A NEW LOOK AT THE FORMATION OF COHOES FALLS ON THE MOHAWK RIVER, ALBANY COUNTY, NY

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Introduction

A reexamination of erosional features at and near the mouth of the Mohawk River in east-central New York indicates that, contrary to interpretations proposed by Hall (1871) and Stoller (1918), the modern Mohawk River is an unlikely agent for development of Cohoes Falls, a ~60 foot high, 950 foot wide waterfall 2.5 miles from the mouth of the Mohawk. The bedrock gorge above and below the Falls and several distributary channels cut in rock just above the Mohawk's confluence with the Hudson River also appear unlikely to have been carved by flows comparable to the modern Mohawk since deglaciation.

Background

The course of the Mohawk River between Schenectady and Cohoes has long been recognized as post-glacial in origin (Cook, 1909, Simpson, 1949; Dineen and Hanson, 1983). The gorge containing Cohoes Falls has near vertical walls ~50 and ~110 feet high immediately upstream and downstream of the Falls respectively. Bedrock in the gorge is deformed Ordovician shale and greywacke with the angle of the fall roughly parallel to the dip of foliation (Kidd and Plesch, 1995). Across the base of the Falls, the depth and width of the plunge pool varies widely, ranging from almost nothing in a few small areas to depths of ~45 feet (below the bedrock floor of the gorge immediately downstream) (Hall, 1871), and a width of as much as 130 feet from the face of the Fall (Figure 1).

Downstream of the plunge pool, the gorge floor is exceptionally flat, but not smooth; Hall (1871) described the surface as similar to a tilled farm field in that it was flat on a coarse scale, but with local relief on the order of a foot. The uniformity of the gorge floor below the Falls is interrupted by a sub-channel with a width ranging from ~30 to 250 feet and a variable depth of ~10 to 20 ft. The sub-channel is in the approximate center of the gorge and rimmed in many locations by concave features which appear to be the remnants of fluvial potholes. This interpretation is supported by several intact potholes set back from the lip of the sub-channel by generally no more than 30 feet. Intact potholes in this area havediameters in excess of 10 feet and are generally filled with gravel suggesting they are currently inactive.

Hall (1871) considered the Falls to be the result of headward erosion of the western edge of the Hudson Valley by the Mohawk River. He interpreted the sub-channel as a plunge pool, which in turn required the Falls to be much narrower during headward retreat. Hall argued that subsequent widening of the Falls and development of the present plunge pool, was the result of the resistive weakness of potholes which may have extended across the current position of the Falls from an area of large potholes he identified just east of the Falls. According to Hall, the widening along this line of potholes subsequently reduced the rate of retreat and allowed the gorge to widen by mass wasting.

Stoller (1918) also attributed Cohoes Falls to the headward retreat of the western wall of the Hudson Valley in post-glacial times. However, he considered much of the gorge containing the Falls to result from simple downcutting which he viewed as more efficient than headward erosion due to the orientation of foliation. Stoller made little mention of the plunge pool and sub-channel except to note that the sub-channel generally contained most summer flows. Stoller produced a block diagram (Stoller, 1918 Fig. 7) which has been widely used since to describe the Falls formation.

Significance of the Plunge Pool

If the position of the Falls is due to steady headward retreat driven by the modern river, we should expect the bedrock floor of the gorge downstream to grade to the level of the bottom of the plunge pool, which it does not. We should also expect the floor of the gorge to be uneven, similar to the varied depths of the plunge pool, but rather the floor is exceptionally flat across the gorge with the notable exception of the sub-channel. The varying depth and width of the plunge pool along its length appears to reflect the relative volumes of water spilling over the Fall during high-flow conditions today; therefore it seems reasonable that the modern river has produced the plunge pool. The depth and overall morphology of the plunge pool relative to the elevation of bedrock immediately downstream indicates the flow conditions that formed the gorge downstream of the pool are different from those observed today.

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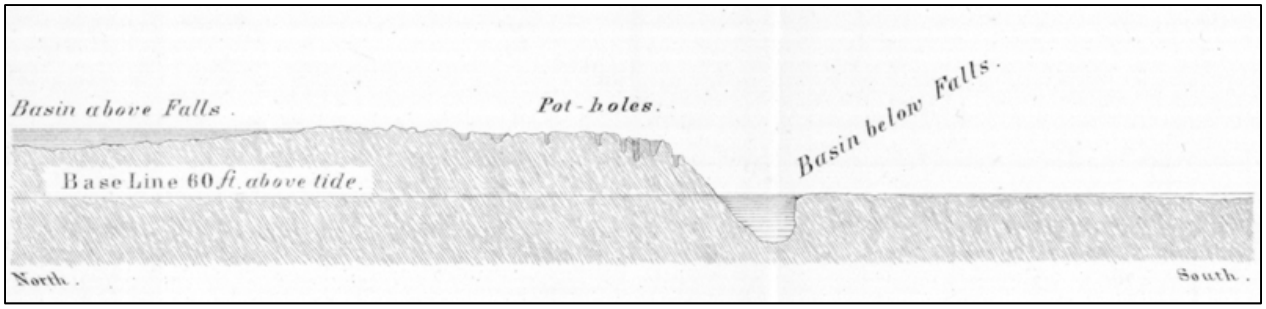

Figure 1 - Mohawk channel bottom profile above and below Cohoes Falls. Scale is approximately 200 feet to the inch. (Surveyed and drawn by G.K. Gilbert *in* Hall, 1871)

Distributary Channels

Downstream of the Falls, just east of the western Hudson Valley wall, are several bedrock islands separated by distributary channels of the Mohawk River; through these channels the Mohawk enters the Hudson in three locations. The islands have near vertical walls of up to 50 feet height. Each of the channels contain knickpoints and/or bedrock rapids, the largest of which has ~15 feet of fall (the full height may be partially drowned in backwater from the Green Island Dam). Knickpoints typically form in response to a lowered base level (Ritter, 1978) suggesting the channel above the knickpoint developed in response to a base level ~15 feet higher than today. The mouths of the channels are at sea level (ignoring backwater from the Green Island Dam), which has been rising in the Hudson Valley since deglaciation (Stanford, 2009). This difference suggests the channels above the knickpoints cannot be the work of the modern Mohawk. Formation of these knickpoints may be in response to the abrupt decrease in Hudson Valley flow (and base level) ~13,000 years ago (Rayburn and others, 2007) following the diversion of Great Lakes drainage from the Champlain and Hudson Valleys to the newly ice-free St. Lawrence Valley.

Further argument against the modern Mohawk steadily developing these distributary channels since deglaciation comes from the height of the bedrock islands themselves. It seems entirely unlikely for all the distributary channels to become so deeply entrenched, in dissimilar sized channels without one channel becoming dominant or one channel being abandoned by piracy of flow. Development of the bedrock islands and channels seems much more plausible if they were cut rapidly by an exceptionally high volume of water.

Potholes

Hall (1871) documented the dimensions of 226 fluvial potholes (Figure 2) across the area just upstream of Cohoes Falls. The extreme dimensions of a few of these potholes, notably one with a width of 3 feet and depth of 23 feet again suggest a set of hydraulic conditions not seen under modern flow conditions. “Conventional” pothole development by circulating grindstones is difficult to invoke to explain the formation of a hole with such dimensions based on the amount of energy likely lost to friction. Cavitation may be a more plausible mechanism for carving such a deep and narrow pothole, and a large basin in the channel floor just upstream of the pothole area (Figure 1) may support the hydraulics necessary under certain conditions. The question of how these potholes with extreme depth-to-width ratios formed would benefit from more detailed hydraulic analysis, but either mechanism would likely require much deeper and faster flows than observed today.

The 1866 discovery of the Cohoes Mastodon in a large pothole adjacent to the Falls gorge prompted a search for similar features around the gorge. G.K. Gilbert’s mapping of the area (Hall, 1871) depicts several exceptionally large potholes adjacent to the gorge in an area devoid of glacial overburden. Hall (1871) called these potholes “ancient” and considered the modern Mohawk River incapable of carving features of this scale, instead he attributed their formation to water discharging from moulins in glacial ice. Stoller (1918) made no reference to these “ancient” potholes, but considered the area adjacent to the gorge as having been “laid bare…by the flooded Mohawk waters of late glacial time”. Hall and Gilbert were unaware of these “flooded waters” which are more commonly referred to today as the Iromohawk River.

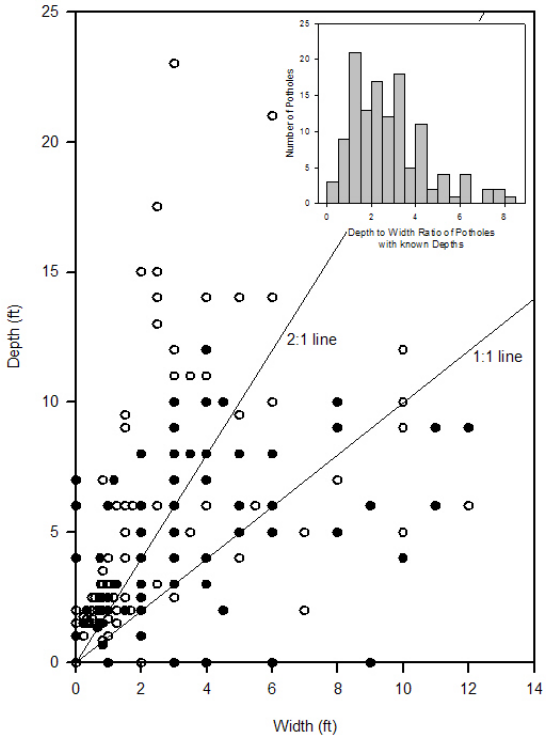

Figure 2 - Dimensions of channel-bottom potholes above Cohoes Falls described by Hall (1871). Open circles are empty potholes, closed circles indicate partially filled, filled, or no information (true depth unknown).

The Iromohawk River

For approximately 500 years runoff from much of the Great Lakes watershed plus glacial ice to the north drained into a large lake (Glacial Lake Iroquois) that occupied the lowland that lies south of and includes Lake Ontario. The Iromohawk River drained Lake Iroquois through the Mohawk Valley (Muller and Prest, 1985) until ice retreated from the northern flank of the Adirondacks ~13,000 years ago (Toney and others, 2003; Rayburn and others, 2007). With retreat of the ice, the Mohawk Valley was no longer the low point for Ontario Basin drainage and lake-outflow was rerouted into the Champlain Valley and eventually through the St. Lawrence Lowland. Wall (1995) estimated the maximum Iromohawk discharge was at least ~1.5 million cubic feet per second - roughly 10 times the highest discharge recorded on the Mohawk over the last 90 years and more than 200 times "typical" flows observed today. LaFleur (1979) considered the Iromohawk a possible agent for initiating formation of the gorge, but not for its complete development.

A New Hypothesis

The depth of the plunge pool relative to the channel bed downstream of the pool suggests flow conditions that carved the gorge are different than those observed today. The largest distributary channel knickpoint suggests the channels upstream of the bedrock rapids and knickpoints were formed when Hudson Valley base level was ~15 feet higher than today. The number and dimensions of the distributary channels (and islands), the amount of glacial overburden removed from the area adjacent to the gorge, the exceptionally large potholes found in that area, and the apparent need for much greater water depths and velocities than seen today to form the potholes just upstream of the Falls, all suggest higher flows than observed in the Mohawk today.

If higher Mohawk flows and a higher Hudson Valley base level than today are required to explain these observations in a post-glacial section of the Mohawk, the agent responsible is almost certainly the Iromohawk River. The evidence points to the Iromohawk as having eroded nearly the entire gorge containing Cohoes Falls and all of the distributary channels near the mouth of the Mohawk. It appears that the modern Mohawk is responsible for the plunge pool at the base of the falls, but the Falls have retreated no more than the width of the plunge pool under post-Iromohawk flow conditions. This is an exceptionally slow rate of retreat for any waterfall - it is explained by the fact that the Mohawk River is underfit in the gorge and its erosive power is spread thin across the channel. The sub-channel also appears to be a product of the modern Mohawk developed from an interconnection of Iromohawk potholes.

The elevation profile of the gorge and adjacent landscape suggests the headward migration of two knickpoints are responsible for the gorge and the position of the Falls today. The upper knickpoint was the western wall of the Hudson Valley, as first proposed by Hall (1871); this knickpoint migrated upstream to at least Crescent where it may have diminished in size in response to a lower bedrock surface elevation. The lower knickpoint, Cohoes Falls, started immediately west of the present day Hudson River and carved the network of distributary channels at the mouth of the Mohawk then coalesced and continued to migrate upstream as a single massive falls deepening the cut initiated by migration of the upper knickpoint.

The Iromohawk introduced a huge influx of meltwater and sediment into the Hudson Valley eroding glacial and glaciolacustrine sediment from the area around the Hudson-Mohawk confluence, exposing bedrock, and carving Hall's "ancient" potholes. The headward migration of the upper knickpoint initiated channelization of the Iromohawk in the area and formed the gorge above the Falls. Simultaneous headward retreat of the lower knickpoint carved the distributary channels that eventually coalesced to deepen the gorge below the Falls. When the northern Adirondack flank deglaciated, the Iromohawk flow ceased, causing the headward retreat of the lower knickpoint (Cohoes Falls) to stop.

Further development of this hypothesis would benefit from detailed mapping of the Mohawk channel-bottom elevation and study of archive records depicting the condition of the channel prior to the construction of dams now in place between Crescent and Green Island.

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