conclusions presented by the five Vermont fans.

Office work that remains to be completed includes: digitization of the stratigraphic logs, formalization of unit descriptions and field notes, reduction of the survey data, and survey map production. Further carbon dating will ensue, and will be combined with topographic maps from the surveying in order to calculate deposition rates over time on each fan. I also plan to develop a web page in order to present my findings to the public. Possible outcomes to this project remain as stated in my Thesis Proposal (1998).

Timeline for completion:

October 13 - 22, 1999	Field work at Bristol fan site
October 23-28, 1999	Poster presentation at GSA annual meeting
November 8, 1999	Progress Report Oral Presentation
November - December, 1999	Finish Survey work on fan surfaces and drainage basins
December, 1999 or January, 2000	Dating at Lawrence Livermore Laboratory
Spring, 2000	Process survey data
	Digitize stratigraphic logs
	Formalize field notes and unit descriptions
	Complete data reduction and interpretation
	Calculation of depositional rates
	Correlation of depositional events on the five fans
May, 2000	Possibility of two weeks of field work on a fan in the Catskills, New York
Summer, 2000	Write up thesis
Autumn, 2000	Defend thesis

Figure 1. The White River Valley of Vermont, typical morphology of steep valley walls abutting flat valley floor.

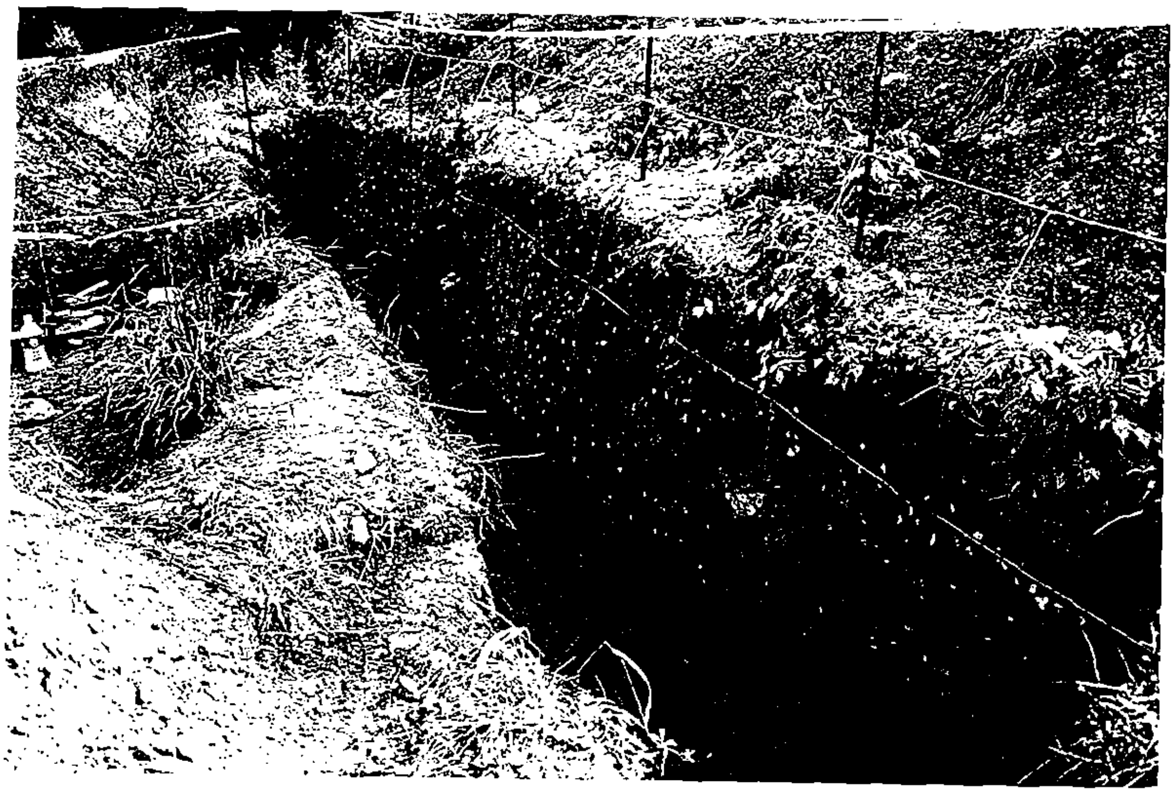

Figure 4. Grid network and pegged units, Hancock fan.

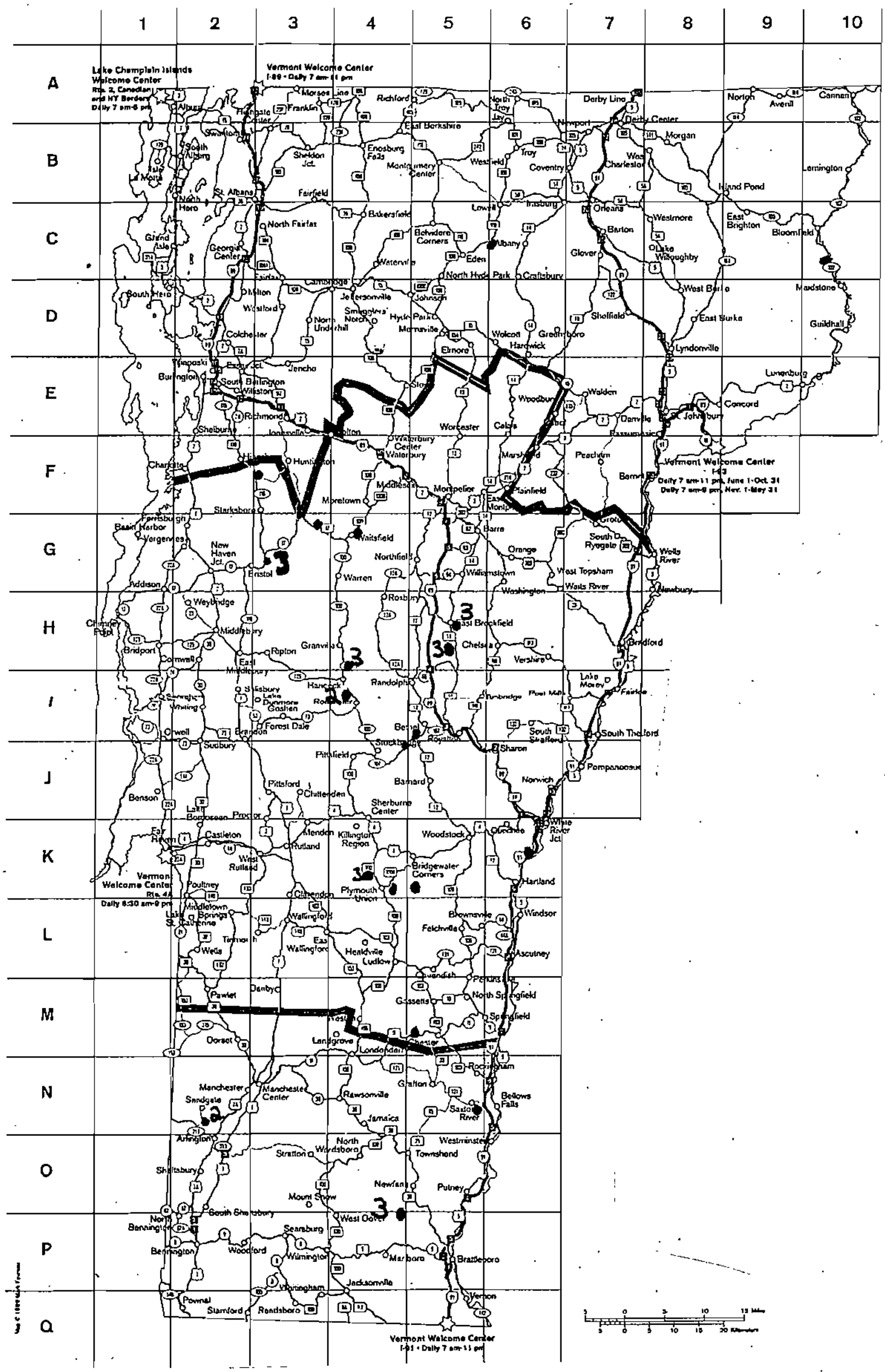

Figure 2. Location of alluvial fans in Vermont indicated by dot, number indicates more than one fan at that sitelocation.

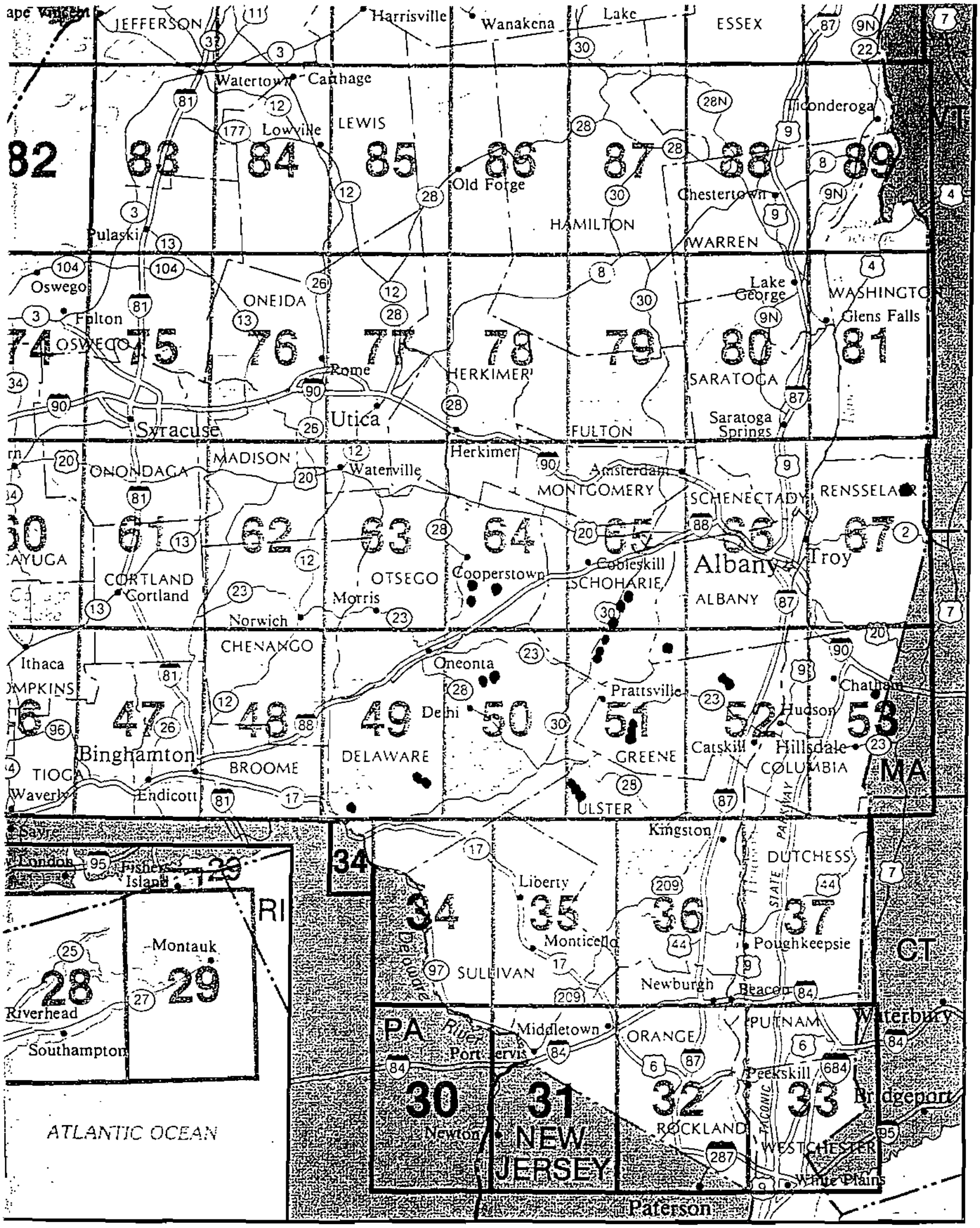

Figure 3. Alluvial fan locations in the Catskills, New York indicated by dot.

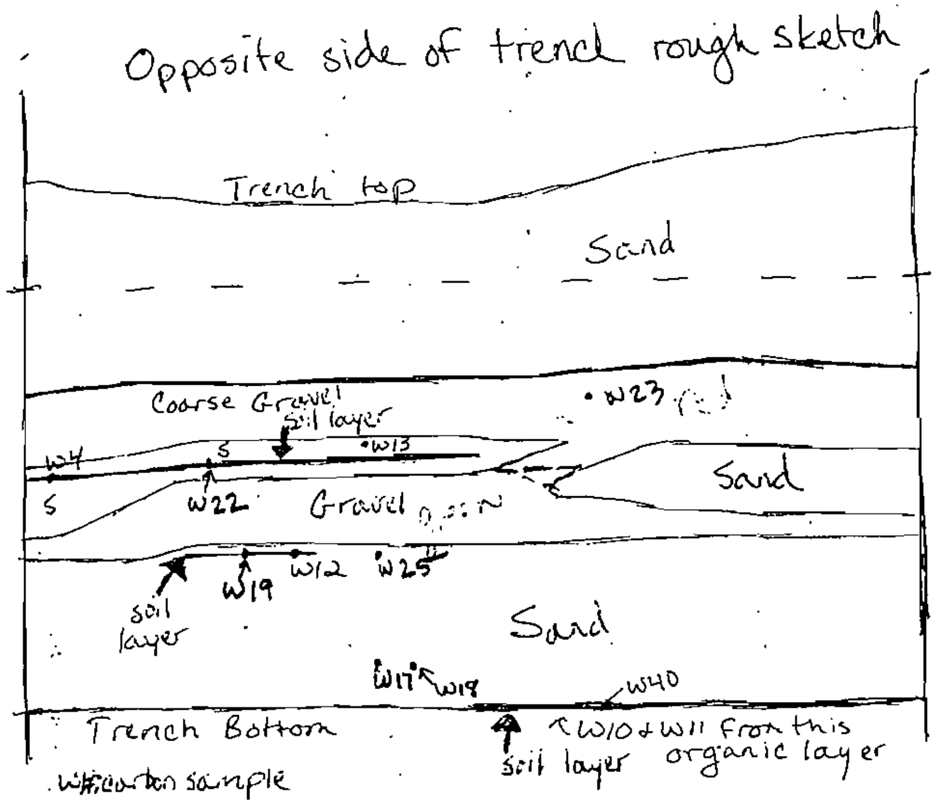

Figure 5. Stratigraphic section from stem trench, Bridgewater Corners fan.

Figure 6. Panorama of alluvial fans at the Hancock site (left to right = north to south).

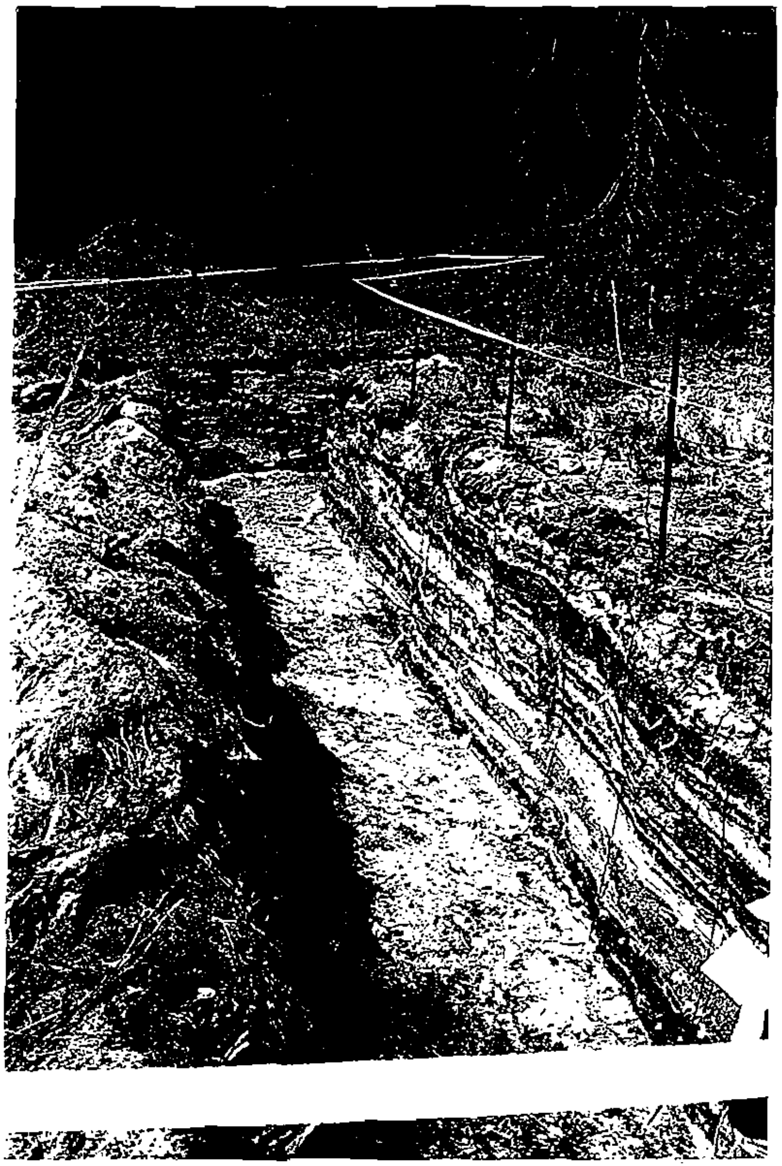

Figure 7. Continuous sand beds in the Maidstone fan.