EARTH SCIENCE FIELD TRIPS FOR HIGH SCHOOL STUDENTS
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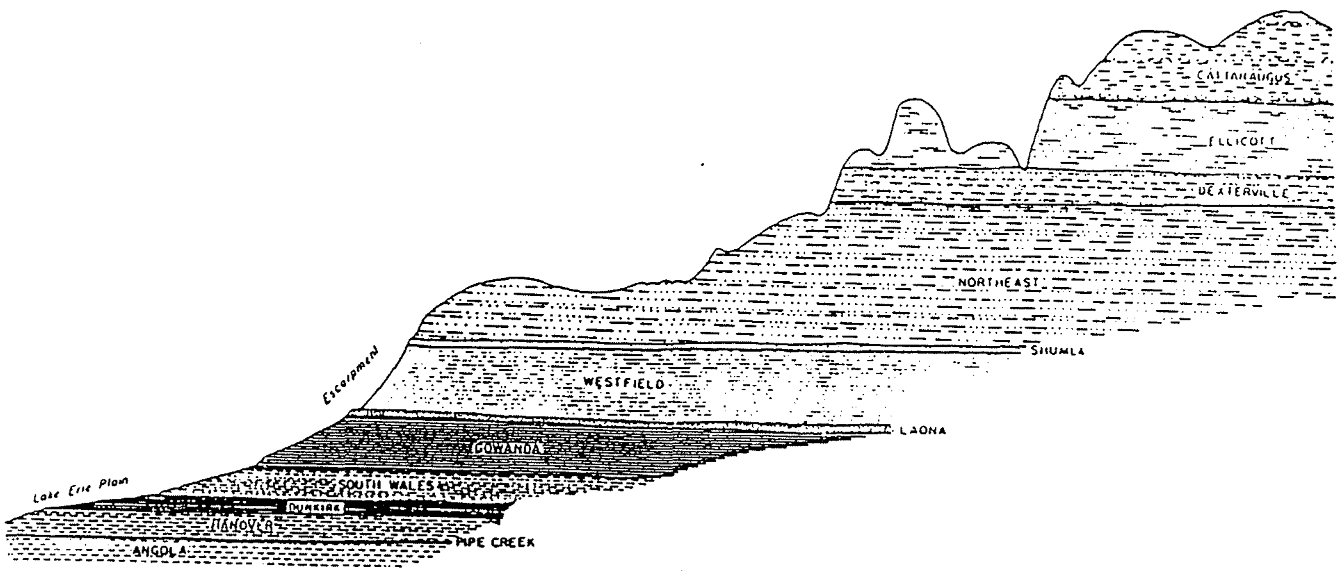
INTRODUCTION: A BRIEF GEOLOGICAL HISTORY OF CHAUTAUQUA COUNTY

Chautauqua County has an exposed geological record dating back about 370 million years to the Late Devonian Period (see geologic time scale, fig. 2). The majority of the bedrock exposed in the county (fig. 1) formed from sediment deposited during that time period, although some scattered outcrops of Early Mississippian bedrock occur southeast of Jamestown near the Pennsylvania state border.

Figure 1. Cross-section of a segment of the Portage Escarpment, showing the sedimentary layers of Chautauqua County. From Tesmer (1963).



The Late Devonian sediments were derived from erosion of the Acadian Mountains which rose to the east of New York State in New England. These mountains formed from the collision of a small continent, Avalon, with ancient North America during Early Devonian time. As the Acadian Mountains eroded, sediment shed from them accumulated in a shallow tropical sea called the Catskill Sea. This sediment deposit was named the Catskill Delta (fig. 3) and the bedrock layers of Chautauqua County formed a small part of the marine section of the delta.

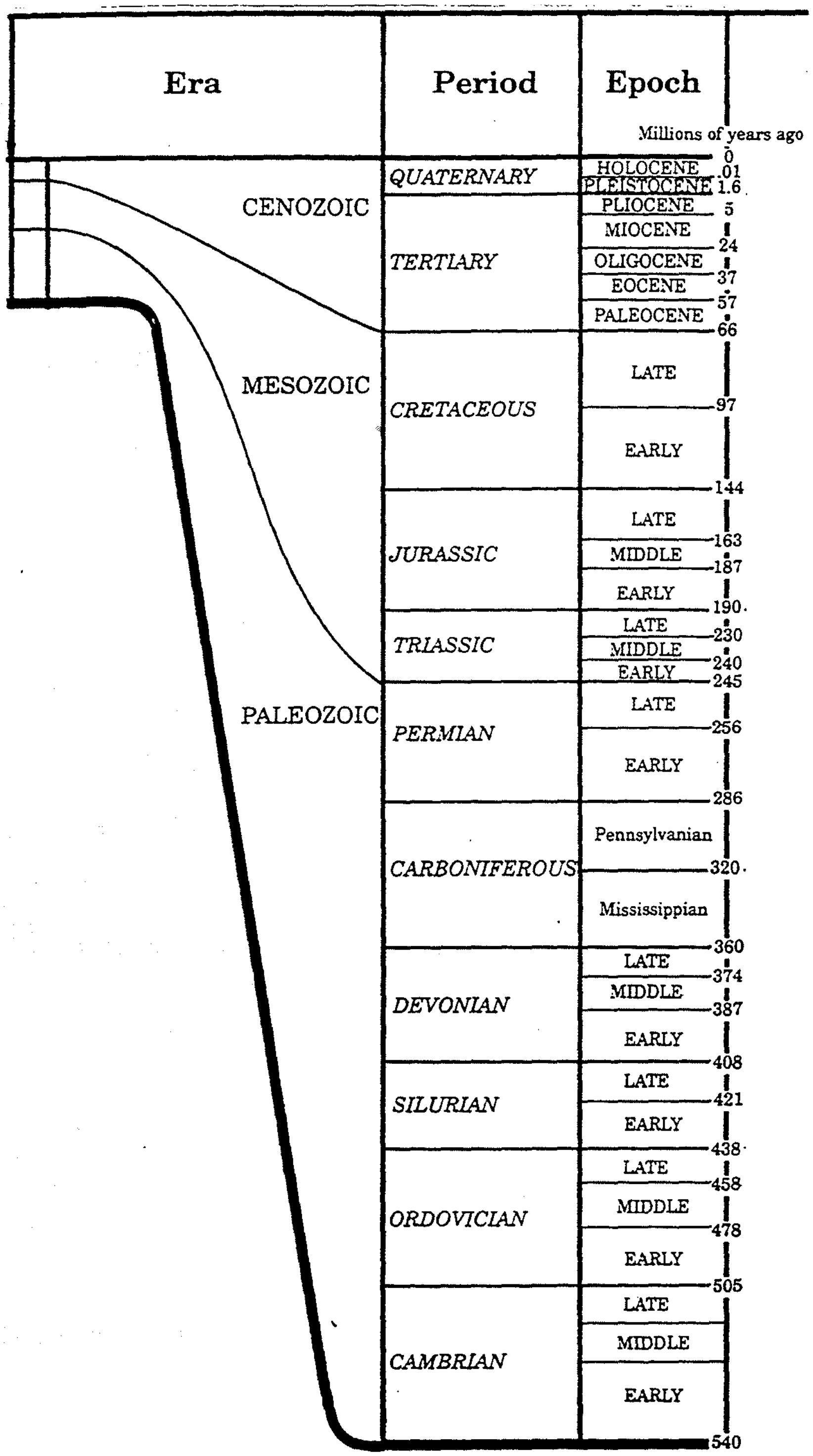


Figure 2. Geologic Time Scale. Adapted from the Earth Science Reference Tables.

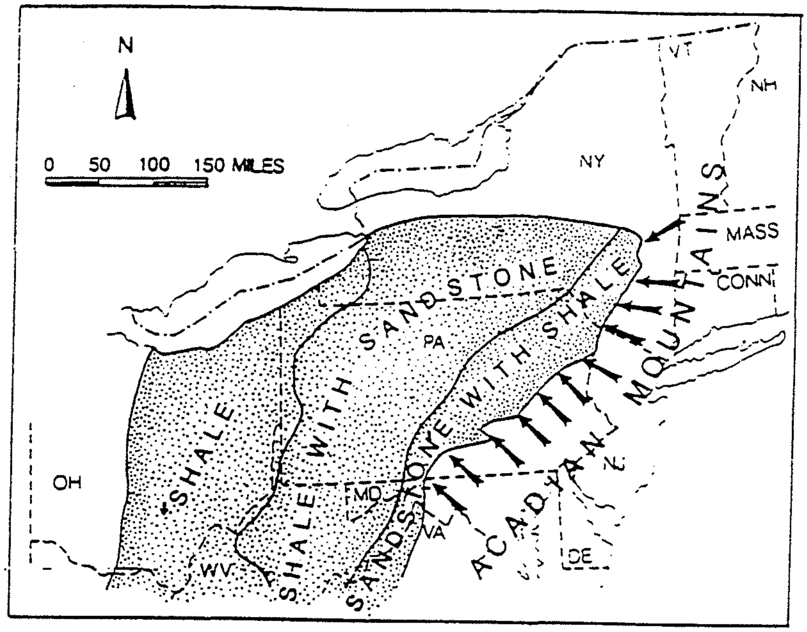


Figure 3. Erosion of the Acadian Mountains formed the Catskill Delta. From Isachsen et al., 1991.

As the Late Devonian progressed, the shoreline of the Catskill Sea in eastern New York gradually shifted westward across the state due to the sediment accumulation. The result was that coarser grained nearshore and terrestrial sediments were deposited on top of finer grained marine sediments. An example of this is represented by the sequence of layers from the Dunkirk Shale up through the Panama Conglomerate (bottom of the Cattaraugus Formation). This stratigraphic succession shows a coarsening upward trend in which sand and pebbles were deposited on top of muds and silts. It is assumed that sediment from the Mississippian Period was then deposited on top of the Devonian sediments over the entire region as the Catskill Sea slowly filled in.

The rock record from the Pennsylvanian Period (Late Paleozoic Era) through the Tertiary Period (Cenozoic Era) is not exposed in Chautauqua County. It is not known whether sediment from that time span was ever deposited in this area or if it accumulated and then was eroded. No bedrock from the Mesozoic Era exists anywhere in western New York.

Chautauqua County is located within two landscape regions: the Allegheny Plateau, which comprises most of the county, and the Erie-Ontario Lowlands, represented by a relatively flat strip of land approximately four miles wide oriented southwest to northeast along the Lake Erie shore. According to Isachsen et al. (1991), uplift of the Allegheny Plateau occurred during the middle of the Cenozoic Era. The Erie-Ontario Lowlands are believed to have formed by erosion prior to glaciation during the Pleistocene Epoch (Gilman and Berkley, 1990).

The Pleistocene Epoch, which began 1.6 million years ago, witnessed four major events of continental glaciation in North America. Only evidence from the last glacial advance, the Wisconsinan Phase, is found in Chautauqua County. As the Wisconsinan ice sheet melted and retreated north from the region it left a deposit of unsorted sediment on top of the Late Devonian bedrock. This deposit, known as glacial till, contains igneous, metamorphic, and sedimentary rocks transported from Canada, as well as pieces of ripped up Devonian bedrock of local origin. The boundary between the bedrock and till is a major unconformity representing a large gap in the rock record of Western New York.

As the ice sheet melted northward, flowing glacial meltwater deposited sediment called glacial outwash within pre-existing stream valleys. Deposits of glacial outwash can be found in several areas, such as Chautauqua Gorge. In addition, the meltwater produced two large glacial lakes that existed before Lake Erie. These lakes have been named Lakes Whittlesey and Warren, and clay and silt deposits from them can be observed on top of glacial till along the Lake Erie shoreline.

The Pleistocene Epoch ended ten thousand years ago with the final retreat of the ice sheet from New York State and thus began the Holocene Epoch. No major geological events have occurred in Chautauqua County since the beginning of the Holocene. Erosion is currently wearing down the Earth's surface with running water as the major agent. Deep gorges, such as Chautauqua Gorge, which cut into the landscape serve as evidence for such erosion.

A southerly bedrock dip (or inclination) of a few degrees and the forces of erosion have produced a distinct outcrop pattern in Chautauqua County (see Tesmer, 1963). The oldest layers are exposed in the northern section of the county while the youngest appear in the south. In the northern part of the county the layers from the Dunkirk Shale up through the Northeast Shale are exposed, or crop out, in a pattern that trends from southwest to northeast, paralleling the Lake Erie shoreline. The bedrock from the Dexterville Siltstone up through the Cattaraugus Formation is best exposed in the central and southern sections of the county.

POINT GRATIOT PARK

Point Gratiot is located in the northern part of the county, in Dunkirk.

At this location these features can be observed:

1. The Dunkirk Shale (see fig. 1)
2. Hydrocarbon odor from freshly broken pieces of black shale
3. Rust stains from oxidation and hydration of iron
4. Bedrock jointing
5. Fossil wood fragments
6. Glacial features:
    a. till
    b. erratics
    c. scratches (striations) on bedrock
7. Devonian/Pleistocene unconformity
8. Shoreline features:
    a. beach sediment
    b. clast imbrication
    c. longshore current
    d. headland-cove pattern
9. Soil development in glacial till

UNIQUE FEATURES

BEDROCK: The bedrock at this location is the Dunkirk Shale (see fig. 1), a unit of black shale that was formed from mud deposited on the floor of the Catskill Sea. Black shales form from sediment that is deposited underwater in low oxygen conditions.

HEADLAND-COVE PATTERN: Wave erosion along joints has produced an alternating headland-cove pattern on Point Gratiot where the bedrock is exposed. Because the joints are weakened zones where water can erode the bedrock faster, the heavily jointed sections have become the coves or inlets while the less jointed sections are small promontories protruding out into the water as headlands.

SOIL DEVELOPMENT: The relatively young age of the glacial till makes this site an excellent place to discuss soil development and maturity. Trees, shrubs, and weeds are growing in the soil, but the amount of biological activity and weathering has not been sufficient to produce a mature soil profile containing the A, B, and C horizons. The soil profile here is classified as immature because the B horizon is missing, and more time is needed before weathering produces a mature soil.

DIRECTIONS: If coming from the east, take Route 5 West through the city of Dunkirk. In the western part of the city you will pass the entrance to the Niagara-Mohawk power plant. Proceed for 0.3 mile past the entrance and then turn right on to Point Drive. Continue on Point Drive to the park entrance. Park at any one of the lots along the park road.

If coming from the west take Route 5 East to Dunkirk. As you enter the western part of the city you will pass the Moose Lodge on the left. The street on the left immediately after the Moose Lodge is Point Drive. Turn left on to Point Drive and proceed to the park entrance. Park your car at any one of the lots along the park road.

DJ'S CAMPGROUND

DJ'S Campground is located on the shoreline of Lake Erie, a few miles west of Brocton.

A rock hammer, chisel, and safety glasses will be helpful for collecting fossils at this location.

At this location these features can be observed:

1. The Gowanda Shale (see fig. 1)
2. Bedrock jointing
3. Hydrocarbon odor from freshly broken pieces of dark-gray shale
4. Rust stains from oxidation and hydration of iron
5. Glacial features:
    a. glacial till
    b. glacial erratics
    c. meltwater lake sediments
6. Devonian/Pleistocene unconformity
7. Shoreline features:
    a. beach sediment
    b. beach berm
    c. longshore current

d. clast imbrication

e. storm deposits

8. Septarian concretions
9. Pyrite nodules
10. Ripple marks
11. Fossils: pyritized cephalopods, wood fragments, and trace fossils
12. Erosion by gravity

UNIQUE FEATURES

BEDROCK: The bedrock at this location is the Gowanda Shale (see fig. 1), consisting of light-gray and dark-gray shale with some interbedded thinsiltstone.

SEPTARIAN CONCRETIONS: Within the bedrock are elliptical shaped rocks known as septarian concretions. The local people often refer to these as "turtle rocks" because of their resemblance to turtle shells. However, they are not fossilized turtles. Rather, these round concretions form from the precipitation of carbonate minerals in the sediment. When the concretions harden and shrink, cracks form and are filled in by the precipitation of the minerals calcite ($CaCO_3$), siderite ($FeCO_3$), and, more rarely, barite ($BaSO_4$) (Gilman & Berkley, 1990, pg. G11). It is apparent that the concretions grew after the sedimentary layers were deposited because the layers are warped above and below them.

PYRITE NODULES: The existence of pyrite (FeS_2) nodules in the bedrock indicates a relatively high iron content. The pyrite nodules formed when iron in the sediment bonded with sulfur produced during the decay of organic material by bacteria in the sediment. Many of the nodules are rust-stained and are chemically weathering like the surrounding bedrock.

RIPPLE MARKS: Some of the thin siltstone layers exhibit ripple marks. Ripple marks form when waves or water currents move across loose sediment.

FOSSILS: This section of the Lake Erie shoreline is famous for its well preserved pyritized fossils. The most interesting fossils belong to the Phylum Mollusca, Class Cephalopoda. Cephalopods are marine organisms that swim by jet propulsion of seawater. Modern examples of these organisms include the nautilus and the octopus. The species of cephalopods at this location have long since been extinct and occur in two forms. One form, the orthoconic nautiloid, has a cone-shaped, segmented appearance. The other form, known as the goniatite, is coiled, much like a snail shell. The layer containing these fossils is near the water level and breaking waves may hinder collecting.

Minor fossils at this location include bits and pieces of carbonized and partially pyritized wood, and trace fossils. The fossilized wood is dark-gray to black from carbon and often contains small pyrite crystals. The trace fossils are burrows produced when sea bottom dwelling organisms roamed through the mud looking for food. They appear in the light gray shale as narrow, curved features slightly darker or lighter in color than the surrounding bedrock.

EROSION BY GRAVITY: The weak glacial lake deposits above the glacial till are very susceptible to erosion by gravity. Evidence of mass movement is the landslide debris on the bluff slope and at the base of the bluff.

DIRECTIONS: From the intersection of Route 380 (Lake Ave.) and Route 5 northwest of the village of Brocton, take Route 5 West for 3.4 miles to DJ's Campground, which is on the right.

If coming from the west the campground is 6.5 miles northeast of the intersection of Route 394 and Route 5 East at Barcelona. Turn left into the campground.

Go to the campground office, the small trailer near the entrance, to ask permission to park down at the shoreline. The owner is very accommodating and has been letting people on his land for years, so this should not be a problem. After parking walk about 300 feet southwest along the shore until you come to exposed bedrock.

CHAUTAUQUA CREEK AT BARCELONA

Barcelona is located on the shore of Lake Erie, one mile northwest of Westfield.

At this location these features can be observed:

1. The Westfield Shale (see fig. 1)
2. Root action
3. Rust stains from oxidation and hydration of iron
4. Differential weathering of siltstone and shale
5. Stream erosion and deposition:
    a. sediment shape and size
    b. gravel bars
    c. clast imbrication
    d. relationship of particle size to the water velocity of transport

6. A reverse fault
7. A monocline

UNIQUE FEATURES

BEDROCK: The bedrock at this location is the Westfield Shale (see fig. 1), composed of gray shale with some interbedded siltstone.

REVERSE FAULT: Facing upstream, on the right bank is a reverse fault, a fault in which the hanging wall appears to have moved upward relative to the footwall. Some rock and dirt debris may obscure the fault plane, so a shovel would be handy to expose the fault better. Facing the fault, the hanging wall is on the left side of the fault plane and the footwall is on the right. Especially obvious is that the siltstone layers on the hanging wall are not horizontally continuous across the fault plane to the footwall. By comparing the positions of siltstone layers on each side of the fault it appears that the vertical displacement is approximately 4 feet. In addition, the distorted nature of the rock along the fault plane is observable with closer inspection.

MONOCLINE: Another interesting structural feature is the monocline 50 feet upstream from the reverse fault. This fold has layers dipping (tilting) upstream. A monocline is a one-limbed fold, as opposed to anticlines and synclines which have two limbs.

The monocline and the fault resulted from probable local compressional stress in the bedrock, although the origin of the stress is unclear.

DIRECTIONS: From the intersection of Routes 394 and 5 at Barcelona, go 0.2 mile west on Route 5. Turn left (or right if coming from the west) on to North Gale Road and drive to its end at the closed bridge. Park your car there. Walk down to Chautauqua Creek and proceed upstream for approximately 150 feet. The water level may be high and it is suggested that you wear old shoes or sneakers.

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