Experimentation in 19th century bloomery iron production: evidence from the Adirondacks of New York
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Abstract
Research into the company records and correspondence of the Clintonville, New York, iron works (1824-1890) has revealed that bloomery forge management had a constant concern for improved efficiency and economy in iron production. This concern is evident in several aspects of forge operation, including experimentation in the application of hot blast, the size and number of tuyères in bloomery forges, recovery from river sands of ore lost in the separation process, the employment and modification of new techniques of processing raw ore, and the utilization of waste heat from the forges. It is also evident that information about developments in the industry spread rapidly from one region of the US to another, as well as across the Atlantic. Adirondack bloomery forge production of iron in the 19th century is thus seen as having been a dynamic and creative endeavour that made significant contributions to the industry overall.

Introduction
It is now recognized that the United States charcoal bloomery iron industry of the 19th century was a relatively efficient means of producing high quality wrought iron in areas where there was an abundance of woodlands, water power, and relatively pure ores (cf Gordon 1996: 98-99; 1997, Allen et al. 1990, Gordon & Killick 1992, 1993: 251f, Gordon and Malone 1994: 78-79). The spongy iron formed in the small forges was normally hammered into thick bars, called billets, that could be rolled locally into merchant bars or plate, or simply shipped to other iron plants for working into steel. This process was instrumental in helping to make New York state one of the top iron producers in the U S, placing the state third only behind Pennsylvania and Ohio in total production in the 1870s and 1880s (Swank 1884: 382).

The Adirondack-Lake Champlain region of extreme northeastern New York was particularly committed to the bloomery method of iron making, with 84% of the national output of such iron, in 1880, coming from this region alone. The counties of Clinton and Essex comprised most of this region, which by 1864 contained 28 bloomery sites with a total of 136 forge fires (Figure 1, and Neilson 1867: 259-62, 265-29). Charcoal blast furnaces were occasionally employed, but were rare compared with their use in other parts of the state (see Lesley 1866).

Despite a long period of fluctuating success, the vast majority of the smaller iron industry sites in the Adirondacks were out of business by the early 1890s, due to a variety of national economic trends and industry developments. However, a few large concerns linked to blast furnace operations were able to operate profitably until the late 1960s. These were the Republic Steel mining, separation, and sintering operations at Lyon Mountain, which continued until 1967, and the Mineville/Witherbee iron operations near the shore of Lake Champlain, also owned by Republic Steel, which were the last to close down in 1971 (Farrell 1996, Moravek 1976). While the basic technology of bloomery iron production seemed to change only minimally during the 19th century, it is becoming increasingly clear that iron producers were constantly concerned about any modifications or improvements to the process that would either decrease production costs or enhance product quality. This is particularly revealed in company records and documents that happen to have survived for one of the largest bloomery forge sites in the Adirondack-Champlain region, which was located at Clintonville in the Ausable River valley (Figure 2). Operating under various company names from 1824 to 1890, the works included 20 forge fires, 16 of which were in one building, and turned out an average of 2243 long tons of iron billets per year between 1837 and 1881. The range for a year's production varied from a low of 1095 tons to a high of 3336 tons (production is calculated from Peru Steel and Iron [PS&I] Company papers 64.3 4/2 'Reports' ledger, in combination with figures in Neilson 1867: 267). The main forge building's foundations and associated features ('lower forge' in Figure 2) are the primary archaeological remains of this once-impressive operation, and the author and his students have so far conducted two field seasons of investigations there. Preliminary findings from the 1994 and 1996 investigations were presented by Pollard (1995b, 1997).