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History of Landslides at the Base of Bare Mountain, Tully Valley, Onondaga County, New York

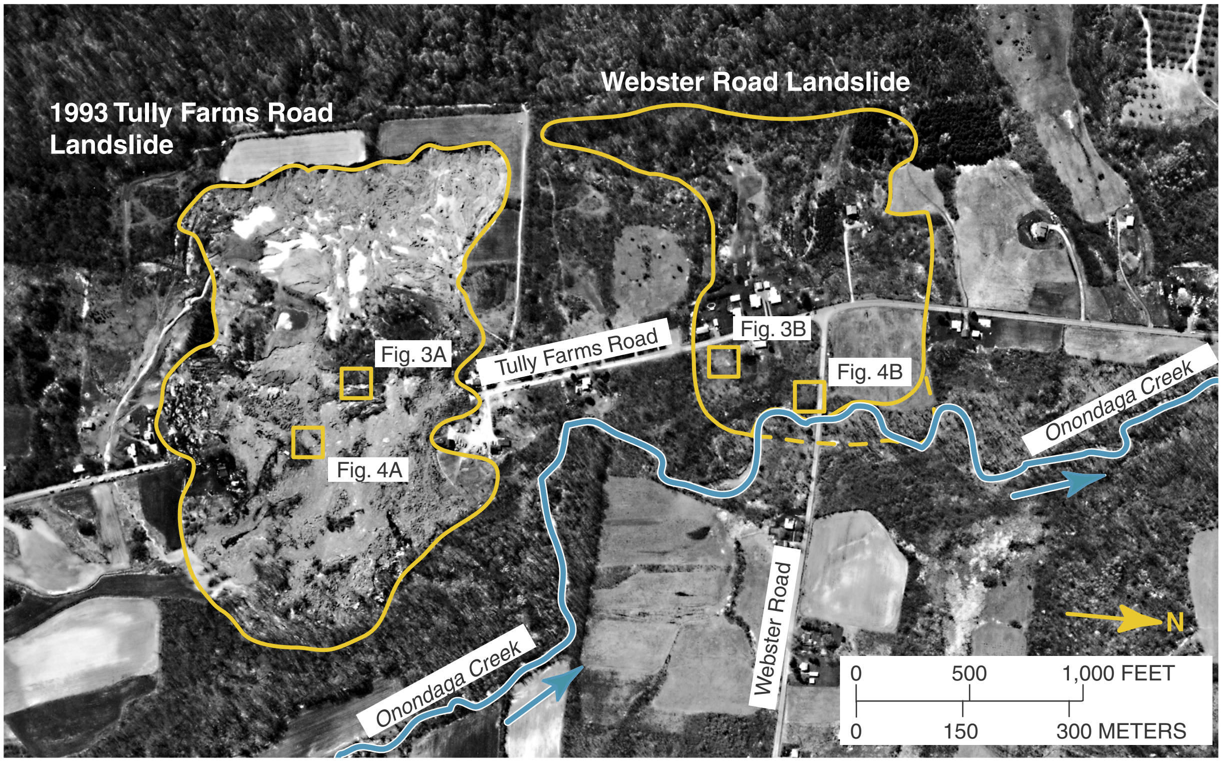

Figure 1. Aerial view of the Tully Farms Road landslide taken May 1, 1993, 4 days after the slide occurred and the approximate location of the Webster landslide, just to the north. Dashed line indicate probable extent of the Webster Road landslide beyond Onondaga Creek, and boxes indicate location of pictures shown in figures 3 and 4.

On April 27, 1993 a large landslide occurred along the foot of Bare Mountain in the Town of LaFayette (fig.1), about 12 miles south of Syracuse. This was the largest landslide to occur in the State since the early 1900's, according to the New York State Geological Survey. Debris from the landslide covered 1,500 feet of Tully Farms Road with more than 15 feet of mud and three homes were destroyed. Most residents were away from their homes at the time, and no fatalities or serious injuries were reported.

Federal and State environmental agencies and several universities have conducted studies in the area to identify the cause of this landslide and assess the potential for future landslides. These studies indicate that several landslides have occurred at the base of Bare Mountain but are not recorded in town records or histories, which date back to the late 1700's. Knowledge of how and when these older landslides occurred could provide an indication of the potential for future landslides along the foot of Bare Mountain.

Department of the Interior
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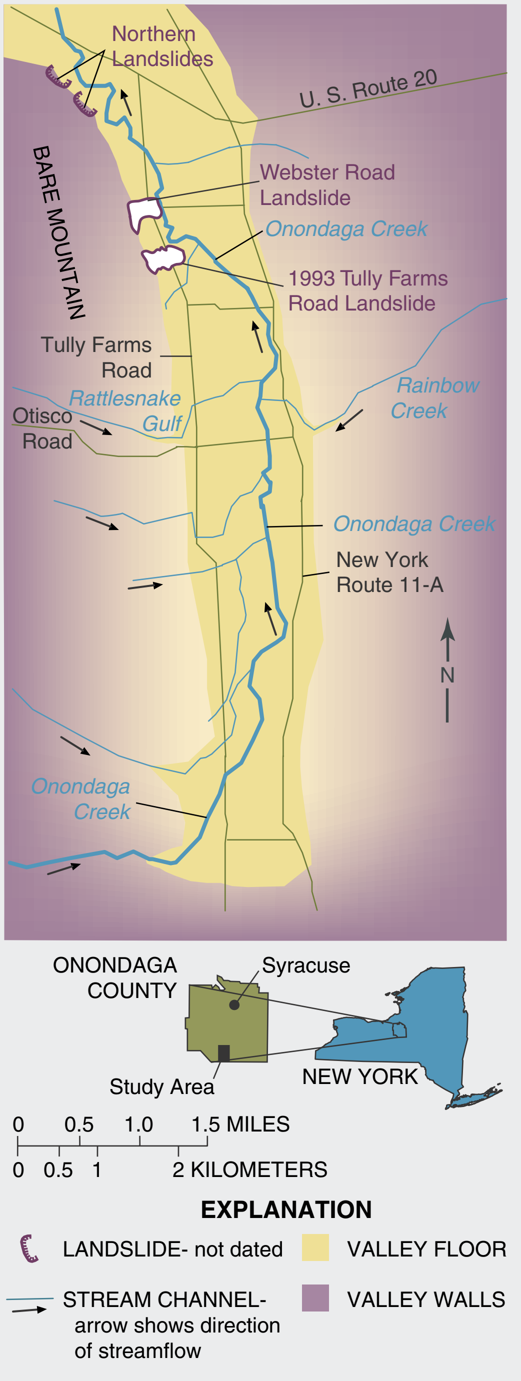

Figure 2. Physical features in the Tully Valley, including the 1993 Tully Farms Road and Webster Road landslides and 2 other landslide areas at the base of Bare Mountain.

PHYSICAL SETTING

Tully Valley is a north-south-trending glacial trough along the northern limit of the Appalachian Uplands. The valley is about 6 miles long, and its floor is 1 mile wide. Onondaga Creek flows northward through the valley (fig. 2). The valley walls consist of colluvium (weathered bedrock) and till over bedrock. The valley floor is underlain by more than 400 feet of glacial-lake (lacustrine) deposits that grade upward through two sequences of gravel and sand to silt and clay. At land surface the valley floor is mantled with a 60-foot-thick silt and clay unit; some of the clays within this unit are saturated and extremely soft. These materials were deposited during and after the last period of glaciation, which ended about 14,000 years ago.

PREVIOUS INVESTIGATIONS

Investigation of the 1993 Tully Farms Road landslide revealed an old, inactive landslide area less than 300 feet north of the 1993 site, and upon further investigation along the foot of Bare Mountain, evidence of two more landslides was found about 1.5 miles north of the 1993 site (fig. 2). Jäger and Wieczorek (1994) investigated possible landslide evidence in five valleys near or adjacent to Tully Valley and constructed a landslide-susceptibility map of a small part of southern Onondaga County. The map (scale 1:50,000) was based on results of their landslide-susceptibility model that used the distribution of glacial clays, the extent of former glacial lakes, and slope steepness as variables. The map classifies the region into areas of low, moderate, and high landslide susceptibility. That study identified the Webster Road landslide described below, as well as several other landslide and earth-flow features in the Tully Valley.

GEOMORPHOLOGY OF TULLY FARMS ROAD AND WEBSTER ROAD LANDSLIDE AREAS

The geomorphology (geology and physical character) of the Webster Road landslide is strikingly similar to that at the 1993 Tully Farms Road landslide. The scarp of the Tully Farms Road landslide is 30 to 50 feet high and 1,400 feet long, whereas the scarp of the Webster Road landslide is 40 to 50 ft high and about 1,200 ft long. Several large blocks of transported soil, some of which retained vegetation and trees, were found at the base of

A.

B.

Figure 3. Hummocks found in (A) the 1993 Tully Farms Road landslide area and (B) the Webster Road landslide area (See fig. 1 for locations)

the slope at the Tully Farms Road site and within the toe of the landslide (fig. 3A). These blocks have weathered since 1993, such that the topography now resembles an area of hummocky ground at the toe of the Webster Road landslide (fig. 3B). Thus, the Tully Farms Road and the Webster Road landslide areas are about the same size, and the two landslides seem to have displaced similar volumes of material from the lower slope of Bare Mountain.

Age of Webster Road Landslide

A 10-foot-deep test pit was dug into 1993 landslide material along Tully Farms Road (fig. 4A), and a similar pit was dug along Webster Road (fig. 4B) to compare the soil horizons in the two landslide areas. The test pit at Tully Farms Road exposed glacial-lake clay at the bottom, overlain by a postglacial alluvium (silt, sand, and gravel deposited in running water) that was in turn overlain by a well-developed soil horizon containing roots and a mat of compressed vegetation at the buried, former land surface. Overlying this buried surface was the mudflow material deposited by the 1993 landslide.

The test pit at Webster Road (fig. 4B) and a natural exposure along the west bank of Onondaga Creek (fig. 5), 150 feet south of Webster Road, are both within the toe of the Webster Road landslide, and both reveal a stratigraphy similar to that at the Tully Farms Road test pit (fig. 4A). The glacial and postglacial sediments at the Webster Road landslide and streambank sites are overlain by a soil zone with compressed organic matter (primarily grass and small pieces of wood) capped by a massive clay unit that resembles the mudflow material found in the toe of the Tully Farms Road landslide. Two samples of the peatlike organic and woody material found directly beneath the mudflow at the Onondaga Creek streambank site yielded radiocarbon dates of 6,160 ± 40 years before present (B.P.), and 6,110 ± 50 years B.P. Attempts to find similar buried organic layers at the two northernmost landslide areas (fig. 2) were unsuccessful.

Further investigation of the Onondaga Creek streambank exposed a second organic layer composed of small, ovoid-shaped logs oriented southwest-northeast. These logs were in a gravel unit overlying till several feet below the 6,100-year-old organic horizon. The radiocarbon date of 9,870 ± 40 years B.P. obtained for one log suggests that the logs were all of postglacial age. Their parallel orientation and crushed condition indicates that they probably were buried in an older landslide whose magnitude could not be estimated from the sparse exposures along the bank.

Possible Causes of Landslides at the Base of Bare Mountain

The cause of the Webster Road landslide remains uncertain but has been attributed to a combination of geologic and hydrologic factors, four of which are:

1. Interbeds of clay within the sand and gravel deposit at the base of the hillside. The fresh scarp face of the 1993 landslide reveals interbeds of clay within the sand and gravel deposit. These clay layers could have trapped ground water in the coarse sand and gravel, and this may have led to soil movement when the artesian pressure exceeded the weight of the overlying soil. Also, below the clay and sand and gravel interbeds is a thick lacustrine unit with a stiff upper part and an extremely soft middle that possibly created a "slip surface."

2. A dense till layer below the clay, sand, and gravel. This unit confines brackish water in the bedrock aquifer and separates it from freshwater in the upper aquifer. Pressure from the confined brackish water may have increased the artesian pressure in the overlying glacial and colluvial sediments.

3. Instability of the lower hillside in the Tully Farms Road landslide area before 1993. Ground cracks, earth bulging, and slumping on the lower hillside were noted by the New York State Department of Environmental Conservation in 1990, and a basement wall of a house along Tully Farms Road was slowly failing in 1992, apparently from the increasing soil pressure on the wall facing Bare Mountain.

4. Greater-than-normal snowfall in the winter of 1992-93, followed by the blizzard of March 1993. The subsequent melting of this snow increased the water content of near-surface soils and increased the artesian pressures in the confined interbed unit. This condition, followed by heavy rainfall in April, increased the already greater-than-normal surface-water and ground-water flow throughout the Tully Valley and increased pore-water pressures within the interbed units along the base of Bare Mountain. This pressure, coupled with the unstable soil conditions along the lower slope, resulted in the April 27, 1993 landslide.

Figure 4. Test pit dug in the 2 landslide areas - (A) the Tully Farms Road pit dug just east of Tully Farms Road, just north of a destroyed home and (B) the Webster Road pit dug on the south side of Webster Road, just west of Onondaga Creek. (See fig. 1 for locations.)

Figure 5. Onondaga Creek streambank exposure south of Webster Road showing the interface between the old land surface and the overlying mudflow materials. Wood fragment (within box) at the interface was dated at 6,160 years before present.

The similarity of geologic and hydrologic conditions at the Tully Farms Road landslide to those at the Webster Road site indicates that the 6,100 year-old Webster Road landslide could have been triggered by similar precipitation patterns. This is supported by paleoclimate data obtained from sediment cores from several nearby Finger Lakes, which indicate highly changeable climatic conditions during postglacial time. The climate data spanning that period indicate an overall trend of warm, dry conditions with cool, wet intervals. Information provided by sediment cores from two nearby Finger Lakes (Mullins, 1998; Dywer and others, 1996) indicate that the Mid-Holocene Hypsithermal period (8,500-3,400 B.P.) was one of the more variable climatic periods in the Finger Lakes region. Thus, a wet episode 6,100 years ago could have triggered the Webster Road landslide.

Conclusions

Recent investigations of the Tully Farms Road landslide have yielded several clues as to the cause of this landslide. The stratigraphy and hydrology of the Bare Mountain hillside and the greater-than-normal precipitation before the landslide were the principal contributing factors. Some form of land-surface movement also occurred near the Webster Road crossing of Onondaga Creek, as indicated by the presence of a buried soil horizon with compressed organic material truncated by mudflow material. Radiocarbon dating of organic materials indicates that the Webster Road landslide occurred about 6,100 years B.P. and that another occurred about 9,870 years B.P. Studies of sediments from nearby Finger Lakes indicate changeability in the postglacial climate. These data suggest that increased precipitation might have been a contributing factor in the Webster Road landslide, as was the case at the Tully Farms Road landslide in 1993.

The discovery of old landslides along the base of Bare Mountain underscores the need to assess the potential for future landslides in the Tully Valley.

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CARBON -14 DATING - HOW DOES IT WORK?

The radioactive isotope of carbon, 14C, originates in the upper atmosphere from the collision of cosmic ray-produced neutrons with elemental nitrogen. The newly formed 14C atom quickly oxidizes to carbon dioxide (14CO2) and is readily distributed throughout the earth's atmosphere. A small percentage of this radioactive carbon ends up in the biosphere, where metabolic processes keep the 14C content of living organisms in equilibrium with the 14C content in the atmosphere. When an organism dies, its 14C content diminishes with a half-life of 5730 years. The amount of 14C remaining in the sample indicates the time of death of the organism.

For example, when a sample's 14C count is one-half that of the modern standard, the sample is one half-life old, that is, it dates from about 5700 years BP (before present). A sample count of one-quarter that of the modern standard would be two half-lives, about 11,500 years BP, and so on. The precision of a 14C date is a function of the counting statistics for the sample and standards and is conventionally reported as one standard deviation of the average counts. For a 14C age younger than 10,000 years BP, the precision is generally reported as +/- 100 years or less.

COOPERATING AGENCIES

Onondaga Lake Cleanup Corporation

University of Dayton

New York State Geological Survey

Town of Lafayette

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