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MARTIN PICKANDS

IRON IN NEW YORK

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Edited by
Martin Pickands



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*To my dear wife and best friend, Marcia, whose love, support
and advice will be forever missed*

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PREFACE

Martin Pickands

In October 2010, a multidisciplinary symposium was held at the New York State Museum bringing together researchers from several different fields whose interests involve the history of the production and use of iron in New York. The idea for this symposium began with an archaeological study of the Watts Blacksmith Shop, a rural blacksmith shop in St. Lawrence County, performed by the Museum's Cultural Resources Survey Program for the New York State Department of Transportation (Pickands 2009, 2010).

Any archaeological project is the study of some more or less complex aspect of human endeavor and benefits from the input of specialists in other disciplines related to the specific questions under study. This is especially so in the field of industrial archaeology, because the archaeologist is often approaching a complex craft or business from the outside and is more or less unfamiliar with the technical knowledge that went into the formation of the archaeological site. He or she needs the input of many kinds of specialists because the research necessary to the interpretation of the data requires knowledge beyond the archaeologist's normal field of expertise. The interpretation of the Watts Blacksmith Shop benefited from the specialized knowledge of people in several different fields. The process also led to encounters with other specialists interested in different aspects of iron history and this, in turn, led to a growing awareness that many of them would benefit from the knowledge of the others, if only they were made aware of it. This was the motivation behind the symposium, and the papers presented in this volume are the result.

THE IMPORTANCE OF IRON IN NEW YORK'S HISTORY

Why is there such a broad interest in the history of iron? Of the many non-farming industries brought from Europe to the Americas, ironworking was arguably the most basic. Without it, the building of productive self-sufficient communities could not have proceeded. Iron was needed for tools to clear and work the land, for vessels and implements for the preparation of food, for nails and hardware for the construction of buildings, and for the many different kinds of tools for the day-to-day trades of a European community. It forged the weapons of war and the chains of slavery.

Iron was so basic to European life that it could truly be said, as the motto of the Ancient Order of Smiths in London stated, "By hammer and hand all arts do stand" (Hogg 1964). The mining and working of iron was therefore crucial to the development of the European colonies in the Americas and to their subsequent struggle for independence. New York possessed abundant sources of both ore and the wood necessary for fuel to turn it into iron, and the production of iron and iron products has done much to shape the history of this state. Although relatively little iron production occurred in New York before the American Revolution in comparison to that of several other colonies, the industry began to expand during the early 19th century. Large deposits of iron ore, already known in southeastern New York, were discovered in the previously unexplored northern and central parts of the state as well, and iron production eventually occurred in every part of New York where ore was available, taking advantage of the seemingly endless forests for the charcoal fuel required for forges and blast furnaces.

As new transportation routes developed, first the canal system and later the railroads, Pennsylvania coal became available as a fuel for smelting. It also became economically feasible to bring both ore and pig iron from more remote areas to create products at sites more convenient to these same shipping routes, which could then be used to ship them to the consumer. Foundries, rolling mills and steel works developed at locations along the Erie Canal and the Hudson River producing rails, wheels and other necessities of the rapidly expanding railroad industry. Foundries and factories along these water routes also produced other specialized iron and steel products for shipment to other states and overseas. Innovations made in New York, such as Henry Burden's hook-headed railroad spike and machine-made horseshoes from Troy, were important worldwide, and Burden's innovative "rotary concentric squeezer" dominated the production of wrought iron until its end in the mid-20th century (Proudfit 1904).

Of the six foundries licensed nationally to make the Bessemer steel that revolutionized the production of railroad rails after the Civil War, one of the first was located in Troy. The famous West Point Foundry on the Hudson River pioneered the construction of steam locomotives, rifled cannon, and iron ships (Walton 2012). The groundbreaking warship, U.S.S. Monitor, was built by

the joint effort of several different foundries, mostly located along the Hudson River. Watervliet Arsenal, near Albany, is the nation's oldest arsenal (Swantek 2009) and has supplied many forms of equipment to the U.S. Army from 1813 to the present, as well as artillery for both the Army and Navy. New York's iron production during the 19th century, while modest compared to that of a few states such as Pennsylvania and Ohio, was large in comparison to that of most other states and many of the important industries for which iron was a basic material had their homes in New York.

The iron industry in New York peaked during the Civil War, but soon began to decline with the development of the iron and steel works of the Midwest. The mines and furnaces of New York State began to close one by one as the late 19th century wore on, and by the late 20th century the last remnants of the iron industry in this state had largely passed into history. Much of the iron made in New York found its way to New York consumers in the form of foundry products such as stoves and farming equipment, but much of it also went to supply local blacksmiths and manufacturers of wagons and farming equipment all over the state. In the seventeenth, eighteenth, and early 19th century, the working of iron by local smiths was so essential to everyday life that every community, no matter how small, had at least one blacksmith and often several. Before the spread of factory-made products made the local production of architectural hardware unprofitable, the Hudson Valley boasted regional smithing traditions from a number of different sources, producing a variety of local styles drawn on traditions from Holland, Germany and other parts of Europe as well as from England.

While the backbone of the blacksmith's business was always the shoeing of livestock, especially horses and mules, the local smith had to be able to make or repair any metal item needed by his customers as well as to make and repair his own tools and those of the other kinds of craftsmen in his community. Often the local blacksmith was necessary to the construction and maintenance of mill and factory machinery as well. Urban areas, because of their large population base, were able to support a variety of specialized smiths making everything from nails to complicated locks and specialized tools. In rural areas, however, the majority of the work involved the manufacture and repair of home products, architectural hardware, farm implements and conveyances, work that necessarily required the smith to be a jack-of-all trades and even, to some extent, a woodworker making handles for tools and wooden parts for wagons and sleighs. The complexity of wagon work was such that many shops specialized in it exclusively.

As the late nineteenth century progressed, however, most of the common items formerly made by local blacksmiths began to be manufactured for sale by the grow-

ing iron products industries, many of which were also located in New York State. Horseshoes were machine-made in Troy and wagons, buggies and sleighs were increasingly mass-produced. By 1897, the Sears, Roebuck & Co. catalog offered seventeen pages of wagons and buggies of all types, and several pages of factory-made blacksmith's supplies. The work of local smiths became increasingly limited to the shoeing of horses and repairing of factory-made goods, until the advent of the automobile sounded the death knell of the craft. By the end of the 1930s, except for a brief revival in response to fuel rationing during World War II, the craft had become obsolete. All of these aspects of the history of the production and use of iron in New York are studied today by a variety of specialists in different fields, ranging from historians and archaeologists to geologists and skilled craftsmen interested in the history of mining, iron production, blacksmithing and industrial processes. This volume is intended as an introduction to this broad field of interest and to the kinds of specialists involved in it.

Dr. Gordon Pollard, professor emeritus of Anthropology at S.U.N.Y. Plattsburgh, introduces us to the iron industry in New York. He describes the workings of the bloomery iron industry that once flourished in the Champlain region of the state, with a detailed commentary on a series of stereo photographs of the Clintonville Forge of the Peru Steel & Iron Company, at one time the largest such forge in the world. The sources of the iron ore that supplied such industries in New York are introduced and explained by Drs. Marian Lupulescu and Charles Ver Straeten of the New York State Museum. Historian Dr. Steven Walton of Michigan Technological University discusses the legal and economic details surrounding the development and mysterious failure of Peter Townsend's Newburg cannon foundry, an early adventure into government contracts for war materiel during the early years of the 19th century.

These are followed by several articles discussing archaeological approaches to the subject: Daniel Seib of the Public Archaeology Facility at S.U.N.Y. Binghamton introduces the basic approach of archaeology to the location and examination of blacksmith shop sites, while Dave Staley of the New York State Museum describes the post-abandonment transformation of the iron works at Tahawus in Essex County. Fred Sutherland of Michigan Technological University demonstrates the usefulness of archaeology for the planning of preservation efforts at the Copake Iron Works National Historic Site. Machinist Robert Rawls of the former Watervliet Arsenal Museum (sadly now closed) details the history of Henry Burden's development of his famous horseshoe-making machine, which he studied by developing working models using a combination of documentary research and personal experimentation, and explains the iron shaping techniques built into this fascinating machine. Links

to video demonstrations of the working models he has constructed are also provided.

The articles in this volume represent a sample of the range of disciplines that can contribute to our understanding of the history of iron in New York. The wide range of topics discussed here reflects the basic level at which the mining, processing and utilization of iron permeate the history of New York. This subject is a broad one subsuming topics such as mining and production, the use of iron in specific industries, or the work of blacksmiths in their local communities, each of which could easily be studied as a theme in its own right. This collection of articles is intended to highlight the fact that in order to have a more complete understanding of their own research interest those studying any one of these subjects need to be aware of the specialized forms of information that they can access from disciplines other than their own.

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REFERENCES

- Hogg, G. 1964. *Hammer & Tongs: Blacksmithery Down the Ages*. London: Hutchinson Co. (Cited on page [xiii](#)).
- Pickands, M. 2009. PIN 7780.04.101 98PR 1826: *Parishville Center Blacksmith Shop Site, NYSM #10653 and the Parishville Center Wagon Shop Site, NYSM #11425*. Hamlet of Parishville Center, Town of Parishville, St. Lawrence County, New York, MCD #089-24. Cultural Resource Data Recovery Report. Albany, NY: New York State Museum Cultural Resources Survey. (Cited on page [xiii](#)).
- . 2010. "A Local Industry Reflects a Local Community." In *Soldiers, Cities and Landscapes: Papers in Honor of Charles L. Fisher*, edited by J. P. Hart and P. B. Drooke. New York State Museum Bulletin 513. Albany, N.Y.: The New York State Education Dept. (Cited on page [xiii](#)).
- Proudfit, M. E. B. 1904. *Henry Burden, His Life and a History of his Inventions Compiled from the Public Press*. Troy, N.Y: Parfaets Press. (Cited on page [xiii](#)).
- Swantek, J. 2009. *Watervliet Arsenal: a History of America's Oldest Arsenal*. Watervliet, New York.: Watervliet Arsenal Public Affairs Office. (Cited on page [xiv](#)).
- Walton, S. A. 2012. "The West Point Foundry in Larger Perspective." *Industrial Archaeology* 35 (1, 2): 9–13. (Cited on page [xiii](#)).

IMAGES OF THE 19TH CENTURY ADIRONDACK BLOOM IRON INDUSTRY

Gordon C. Pollard

The Adirondack-Lake Champlain region of upstate New York is well known for having produced top quality, direct-reduction wrought iron throughout most of the nineteenth century (R. F. Allen et al. 1990; Gordon 1996, 95-9; Gordon and Killick 1992). Dozens of bloomery sites, having a combined total of hundreds of forge fires, smelted magnetite ores that were high in iron content (35-60%) and normally low in undesirable impurities such as phosphorus, sulfur, and manganese. This produced an iron that was highly desirable for a variety of applications, including anchors, chains and bridge cable, railroad car axles, nails, and merchant/bar iron.

The iron was also eminently suited for conversion to cast steel, and in the latter half of the 19th century, much of the Adirondack region's output, in the form of billets, made its way to Pennsylvania, Ohio, and New Jersey steel works. Steel production in the U.S. rose dramatically in the 1860s and 1870s, and it was suggested that success in the manufacture of finer grades of steel during that period was

...greatly indebted to the forge fires of the Adirondacks, for they have not only furnished the iron from which the steel was made, but have furnished it at prices below the cost of the foreign iron that must have been used in its stead. (Chahoon 1880, 426)

At the same time, it is noted that bloom iron was only a fraction of the country's total iron production, which was generated primarily by blast furnaces. In 1856, 813,000 tons of pig iron were turned out by blast furnaces in 22 states, compared to 28,600 tons of wrought iron from bloomery forges in 9 states; 64% of the latter came from New York (Lesley 1866, 759-60). By 1880, U.S. bloom iron output had risen to 33,600 tons, with 84% of that now coming from the Adirondack-Champlain region alone (Moravek 1976, 109). Iron production and the viability of many iron works, of course, fluctuated during the 19th century in association with local, national and international economic conditions, but high-quality ores, abundant forests for charcoal fuel production, excellent water-power resources, relatively low operational costs, and the gradual development of favorable transport systems helped sustain the bloom iron

industry of extreme northern New York longer than in many other areas. [1]

Still, directories of U.S. iron and steel works document the rapid decline in bloomery forges in this upstate area beginning in 1886 when there were 27 forge sites in Clinton and Essex Counties, dropping to 16 in 1890, 9 in 1892, 7 in 1896, and 2 in 1898 (AI&SA 1886-1898). Unfavorable national tariff policies were often cited by iron makers as the source of their difficulties, coupled with the widespread financial depressions of 1882-85 and 1892-96 (Farrell 1996, 130; Moravek 1976, 194-5). Additionally, the rising cost of charcoal fuel in many areas, and steel-works being able to produce iron of comparable quality in puddling furnaces after 1880, have been suggested as more significant factors (Gordon and Killick 1992, 164).

Competition from the opening of new, low-cost iron deposits in the Lake Superior region also has been cited in this regard (Moravek 1976, 199; see also Chapter 2 on Adirondack iron deposits, by Marian Lupulescu, in the present volume). The country's last bloomery forge, which had operated only intermittently since at least 1901 (*Plattsburgh Sentinel*, Aug. 23, 1901), finally shut down in 1907 at the site of the Chateaugay Ore and Iron Co.'s works at Standish in Clinton County (Moravek 1976, 196). The conglomerate company of which it had been a part, however, profitably continued its mining and blast furnace operations well into the 20th century (Linney 1934).

Given that the bloomery forge industry of northern New York once held high prominence, one might well ask what such enterprises involved and what they looked like. In trying to visualize the process of bloom iron production, we have several nineteenth century written descriptions that specifically pertain to operations in the Adirondack-Lake Champlain region. The most detailed are the accounts of professor Thomas Egleston, a native New Yorker who helped found the School of Mines at Columbia University in the 1860s.

His descriptions, published in 1880 by the American Institute of Mining Engineers, include consideration of charcoal production (the fuel used for smelting), ore preparation, the making of blooms and billets, and specific drawings, measurements and weights of forge components and trip hammers (Egleston 1880a, 1880b). Other such accounts, although less extensive, are provided by Hunt (1870, 277-9), Neilson (1867, 265), and

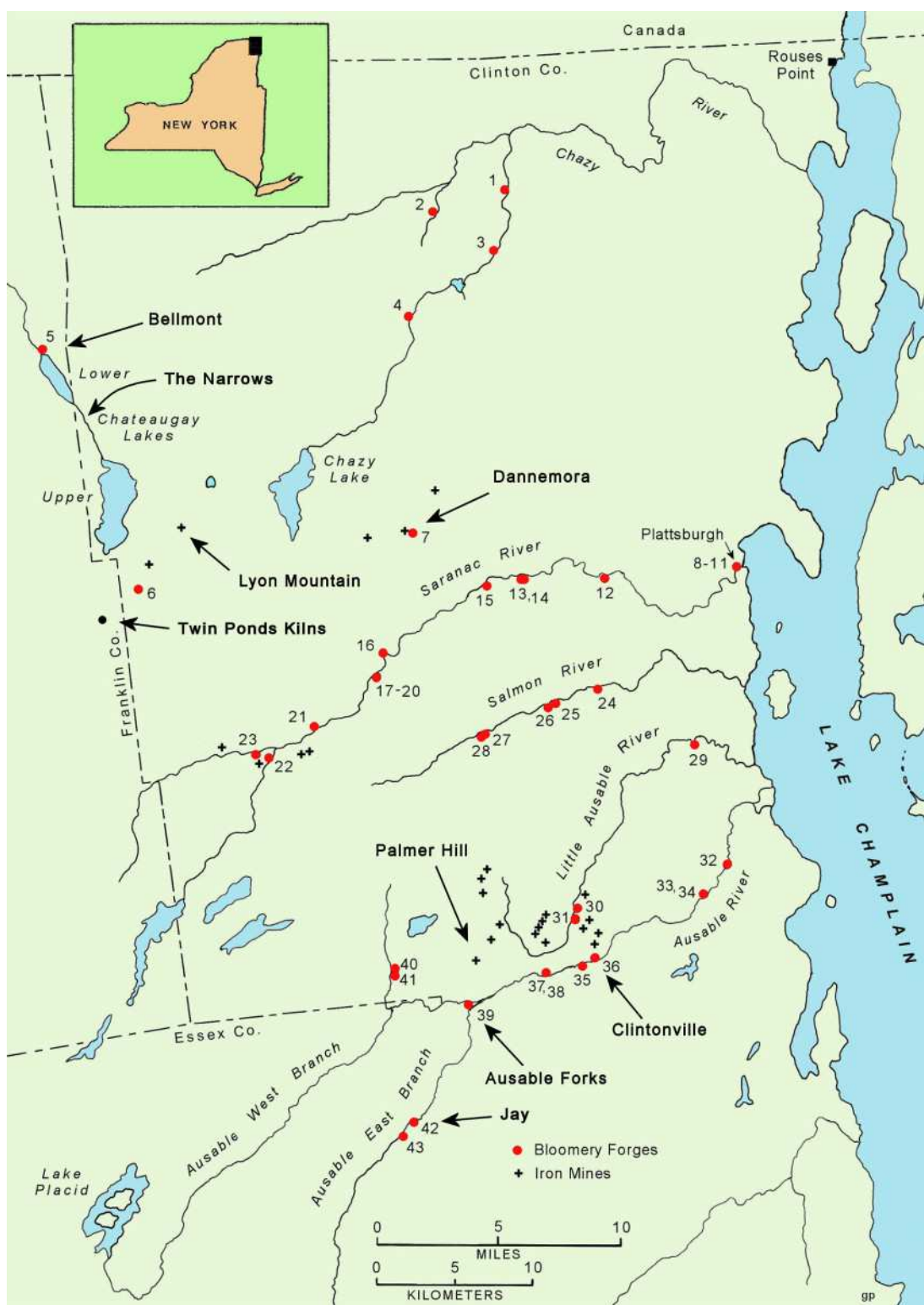


Figure 1.1. Known bloomery forge sites and iron mines in Clinton County and vicinity. Labeled locations are discussed in the text. Modified from Pollard and Klaus (2004, 23).

Table 1.1. Primary photographers of New York ironworks, with locations and subjects.

Seneca Ray Stoddard (1844–1917) , <i>based at Glens Falls, N.Y.</i>	
•Dannemora, Clinton Prison (Clinton Co.)	Separator, forge, rolling mill, machine shop, nail factory, other prison buildings, grounds and inmates
•The Narrows, Chateaugay Lake, and other Adirondack locations (Clinton Co.)	Charcoal kilns
•Irondale, Crown Point Iron Co. (Essex Co.)	Railroad, forge exterior, sawmill
•Hammondville (Essex Co.)	Iron mines
•Lyon Mountain (Clinton Co.)	Mining hoists
George W. Baldwin (1849–1930) <i>variably based at Keeseville, Elizabethtown, Plattsburgh, and Saranac Lake, N.Y.</i>	
•Ausable Forks, J. & J. Rogers Iron Co. (Clinton Co.)	Forge, rolling mill exterior and interior, company store and office
•Palmer Hill, J. & J. Rogers Iron Co. (Clinton Co.)	Mining engine house, ore separators
•Palmer Hill, Peru Steel & Iron Co.	Mining engine house
•Clintonville, Peru Steel & Iron Co. (Clinton Co.)	Company store & office, forge exterior, ore separator, rolling mill, saw mill, grist mill, foundry, barns
•Arnold Hill (Clinton Co.)	Mining engine house and miners
•Adirondacks (Essex Co.)	Charcoal kilns
Crane and Baldwin (George C.) , <i>based at Ogdensburg, N.Y.</i>	
•Dannemora, Clinton Prison (Clinton Co.)	Rolling mill, nail factory, other prison buildings
William F. Cheesman , <i>based at Ausable Forks and Lake Placid, N.Y.</i>	
•Ausable Forks & Black Brook, J. & J. Rogers Iron Co. (Clinton County)	Forge exterior at Ausable Forks, forge ruins at Black Brook

Chahoon (1875, 1880). Where preserved, original company documents and ledgers provide additional, valuable information, as do historical maps, narratives, letters, or diaries written by individuals who lived or were employed at the iron works (e.g., Bailey [Papers](#), 1830–1850; Palmer 1921).

As important and useful as such accounts are, one is often left with an incomplete conception of the real-life configuration and appearance of these kinds of industrial sites. Archaeological and experimental studies, of course, provide the basis for recovering, re-creating, and interpreting various kinds of tangible evidence from specific locations, but to date such investigations have been limited in this region (see R. F. Allen et al. 1990; Dawson et al. 1988; Gordon and Killick 1992; Pollard and Klaus 2004). Landon et al. (2003) offer one of the few archaeological studies of a bloomery forge site from another state, Michigan.

It is photographs, taken when bloomery forge operations were underway, that offer yet another primary source of information for exploring and appreciating various aspects of this vanished industry. Combined with the range of other material resources indicated above, photographs provide a basis for more easily conceptualizing and verifying descriptive accounts, for aiding in evaluating archaeological evidence, and for showing us things in specific contexts that simply went unrecorded in other ways. It is with these considerations

that the present study is undertaken.

THE PHOTOGRAPHIC RECORD

Bloomery forge operations in northern New York centered in the counties of Clinton and Essex, adjoining the Adirondacks and Lake Champlain. Situated primarily along streams and river ways, more than 40 forge sites were established in or near Clinton County alone between 1798 and 1907 (Pollard and Klaus 2004, Figure 1.1; for detailed listing of the numbered forge sites see). Immediately to the south, Essex County included at least two dozen additional sites (Witherbee, Mar. 8–Apr. 5, 1907). Despite such a large number of operations, relatively few seem to ever have been photographed. It was the larger enterprises that tended to receive such attention, and Figure 1.1 pinpoints eight sites in and close to Clinton County for which photographs are known, and which shall be highlighted here.

Overall, images include views of activities and locations that were ancillary to iron production, including charcoal kilns, rolling mills and shops, mining, ore hoists and separators, and company stores as well as forge buildings and their contents. [2] Table 1.1 lists the primary identified photographers and the kinds of images they captured. Most photographs were either stereoviews (ca. 4" x 7"; for Stoddard and Baldwin see lists in Bauer 2007a, 2007b), cabinet (ca. 4 ½" x 6 ½"), or boudoir

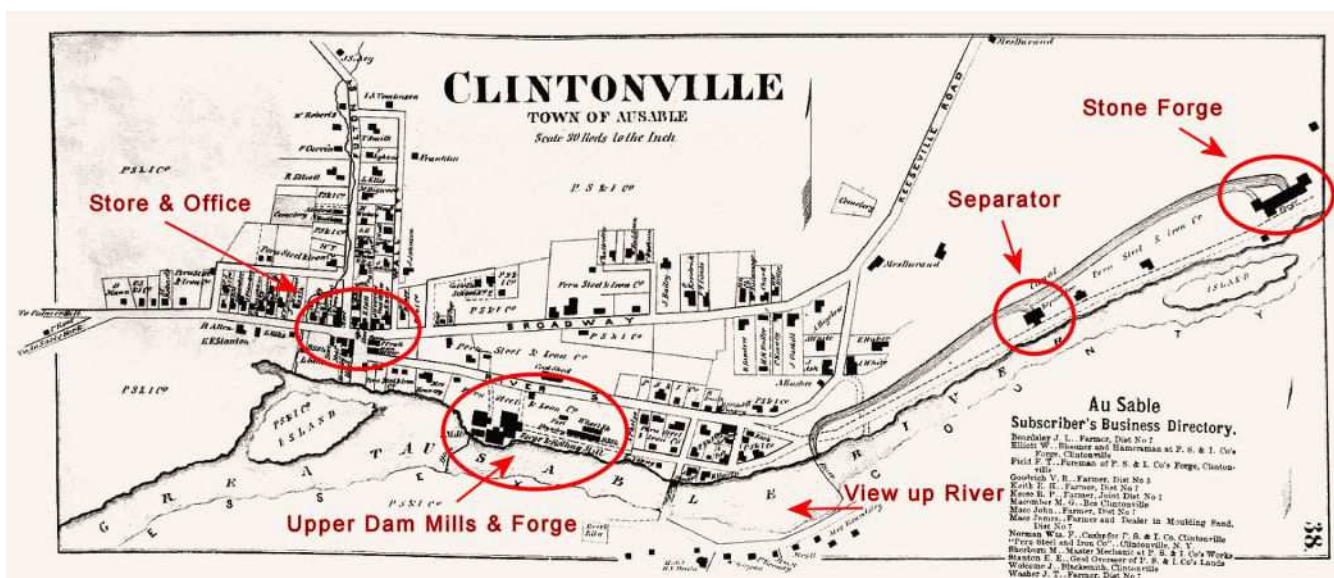


Figure 1.2. 1869 map of Clintonville, from F. W. Beers & Co. Atlas of Clinton County, New York. Labeled overlays indicate the major zones depicted in the G.W. Baldwin stereoviews.

photos (ca. 5" x 8") mounted on card stock, dating from the 1870s to 1890s. Not included here are photographs associated primarily with blast furnace operations.

The rarity of many photographic images is reflected in the example of stereoviews taken by George W. Baldwin of the Peru Steel & Iron Co. works at Clintonville in the Ausable River Valley at the southern end of Clinton County. Research in original company documents in 1994 (IWR) revealed that the company had hired Baldwin, a photographer in Keeseville nearly six miles to the east, to take the pictures in the spring of 1876, possibly to compliment the company's exhibition at the Centennial International Exhibition in Philadelphia. [3]

Archaeological work was carried out at the company's forge site from 1994 to 2001 (Pollard and Klaus 2004). Despite every possible effort for many years, no photographs of any kind were ever found dating to the time of the company's operation, which ended in 1890. It was only late in 2008 that fourteen of Baldwin's stereoviews were obtained, having unexpectedly turned up for auction on eBay®! It is not known if these include the full set taken by Baldwin, but they may well represent the only photographs ever taken of the iron works while they were in operation.

They are reproduced here with half of each stereoview (Figures 1.3 to 1.16 on pages 6–9, from the collections of Gordon Pollard and Ronald Allen), and several will be explored in some detail in this chapter. [4] Photo captions have been added in Figures 1.3-1.16. The stereoviews themselves bore no labeling to indicate their location or subject matter, but the seller had correctly surmised that they might pertain to the Peru Steel & Iron Company [PS&I Co.]. It was only with documentary re-

search and archaeological surveys that they were able to be unequivocally identified as to subject matter and location.

Having risen to prominence in the early 1800s, the ironworks at Clintonville held the reputation of including the largest bloomery forge establishment in the United States. As early as 1830, the works included a building that housed 16 forge fires, and a separate foundry, cupola furnace, nail factory, and rolling mill complex that contained four additional bloomery forges by 1847 (Pollard and Klaus 2004). The Clintonville works operated under different company names at different times, first as the Peru Iron Company (1824-1865), then as the Peru Steel & Iron Company (1865-1886), and finally as the Peru Steel Ore Company, Ltd. (1886-1890). [5]

AN EXPLORATION OF SELECTED IMAGES AND DOCUMENTARY ACCOUNTS

Many photographs can be oriented with the aid of historical maps that show the layout of settlements and the location of specific structures. An 1869 atlas map of Clintonville (Figure 1.2) nicely helps pinpoint the relationships of most of Baldwin's stereoviews related to the Peru Steel & Iron Company.

Company Stores and Offices

The stereoviews of Figures 1.3 and 1.4 depict the main road through Clintonville, with the company store and office being a focal point of the commercial sector of the community. A close-up of Figure 1.3 is presented here in Figure 1.19, and shows several men standing on the

porch of the store at the left. "Peru Steel & Iron Co" is faintly visible on the sign above them. The structure next to it, with a bell tower, is the company office, and the bell was rung whenever a fire broke out in the village. The structure at the right of the photo is a new hotel, the Mountain View House, in the final stages of construction. Its full front porch and second story balcony are yet to be added.

Company stores were often a major source of revenue for many ironworks while providing a local source of foodstuffs and household goods for employees. Clintonville's store was one of the most consistently profitable components of the Peru Steel & Iron Co., returning 11-26% per year on sales between 1865 and 1884. In 1876, the store made sales totaling \$114,561.00, with a profit of \$21,300.00 (IWR, 64.3 3/3). Surviving work records and store ledgers from the 1870s and 1880s show that each employee had an account with the store, with itemized purchases being charged against recorded wages and credits, and paid off monthly by a numbered slip from the company Office (IWR, 65.10, vols. 2-8).

Figure 1.17 shows another company store and office that had been photographed by Baldwin, that of the J. & J. Rogers Iron Company in Ausable Forks, five miles to the west of Clintonville (Figure 1.1). The building was the most imposing structure of that community, and is shown with stacks of iron billets made in the company's forges, to the right of the building. The three story edifice, built immediately after an 1864 fire destroyed the original store (Hurd 1880, 253), was constructed with iron and bricks made in the company's own works, with paneling and columns made from local black ash (Watson 1869, 446-447). The interior of the store is shown in Figure 1.18, from another Baldwin stereoview. The Rogers stepbrothers, James and John, also had a company store at their other two bloomery forge locations, Black Brook and Jay, within four and six miles of Ausable Forks, respectively, which operated under slight variations of the Rogers name (the Black Brook forges are site numbers 40 & 41 on Figure 1.1).

For the J. & J. Rogers Co., Hardy (1985, 90-91) reports that workers at Ausable Forks and Black Brook were paid in scrip which was negotiable only at the company businesses, with there being little in the way of cash payments. Along these lines, in early 1890 *The Evening World* newspaper of New York City ran several articles advocating weekly wage payments for workers everywhere, and decried the "company store" system at Ausable Forks and other Adirondack iron works as turning employees into helpless victims who were extorted with overpriced necessities of life, with no money left after their monthly wages were used to pay off the charges they had made at the store (*Evening World*, Jan. 20, 1890).

One of the local newspapers of Essex County responded strongly to the *World's* sensationalistic attacks

(for which it was noted), countering, for example, that the J. & J. Rogers company in fact paid thousands of dollars in cash to employees, and that many workers simply chose to keep their wage balances in the company store until cash was needed (*Essex County Republican*, Feb. 20, 1890). Similarly, this response stated that the Witherbee, Sherman Iron Co. at Mineville, and the nearby Port Henry Iron Ore Co., both of which had also been attacked by the *World*, paid their workers on the 10th of each month, with $\frac{2}{3}$ of the total amount earned being paid in cash. Even a worker interviewed for the *World's* article on the Chateaugay Ore & Iron Co. at Lyon Mountain in Clinton County stated that the company store's prices were not out of line, but complained that the goods for sale were of a higher quality than he needed (*Evening World*, Jan. 20, 1890).

It is not known how many Adirondack iron works actually issued scrip to employees for use in their company stores, but Figure 1.20 shows \$1, \$2, \$3, and \$4 notes that were issued in the early 1880s for Stower & Esmond's forge store at Lewis in Essex County. These measure 4.75 inches in length, and could be punched for any combination of cents when used. The proportion of an ironworker's wages that was paid in store scrip remains unknown.

Mining and Ore Separation

There were more than 60 magnetite iron mines opened in the Adirondack region during the 19th century, many of which were worked with multiple openings (Newland 1908; Smock 1889). The size and extent of ore veins varied considerably, ranging in width from less than 3 feet to more than 120 feet. While some beds could be worked as open cuts or pits, others were mined with sloped and horizontal shafts. Mine owners could often supply several bloomery forges with ore for smelting, with the distance from mine to forge usually being between three and fifty miles (Pollard and Klaus 2004, for specific examples see). Transport was most often by wagons on plank roads, but could also involve narrow gauge ore trains and lake barges.

For both the Peru Steel & Iron Co. at Clintonville, and the J. & J. Rogers Co. Iron Co. at Ausable Forks, the primary ore source was the nearby Palmer Hill (see Figure 1.1, which shows the location of all the major mines in Clinton County; also see Figure 2.1 on page 44 in Chapter 2 by Marian Lupulescu, which places Palmer Hill in the broader geological context of the Adirondacks). Palmer Hill had been mined as early as 1825, and the two companies eventually owned different parts of the same hill; the Rogers' company mined the western end, and Peru Steel & Iron worked the eastern extension. Figure 1.21, based on a geologist's plane table map drawn in 1920 (Kemp and Alling 1925, 102), shows



Figure 1.3. Looking east on Clintonville's main street.



Figure 1.4. Looking west on Clintonville's main street.



Figure 1.5. Ausable River at Clintonville, looking west.



Figure 1.6. Ore roasting pits and separator, looking east.



Figure 1.7. The stone forge, looking northwest.



Figure 1.8. Front of the stone forge, looking west.



Figure 1.9. Edge of the charcoal mound at the west end of the forge.



Figure 1.10. Grist mill and saw mill at the upper dam, looking southwest.

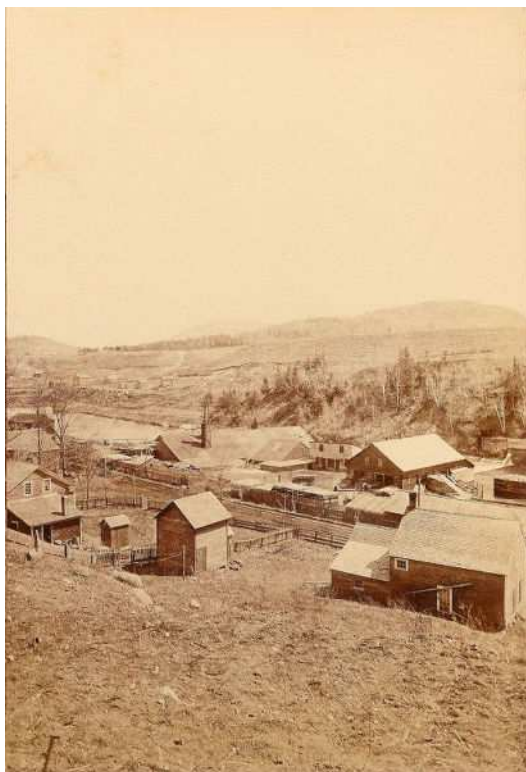


Figure 1.11. Mills at the upper dam, looking southeast.

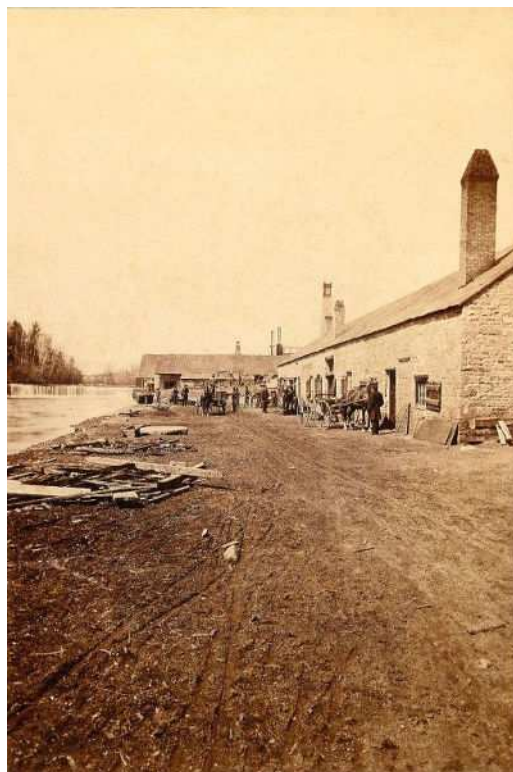


Figure 1.12. Foundry and blacksmith shop next to the river, looking west.



Figure 1.13. Horse barn at Clintonville, looking west.



Figure 1.14. PS&I Co. engine house at Palmer Hill mines, view 1.



Figure 1.15. PS&I Co. engine house at Palmer Hill mines, view 2.



Figure 1.16. PS&I Co. engine house at Palmer Hill mines, view 3.



Figure 1.17. The company store and office of the J. & J. Rogers Iron Co., Ausable Forks, New York. G.W. Baldwin stereoview c. 1876. Courtesy of Guenther Bauer.



Figure 1.18. Interior of a portion of the J. & J. Rogers Co. store at Ausable Forks. G.W. Baldwin stereoview c. 1876. Courtesy of Guenther Bauer

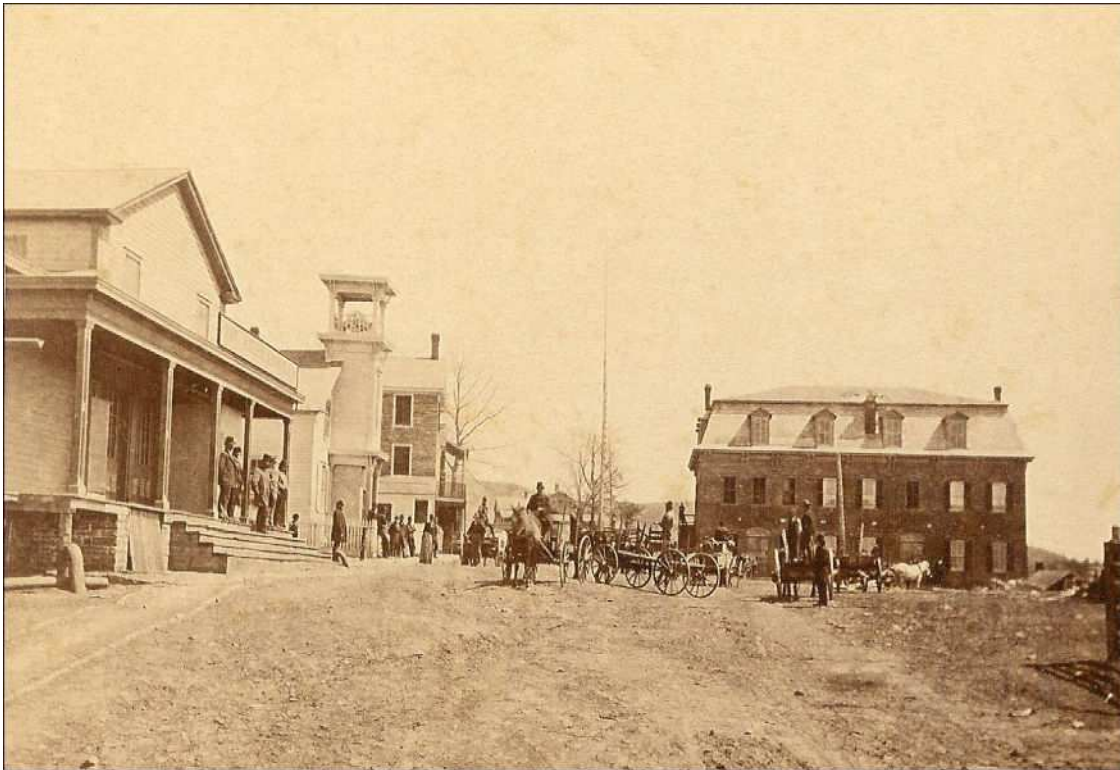


Figure 1.19. Clintonville, looking east on the main street. The Peru Steel & Iron Co. store and office are at the left, and a newly erected hotel on the right. G.W. Baldwin stereoview 1876. Courtesy of Ronald Allen.



Figure 1.20. Scrip issued to employees of the Lewis Iron Works in Essex County, New York, for use in Stower & Esmond's Forge Store, 1880s. Collection of Gordon Pollard.

the configuration of the hill and 24 mine openings that were made up to 1890, when mining ceased. The location of each company's engine house for operating mining equipment and ore hoists is indicated on the map.

A cross section and plan of the Palmer Hill mines as they appeared in 1865 is shown in Figure 1.22. These were prepared by Rudolph Keck of the Peru Steel & Iron Co., and published in 1886 as part of a census report compiled by Raphael Pumpelly on mining industries of the U.S. (Putnam 1886, Plate XXVIII facing p. 119, miscaptioned as being in Franklin County; plans of several Essex County iron mines are also included in Putnam's report). In 1865 the primary workings, which focused on two large shoots of ore about 10 feet thick, had been run a few hundred feet. By 1874 the Rogers' company pit was at 850 feet, with a lower cavern 80 feet in height which was supported by pillars of rock and ore (*Plattsburgh Sentinel*, Feb. 27, 1874). The iron mines of both companies at Palmer Hill continued to be enlarged, and were extended to as much as 2200 feet in the 1880s (Kemp and Alling 1925, 102; Smock 1889, 38).

In the mid-1870s, the Rogers' company operations involved up to 100 miners who were said to have each averaged a ton of ore per day (*Plattsburgh Republican*, Aug. 9, 1873). During the same period, the Peru Steel & Iron Co. employed about 60 miners at Palmer Hill, who produced an average of 40-50 tons per day (*Plattsburgh Republican*, Apr. 17, 1875). For the 18 year period of 1865-1882, the PS&I Co. alone mined 228,443 tons of ore, averaging 12,700 tons per year (IWR, 64.3 3/3).

Most of the old pits along the brow of Palmer Hill are still visible and open, but lower shafts are all now filled with ground water. Figure 1.23 shows one of the larger openings toward the eastern end of the hill. Here one can climb down into its huge antechamber, seen in Figure 1.24, and peer into its flooded shaft dipping into the darkness.

Photographer George Baldwin of Keeseville captured images of the engine houses of both mining companies on Palmer Hill. Figure 1.25 shows the substantial brick structure of J. & J. Rogers Iron Co., and its ore hoist. The building's 40 horsepower steam engine powered the reels of wire cables that lowered and raised ore carts, each of which held 8000 lbs. of ore, as well as a pump for extracting mine water. A separate 25 horsepower engine and compressor were installed here in 1873, running the first pneumatic drill to be used in the mine (*Plattsburgh Republican*, Aug. 9, 1873; *Plattsburgh Republican*, Feb. 21, 1880). Baldwin also took three views of the Peru Steel & Iron Co. engine house (Figures 1.14-1.16), one of which is shown enlarged in Figure 1.26. Built of stone with a brick stack, it was not as impressive as the Rogers' facility. The engine in the PS&I Co. structure also drove a hoisting apparatus, as well as pumps discharging water

from several mine shafts (*Plattsburgh Republican*, Apr. 17, 1875). Neither structure has survived to the present.

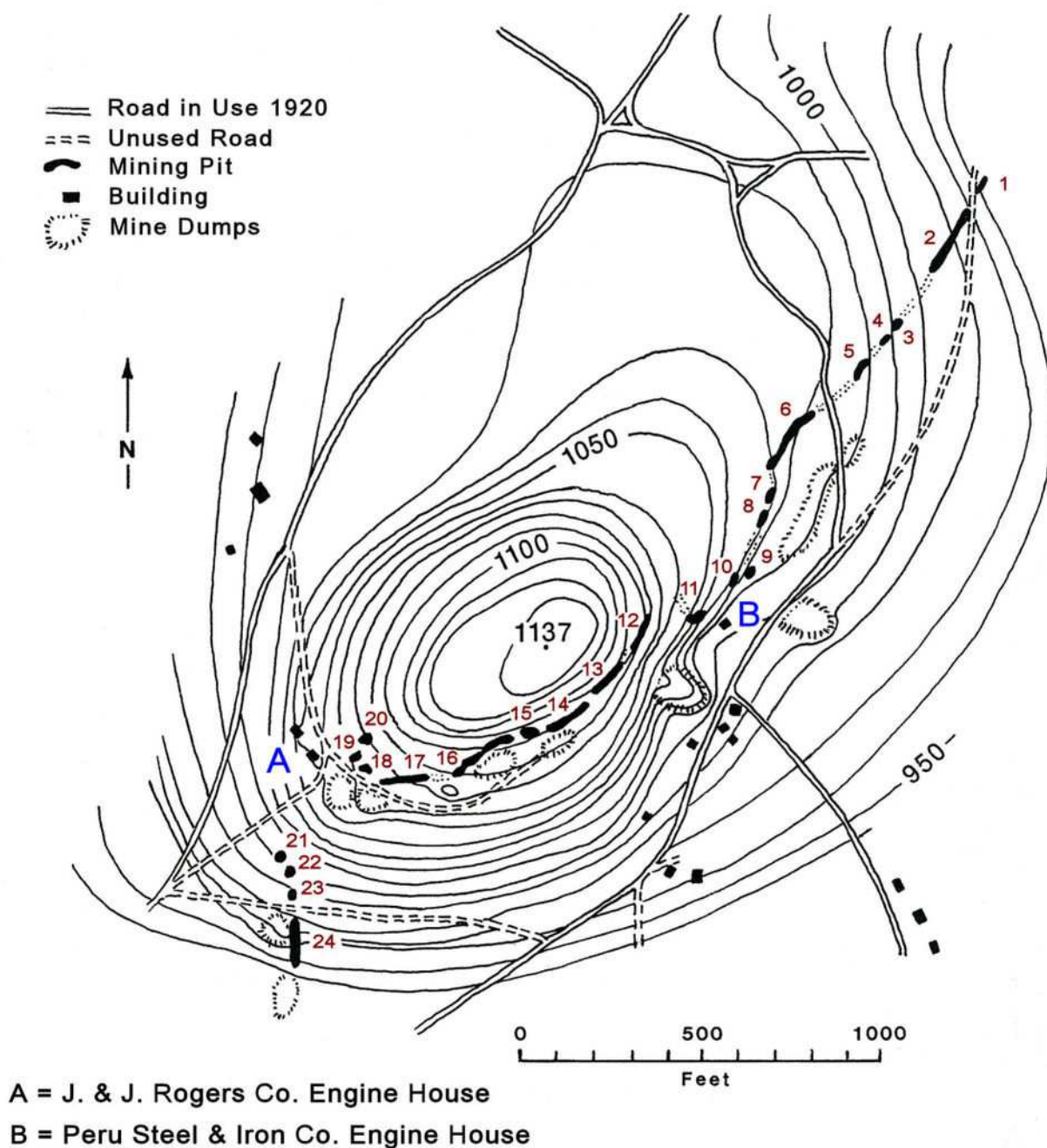
Once mined, iron ore destined for smelting in bloomery forges, often referred to as raw or "primitive" ore, first had to be separated. Primitive ore always contains varying amounts of gangue (rocks or minerals such as feldspar and quartz) that occur with the metallic ore (Fe_3O_4 in magnetite). While the liquid slag that formed from gangue during the smelting process was beneficial to protecting the iron from re-oxidation as it formed in the forge, it was desirable to remove as much gangue from the ore as possible beforehand, while crushing the iron ore down to the size of sand (for a concise, technical description of the smelting process see Gordon 1996, 90-96). To help facilitate the removal of gangue from iron ore, the common practice was to first roast the primitive ore in large open pits at the separator location (described below), followed by mechanical crushing and separation.

In one of the earliest endeavors of its kind in the Adirondacks, the Peru Iron Co. at Clintonville had erected a magnetic ore separator in the early 1830s near the Palmer Hill mines. Invented and patented by Joseph Goulding of nearby Keeseville in 1832 (R. S. Allen 1967), the separator's operation was briefly described by a local newspaper in 1875:

This consisted of a hollow cylinder about the size of a hogshead, having an axle running through its center longitudinally and furnished on the inside with a great number of small horse-shoe magnets. This cylinder, the ends of which were both open, was arranged with one end raised a little higher than the other, and as it revolved upon its axis by horsepower the ore, which had previously been roasted and stamped fine, was shoveled into the upper end, and as it was tumbled around by the motion, the particles of ore would adhere to the magnets, from which it was then removed by stationary brushes and carried away by a system of elevators, while the particles of stone would fall out at the lower end. A large pile of coarse sand marks the spot where this stood, and nearby are the remains of the barn where thirty horses were kept for working the separator. (*Plattsburgh Republican*, Apr. 17, 1875)

Ultimately found to be expensive and overly wasteful, this approach to separation was replaced in 1835 by water separation using a brook running off Palmer Hill. In the following year these operations were moved to a new separator close to the company's forge in Clintonville, at the location shown in Figure 1.2. It was powered by water from a half-mile long canal that drew from

Palmer Hill Iron Mines



gcp

Figure 1.21. Topographic map of Palmer Hill showing 19th century mine openings. Redrawn and adapted from Kemp and Alling (1925, 102).

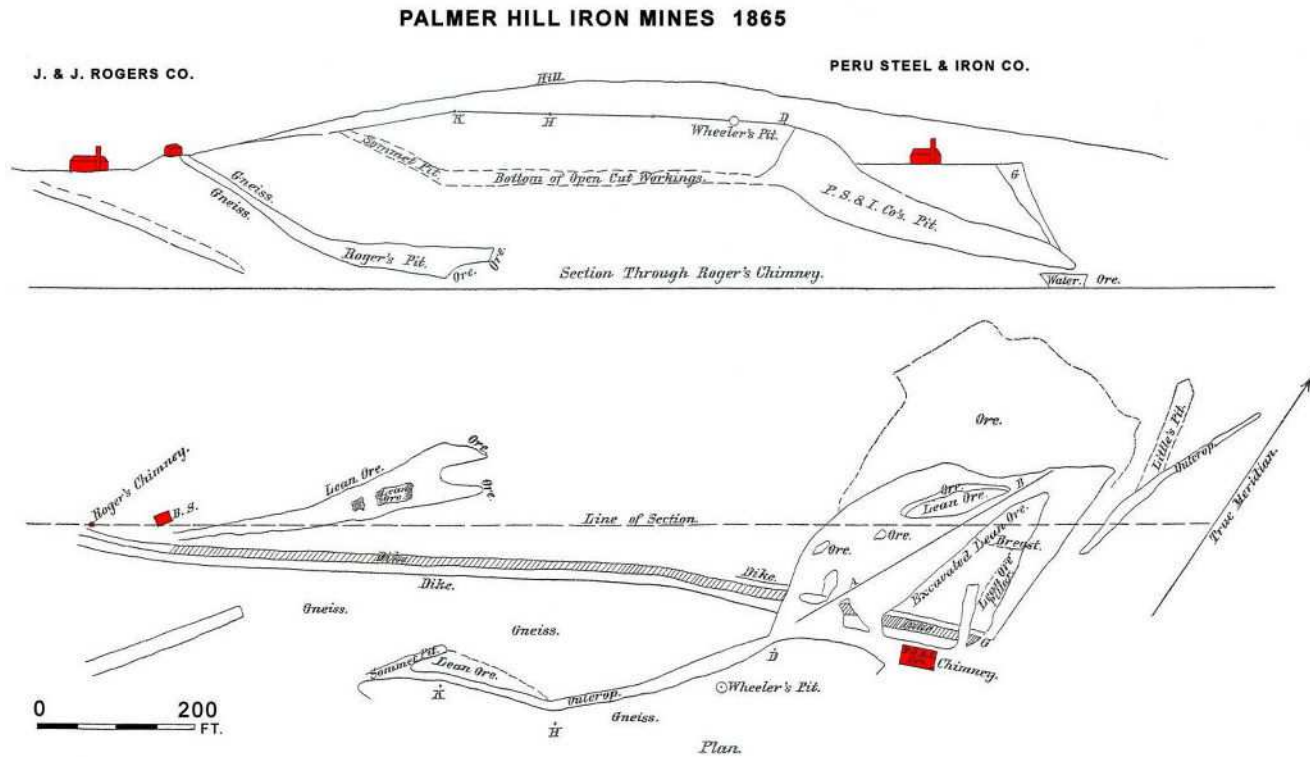


Figure 1.22. Cross section and plan of the Palmer Hill Iron Mines near Ausable Forks in 1865, made by Rudolph Keck of the Peru Steel & Iron Co. (Putnam 1886, Plate XXVIII). Mining company engine houses and workshops are highlighted.



Figure 1.23. One of the larger mine openings on the eastern portion of Palmer Hill. Photo by Gordon Pollard 2008.



Figure 1.24. In the antechamber of the mine opening of Figure 1.23. Photo by Gordon Pollard 2001.



Figure 1.25. The J. & J. Rogers Iron Co. engine house on the west side of Palmer Hill. G.W. Baldwin stereoview, 1870s. Courtesy of Guenther Bauer.



Figure 1.26. The Peru Steel & Iron Co. engine house on Palmer Hill. G.W. Baldwin stereoview, 1876. Collection of Gordon Pollard.

the Ausable River, and which also drove the blast bellows and trip hammers in the forge a little further downstream. The control gate at the beginning of the canal, at a dam, is seen in the photo of Figure 1.27, which probably dates to near the end of the nineteenth century. The Baldwin stereoview of Figure 1.5, looking upriver, had to have been taken from very near the location used by the photographer of Figure 1.27.

The new separating house, in which there were ore stampers and a water jigging process to separate off the gangue from the iron ore, was another subject for Baldwin's stereoview camera in 1876 (Figures 1.7 and 1.28), 40 years after it had been built by the same mason who constructed the large forge at the end of the canal. While only a few remnants of its stone walls are visible at the site today, the original separator had measured 34 x 56 feet (IWR, 65.5 5/1). As viewed in Figure 1.28, water would have entered the structure from the canal out of sight to the left, re-entering the river via a covered tail-race going under the roadway seen on the right.

The following description helps to visualize the ore roasting and separation process as it was commonly undertaken.

The methods at present employed in the Adirondacks for separating the impurities from the ore are as follows: The ores are roasted in open kilns, where about 300 tons of raw ore are piled upon about 25 cords of wood; the heat causes the stone to lose its hold upon the ore. As soon as the ore is cooled it is wheeled to the separators and put into long trough with grate bottoms, where it is stamped with heavy iron hammers; after it is stamped it is passed through screens and finally deposited in what are known as the sieves. These sieves are quite different in different places. The oldest and still most generally used are rectangular boxes with perforated or sieve bottoms. The bottoms of these sieves are covered with pieces of hard ore about the size of a hickory nut; this covering is called bedding. On the top of this bedding the unseparated ore is placed, and the sieve is then lowered into a trough of water and shaken up and down with a machine called a jigger. The difference in weight (ore, G.5-sand, G.2 ½), causes the ore to get to the bottom and the sand on top. After the sieve has been shaken under the water for some time, which time is determined by the experience of the men in charge, the sieve is raised up and the sand scraped off and thrown away; the sieve is again loaded and the same operation repeated. In the meantime the ore has been working its way through the bedding and the holes in the bottom of the sieve

and is deposited in the bottom of the trough, from whence it is taken in iron cups or buckets fastened to a revolving belt and dumped into bins ready to be taken in wagons to the forge-fires. (Chahoon 1880, 415)

There were at least four gigs within the Clintonville separator, and the operation of some of them was in need of repair and possible reconfiguration a few months after Baldwin took his photograph of the structure, as indicated by letters from the forge superintendent to the company vice-president in New York, written in January of 1877:

One of the large water vats at [the] separator that holds the water in which the Gigs work is so badly decayed it will need to be made new before it is used much more.

It seems to me that the Gigs arranged to clean themselves would separate ore enough for sixteen fires in twelve hours. That is four gigs on one side, as this would run right along without interruption. (IWR, 65.5 9/2, pp. 220, 236)

In the foreground of Figure 1.28, to the left, can be seen part of the four roasting pits in which the raw ore was treated before being hauled the short distance to the separating house. Although eroded and overgrown, these U-shaped pits are still visible today. Company documents indicate that one of the pits was rebuilt in 1863, with stone walls that measured 3 feet thick, 19 feet wide and 8' 6" to 9' 3" tall at the back end, and 35 feet long on the sides, which tapered to 4 feet and 6' 10" high at the open end. Egleston (1880a, 517) indicates that the 4 feet long wood used in a roasting kiln at Ausable Forks was laid in crossed rows up to a height of about 3 feet before piling in the raw ore, and that it would take three to six days to burn out. In December of 1882 the PS&I Co. built a new separator at their rolling mill, discontinuing the one along the canal in order to provide greater water power at the forge.

The J. & J. Rogers Iron Co. at Ausable Forks provides comparative views of such ore separating facilities. Figure 1.29, from another Baldwin stereoview, shows one of two separators that the company had on the lower slopes on Palmer Hill. Here we can see smoking ore pits close to the back of the separating house, positioned so that the roasted ore could be relatively easily brought into the structure for stamping. A more distant view of that same separator, along with the second separator which was just down slope from it, is seen in Figure 1.30.

This photo apparently was taken a number of years after that of Figure 1.29, since a shed roof and an additional structure are now adjacent to the upper separator. This image is believed to also have been taken by Baldwin, perhaps around 1880. A large pile of ore waiting



Figure 1.27. Dam and control gate (center) for the canal at Clintonville. Photographer unknown, c. 1890s. Courtesy of Cecile Latourelle Arthur.



Figure 1.28. G. W. Baldwin stereoview of the PS&I Co. separator and ore roasting pits on the Clintonville canal, 1876, looking east. Collection of Gordon Pollard.



Figure 1.29. One of the two separators of the J. & J. Rogers Iron Co. on Palmer Hill. G.W. Baldwin stereoview c. 1876. Courtesy of Guenther Bauer.

to be roasted is seen lying between the two separators. Palmer Brook was used in the separation process, and is partly visible winding down the hill next to the road. In the lower left corner of the photo can be seen a pair of troughs in the brook, from which men seem to be recovering fine ore tailings that ran off in the separation process.

Another nineteenth century establishment relevant here was Clinton Prison at Dannemora, on the northern edge of the Saranac River Valley (Figure 1.1; the prison is still operating today as the maximum-security Clinton Correctional Facility). It was established by the state in 1845 for the purpose of employing convicts in mining and manufacturing iron (David 1949). Information on the bloomery forge setup of the Peru Iron Co. at Clintonville was used heavily in planning and implementing the iron works at Dannemora (Cook 1843, and several 1846-1848 letters in the Bailey Collection Papers).

Mining within the prison walls began in the first year of the prison's erection, but a bloomery forge of six fires was not operational until early in 1855, expanded to twelve fires by 1873. A blast furnace had been erected in 1854, but burned down in 1856 (Prison Report 1857, 10-11) and was not rebuilt. Other components of industry followed, including a rolling mill whose construction

began in 1858, and the manufacturing of nails during the following year. The latter began in a 35' x 75' stone walled factory with 10-12 nail machines, and expanded to 48 machines by 1861 (Prison Report 1859, 156; 1860, 171; 1862, 250).

With no major water source except what was diverted to and collected in the prison reservoir, all operations were run by steam power which, along with charcoal production requirements, involved the cutting of vast quantities of wood from 17,000 acres of surrounding State lands (Prison Select Committee 1869, 30). Nearly all of the iron industry and other manufacturing operations took place within the 37 acres of the prison yard, except for making charcoal in 15 kilns that were up to six miles away, which were in addition to 5 kilns within the prison walls. In 1876, of the 623 inmates at the prison, 374 (60%) were involved in making iron and nails (Prison Report 1877, 274). The iron industry focus of the facility had proved to be a financial disaster for the State, however, and was terminated in 1877. Manufacturing at the prison was initially reoriented to having the convicts make felt hats, mostly for women (Hurd 1880, 49).

Beers' 1869 atlas map of Dannemora (Figure 1.31) gives a somewhat simplified illustration of the general layout of structures and facilities at the prison (area shown in green). This is complemented by the more detailed 1868 bird's eye view drawing of Figure 1.32, which was included in an annual report of the prison (Prison Report 1869, facing p.189).

It is noted that some aspects of the 1869 Beers atlas map of Figure 1.31 are not entirely accurate or based on up-to-date information at the time of its publication. Tramcar tracks from the iron mine at the far western corner of the prison yard are strangely, and incorrectly, shown ending at the shoe shop (which had been used as a storage house since 1865), rather than continuing to the separator. As well, the map shows eight charcoal making kilns near the reservoir and the forge building on the eastern side of the compound. Eight kilns had in fact been erected there in 1854 (Report 1855, 781), but had been reduced to five kilns in 1867 (Prison Report 1868:10), as correctly depicted in the prison report's bird's eye map of Figure 1.32. Some secondary structures are also not shown on the atlas map, including the engine house and charcoal sheds that were to the left of the forge building, as shown in Figure 1.32.

A further indication of the timeliness of the bird's eye drawing is that it shows a telegraph line running along the main road to the prison. This had been installed in 1868, coming from Plattsburgh (Prison Report 1869, 196). In addition to the primary iron mine within the prison walls, Figure 1.32 also depicts what is identified as the "Hall mine" in the caption, which was actually about a mile north of the prison. It was minimally utilized to supplement the main workings.



Figure 1.30. The two ore separators of the J. & J. Rogers Iron Co. on Palmer Hill near Ausable Forks. Photo believed to have been taken by G. W. Baldwin, c.1880. Collection of Henry G. Rogers, Elsa Voelcker®, by permission.

In 1874, Seneca Ray Stoddard took 21 stereoview photographs within the prison (listed in Bauer 2007a, 21; see also Stoddard 1968). Among these is a superbly composed sunset shot looking west from the high guard tower near the middle of the prison yard ("Guard No. 9" in Figure 1.31, and "k, Guard Post" in the center of Figure 1.32). The image from that stereoview is shown here in Figure 1.33, and encompasses several features. The iron mine is in the distance, a little beyond where a steam engine plume is visible. From that point tracks for the ore tramcar extend past the old three story shoe-making shop with its rooftop turret, and a new reservoir just opposite the shoe shop. The tracks end at three ore roasting pits which adjoin the steam-operated separating house, which is seen at the left in the foreground.

Removable track sections atop the pits allowed the raw ore to be easily dumped for the roasting process. The roasting kilns had a capacity of 400 tons each, and the separators could generate 25 tons of separated ore in twelve hours (*Plattsburgh Republican* 1876). One other feature of Stoddard's photo relates to the bird's eye view of Figure 1.32, which shows some of the picket walls of the prison being buttressed on their exterior by poles, suggesting they were beginning to age severely. Prison reports in fact indicate that erection of a new 20 feet high plank enclosure for the entire facility was undertaken in 1871 and 1872. Some of this appears to be visible in Stoddard's stereoview, with the fresh-looking picket

wall running behind the shoe shop toward the mine.

Ore roasting pits and separators are relatively rare in the photographic record of the Adirondack bloom iron industry, but with the three examples that have been illustrated here it seems clear that the scale and placement of such activities varied significantly, depending upon the local landscape and power provisions. Frequent modifications and renovations were common.

Bloomery Forges

The three stereoviews taken by Baldwin of the Stone Forge at Clintonville in 1876 represent important additions to our conceptualization of Adirondack bloomery forge sites (Figures 1.6-1.9). The structure, built of local sandstone and measuring 236 by 52 feet, had been erected in 1836 for the Peru Iron Co. by mason Solomon Townsend of nearby Keeseville, immediately following the loss by fire of the original 1830 wooden forge building at the same site. With its sixteen forge fires, the stone forge was the country's largest bloomery operation up until the mid-1870s (see Pollard and Klaus 2004). Most bloomeries were much smaller, usually working only two to four fires. When four forges were added to the company's upstream rolling mill in 1847, making a total of 20, the stone forge also became referred to as the "lower forge" in company records. It was also at Clintonville that the earliest known application of hot blast

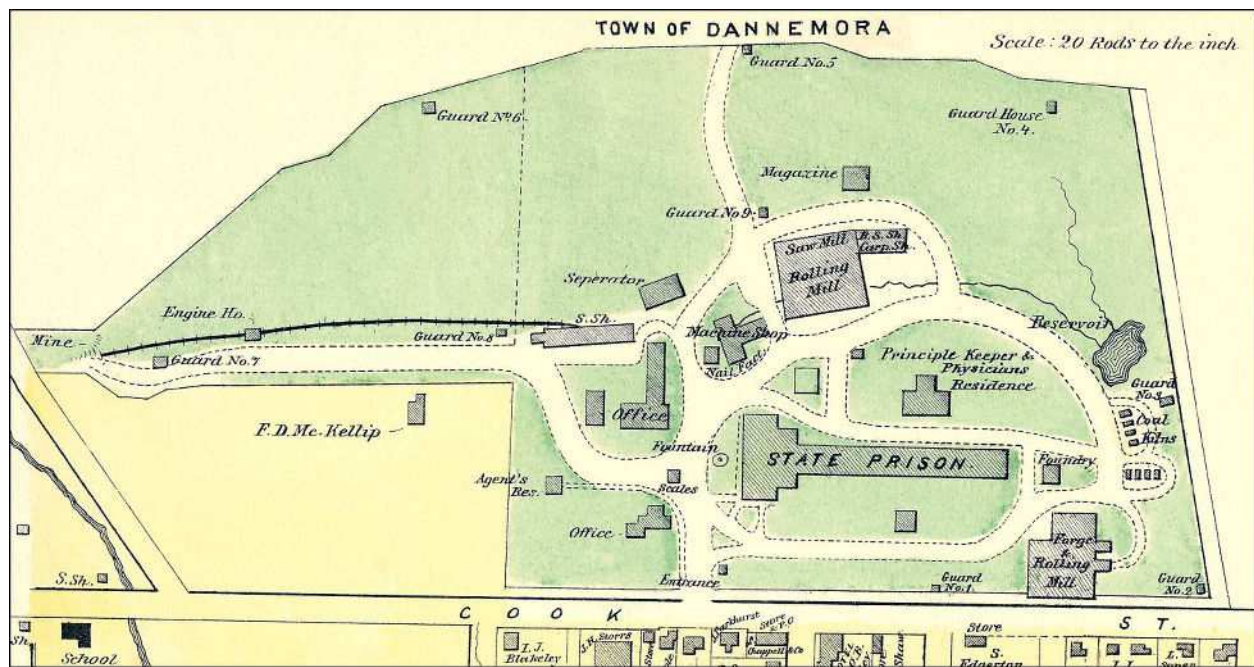
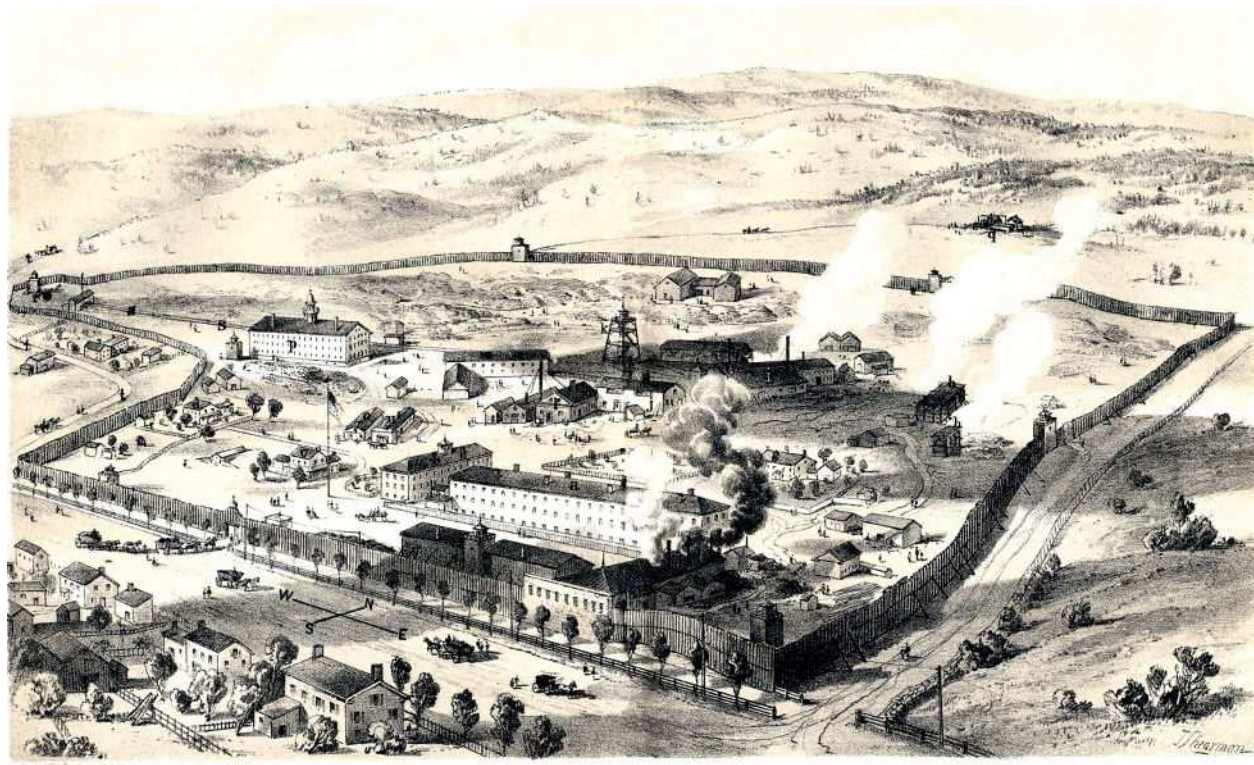


Figure 1.31. 1869 map of Clinton Prison at Dannemora, from F. W. Beers & Co. *Atlas of Clinton County, New York*.



STATISTICS, 1868.—Location, at Dannemora, 16 miles north-westerly from Plattsburgh, 1700 feet above level of Lake Champlain. Established 1844. Area of prison enclosure, 37 acres. Wood-lands for supply of charcoal, (mostly over mountains) about 17,500 acres. Valuations,—Real, \$465,467.66; Personal, \$460,349.65; Total, 925,817.31. Average number of Convicts for the year, 518. Occupation,—Manufacturing Iron and Nails for the State, 352; Tailors, Shoemakers, Carpenters, Laborers, Cooks, &c., 149; in Hospital, and ; disabled, 11; Total, Sept. 30, 1868, 512. REFERENCES.—A, Prison Dormitory, 500 feet long, 30 feet wide, (in the clear) containing 144 Cells. B, Kitchen, Dining Hall and Storeroom in 1st Story, Chapel, Guard House and Armory in 2d story. Hospital in 3d story. C, Offices of Agent and Warden, Clerk and Manufacturing Department. D, Agent and Warden's Dwelling. E, Forge Shop. F, Engine Room and Coal House. G, Dwelling for Clerk and Principal Keeper. H, H, Coal Kilns. I, Rolling Mill. J, Nail Factory. K, Guard Post. L, L, Machine and Carpenter Shops. M, Ore Separator. N, Chaplain's Office and Library and Tailor Shop. O, Store. P, Old Shue Shop (used as a Store House). Q, Hall Mine. R, Thomas and Watson Mine. S S, Tram Railroad. T T T, Plank Road over mountain to Coal Kilns and woodlands, and to Ellenburgh (built by the State). Production in 1868: 45,146 Kegs of Nails and 80 Tons of assorted Merchant Iron. Consumed about 900,000 bushels of Charcoal.

Figure 1.32. 1868 Bird's eye view of Clinton State Prison, from Prison Report (1869, facing p. 189).



Figure 1.33. S. R. Stoddard stereoview of Clinton Prison, looking west from the high guard post, 1874. Collection of Gordon Pollard.

to bloomery fires was made, in 1837 (Pollard 1998, 35; Pollard and Klaus 2004, 20).

Figure 1.34 is a close-up of Figure 1.6, with the forge viewed from the south side of the Ausable River. While somewhat difficult to see at this scale, the photo captured a number of details that were never comparably recorded in company records. The separate forge office lies to the left, behind which is a huge mound of charcoal for the forge fires. The forge structure itself had been described in 1843 by Ransom Cook, who would become the first warden of Clinton Prison:

...I will state, that the Peru Iron Company's forge is built of stone, with thick and strong walls; the roof is supported by an arched frame work of iron bars, and covered with thick sheet iron, which is painted. The light is admitted through an unglazed opening in the centre of the roof, extending the length of the building... The most of the other forges in that section are cheap structures, the buildings alone not being as good or as expensive as an ordinary barn. (Cook 1843, 2)

The "unglazed opening" described by Cook in 1843 is not present in Baldwin's stereoview, and clearly indicates the original roof had been replaced sometime prior to 1876. The front of the building shows arched

entrances between sets of four forge fires, and three window openings between each archway. The west end of the structure exhibits a southerly extension in which a blacksmith forge was set up. Much of that area has been archaeologically excavated, as reported in Pollard and Klaus (2004, 39-41). At the eastern end of the forge is an attached bellows house, which in 1836 was initially equipped with two 5 ½ feet diameter blowing cylinders (IWR, 64.3 3/4). A smaller bellows house at the western end of the forge is present, but not visible in this photo. Baldwin was unable to get a photograph of the interior of the forge building, probably due to poor lighting (IWR, 65.5 9/2, p. 8).

The archaeological surveys and excavations that were carried out at the site between 1994 and 2001 had delineated the full plan of forge and the bellows houses, as shown in Figure 1.35. The lower portions of several of the bloomery fires along the west end of the structure were revealed, along with the placement of two of the trip hammers and one of the waterwheels which were near the back center of the building. The excavations also pinpointed several modifications that had been made to the structure at various times, including the addition of at least one small charcoal storage shed to the front of the building (Pollard and Klaus 2004, 32).

Another informative feature seen in the photograph of Figure 1.34 is the six tailrace openings visible at the edge of the river. These carried the water runoff from the bellows operations and from the four waterwheel-driven trip hammers in the forge that shaped the iron blooms. Today, only shallow surface depressions of these can be seen at the site, where almost no above-ground structural remains are visible (Figure 1.36). Most of the stone from the forge walls had been carried off in the 1920s for reuse.

Baldwin's second view of the stone forge (Figures 1.8 and 1.37) is a wonderful shot that illustrates several things. What are undoubtedly bloomers and hammersmen are standing in the foreground, near stacks of iron billets they produced in the forge. The man in the middle is holding the handle of a small, wheeled billet cart used to bring them out (another version is drawn in Egleston 1880a, plate 5). Each iron maker stacked their billets separately outside the forge, eventually to be taken to the office seen on the left, where they were weighed. Midway down the front of the forge are men and boys next to an empty hand cart. This was used to transport stacked baskets of charcoal into the forge (see drawing of an almost identical cart in Egleston 1880a, plate 5, which he labels a "charcoal car"). A low pile of charcoal is seen on the left, and the edge of the huge charcoal stockpile is in view beyond the forge.

In the right foreground of Figure 1.37, and at several points along the front of the forge, can be seen piles of waste slag that have accumulated from the smelting



Figure 1.34. PS&I Co. stone forge with sixteen bloomery forge fires, looking northwest. G.W. Baldwin stereoview 1876. Collection of Gordon Pollard.

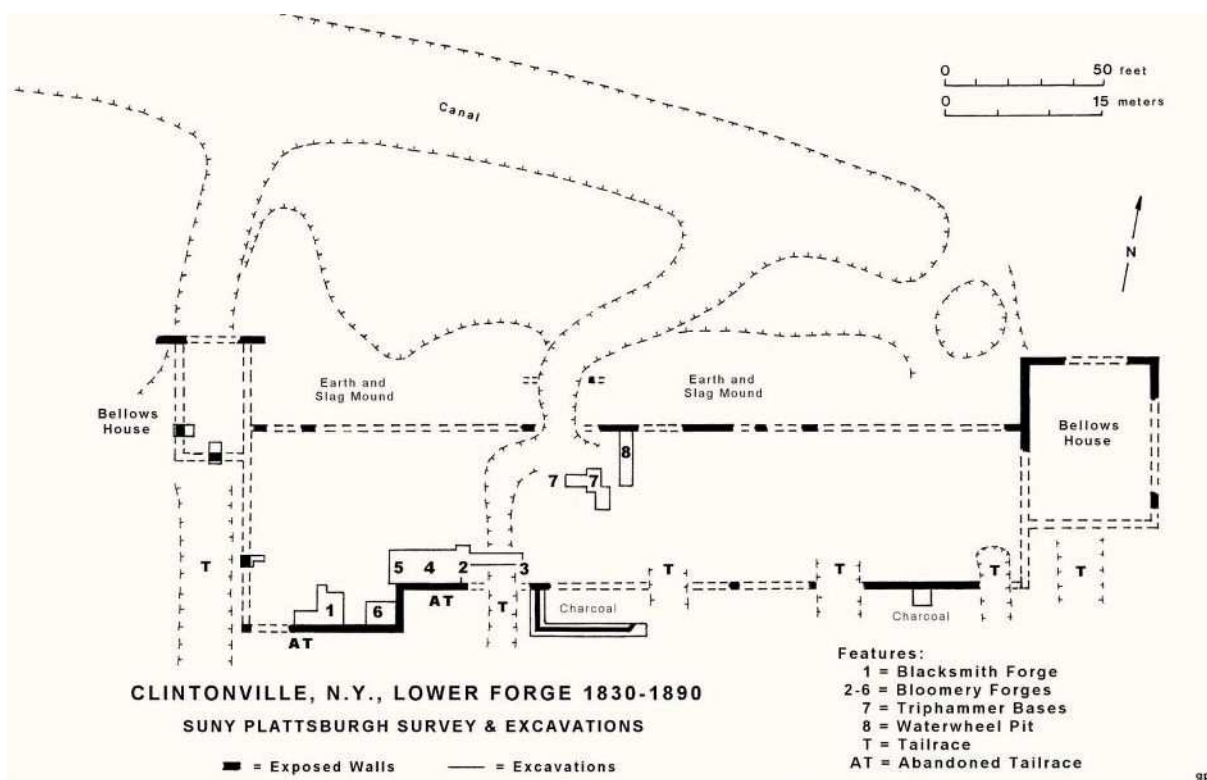


Figure 1.35. Plan of the Stone Forge based on archaeological surveys and excavations from Pollard and Klaus (2004, 31).



Figure 1.36. The stone forge site as it appeared in April of 1995, looking northwest. Arrows point to shallow surface depressions where covered tailraces were originally constructed. Photo by Gordon Pollard.

operations. These piles periodically would have been picked up and discarded elsewhere, and a wagon and crew seen just behind the charcoal cart seem to be doing just that. The photo also shows something that documents and the archaeological record did not reveal. The stacks of the 16 forge fires emerging through the iron roof are shown as round in shape, and constructed of what appear to be conjoined sections of sheet metal. Every other depiction (known to this researcher) of nineteenth century Adirondack forge stacks clearly shows them to be constructed of brickwork. The stack of the blacksmith forge at the far end of the building appears to be definitely made of brick.

Baldwin's third view of the forge (Figures 1.9 and 1.38) portrays the gentleman in charge of raking and sorting the charcoal at the main stockpile, which in 1875 was reported to be comprised of some 300,000 bushels (*Plattsburgh Republican*, Apr. 17, 1875). Behind the pile can be seen a corner of the west bellows house against the forge building. In front of the forge is a cart loaded with stacked charcoal baskets, to the right of which are two men (boys?) with a portable box that was used for measuring the charcoal. Such a box held ten bushels (*JUSACIW*, 1881, 259).

The photo of Figure 1.38 allows us to better visualize another kind of account that was written about the men who worked in the stone forge. Notice the large tree at the end of the forge. In the 1870s William Palmer and his son Daniel were hammersmen in the stone forge. William also had a much younger son, Grant, who spent his boyhood years in and about the works. In 1921 Grant wrote down his personal reminiscences of some of the sights and activities he had witnessed while living there. Here is an excerpt:

There used to be a large tree near the river bank near the east end of the forge and the

men at one time built a platform beneath the tree where they would hold forth on an afternoon and have sports of different kinds. I remember that at one time they had what they called a minstrel troupe and the songs that they sang and the jokes that they cracked on each other were surely amusing. They had a wash tub for a drum, some clappers or bones that were held between the fingers, some harmonics, Jews harps, tambourines and a motley assortment of other things that they used to make a noise with. Occasionally someone would go for his horn and would find it filled with black oil or something that sort. Pat O'Neil who used to play the drum would find it smeared with something, and of course it being wholly in fun there would be more or less horse play whenever these tricks would be found out. They would have games of pitching horseshoes, some hand ball practice, feats of strength, etc. Among the feats of strengths, Dan [Grant's older half brother] would generally take the lead and as a general thing he was the center of any jollity that was going on. I remember that one occasion the bloomers piled about 3000 pounds of iron on a wheelbarrow that they used for wheeling ore in, and wagered that there was not a man in the forge that could wheel it, but Dan promptly walked up to it and picked it up and wheeled it a few feet... He was as good natured as he was large and was a man that was liked by everyone who knew him. (Palmer 1921)

It was surely from the platform beneath that large tree that George Baldwin took the picture shown in Fig-

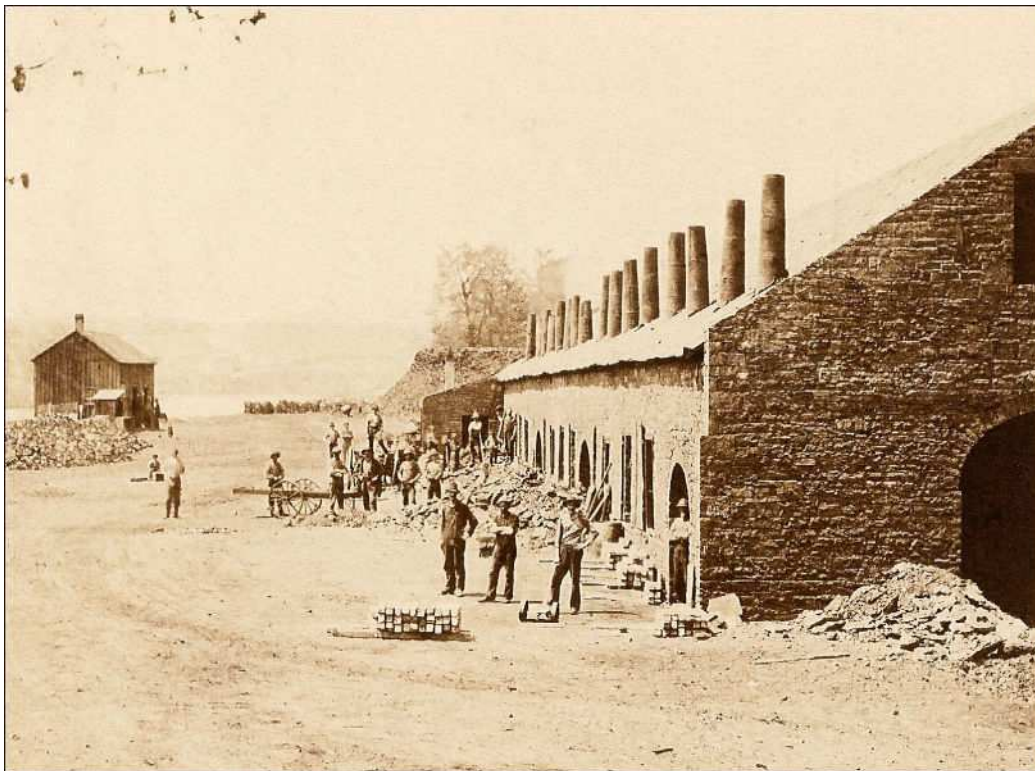


Figure 1.37. PS&I Co. stone forge with 16 bloomery forge fires, looking northwest. G.W. Baldwin stereoview 1876. Collection of Gordon Pollard.



Figure 1.38. Edge of the huge charcoal stockpile at the western end of the forge. The corner of the west bellows house of the forge is just visible behind the pile. G.W. Baldwin stereoview 1876. Collection of Gordon Pollard.

ures 1.8 and 1.38 (note the branch shadows on the ground in Figure 1.8).

Grant Palmer's reminiscences mention that people on their way from the cities to summer resorts in the Adirondacks would sometimes stop at the forge to see iron being made. As well, newspaper reporters would occasionally tour the region and write articles on the observations they made at various ironworks. In 1871 a reporter for the *New York Times* visited a number of sites in both the Saranac and Ausable River valleys, including Clintonville. He was clearly impressed by the "wild, savage picturesqueness" of the region, as well as the entire iron making process. His article appeared in the *New York Times* on December 7, 1871, and was reprinted in a local newspaper, the *Plattsburgh Sentinel*, a couple of weeks later. His exuberant reaction to witnessing operations in the Clintonville forge is apparent in the following excerpt, which provides an image of forge activity that the iron makers themselves may have found amusing:

The loupes are drawn from the fire every two hours and twenty minutes, and the scene at night time would thrill with rapture the soul of a Rembrandt. The deep shades of night around the waterwheels are suddenly broken, when the glowing loupes are placed upon the anvils, by rays of dazzling light and bewildering showers of bright sparks, that are reflected upon the water, falling in showers from the blades of the wheels and making the drops glisten like diamonds. The activity becomes contagious, and the spectator who sees everything in motion and turmoil around him, men drawing iron from the furnaces, hammerers dealing tremendous blows upon the red-hot masses, firemen working away at the fires that roar back in sympathy, coalmen rushing down the decline with their iron trucks loaded with baskets of charcoal, wheels revolving, water flashing, sparks flying, half-forged billets being wheeled away to the fires, completed ones being added to the piles in a corner, feels an almost irresistible impulse to take off his coat, roll up his sleeves, and rush at something, to be in unison with the surroundings. (*Plattsburgh Sentinel*, Dec. 22, 1871)

The first bloomery forge to match the single-building scale of Clintonville was the Chateaugay Ore & Iron Co. (CO&I Co.) operation at Bellmont, in Franklin County (Figure 1.1). Initially called Popeville (Figure 1.39, aka "the Forge", or "Lower Chateaugay Lake"), and situated on the Chateaugay River at the northern outlet of Lower Chateaugay Lake, the community formed by

Pope, Williams and Co. began operating a forge of six fires at this remote spot in January of 1875, increasing the number of fires to ten in 1877. The company worked ore of the Chateaugay Iron Ore Co., brought eleven miles by wagon and lake barge from Lyon Mountain to the south (Figure 1.1), where it had been mined, crushed and separated (*Plattsburgh Sentinel*, Aug. 19, 1881).

Smelting operations expanded further, but unlike Clintonville, no rolling mill or manufacturing ever developed at the site. In 1881 the forge became part of a conglomerate incorporated as the CO&I Co., which included three forge sites in the Saranac River valley and a blast furnace in Plattsburgh, along with 99 charcoal kilns, the Chateaugay Railroad Co., the Chateaugay Iron Ore Co., and over 80,000 acres of forest in Clinton and Franklin counties (*JUSACIW*, 1881, 255-360). To this was added a charcoal cold-blast furnace at Standish, near Lyon Mountain, which was blown in on February 8, 1887 (site 6 on Figure 1.1).

The Bellmont forge was virtually closed down in 1890 (*Plattsburgh Republican*, July 19, 1890), and historical sources are not unanimous on the number of bloomery fires it contained at the height of its operation. One local newspaper account of the day says there were 16 in 1883 (*Plattsburgh Republican*, May 5, 1883), while others later say there were 18 running that year (*Plattsburgh Daily Press*, Mar. 12, 1898; *Plattsburgh Sentinel*, Feb. 16, 1900). Joseph Linney, a company executive who wrote the history of the CO&I Co. long after the end of bloom iron production, claims there were 20 in 1883 (Linney 1934, 31,45)! Still another account, written the last year that any of the forge fires were still being used, says that "only 3 out of 16 fires" were still burning in 1893, and that the former work force of 200 had dwindled to 30 (*Malone Paladium*, June 8, 1893). While the final figure is still unresolved, it seems certain there were 16 forges there by 1879 (*Plattsburgh Sentinel*, Aug. 19, 1881). Photographic evidence for the forge can now be considered.

Several informative photos of the Bellmont forge were taken in 1884 by a photographer that has not been substantiated. Figure 1.40 is a dramatic view of the western side of the long, wooden forge building. A flume runs the length of the structure, coming from a dam and crossing at the end of Lower Chateaugay Lake, atop which the photo was taken. The flume fed waterwheels that drove three trip hammers positioned just inside the west wall, as well as turbine-driven sets of bellows at each end of the forge. In 1881 the forge was 270 feet long by 50 feet wide (*JUSACIW*, 1881, 357), 34 feet longer than the one constructed in 1836 at Clintonville. Three large air vents are seen on the flat roof, possibly centered over the trip hammers and their waterwheels. Also visible are the tops of many of the stacks of the bloomery forges which were along the eastern wall of the forge (the total number cannot be determined from this view). At the

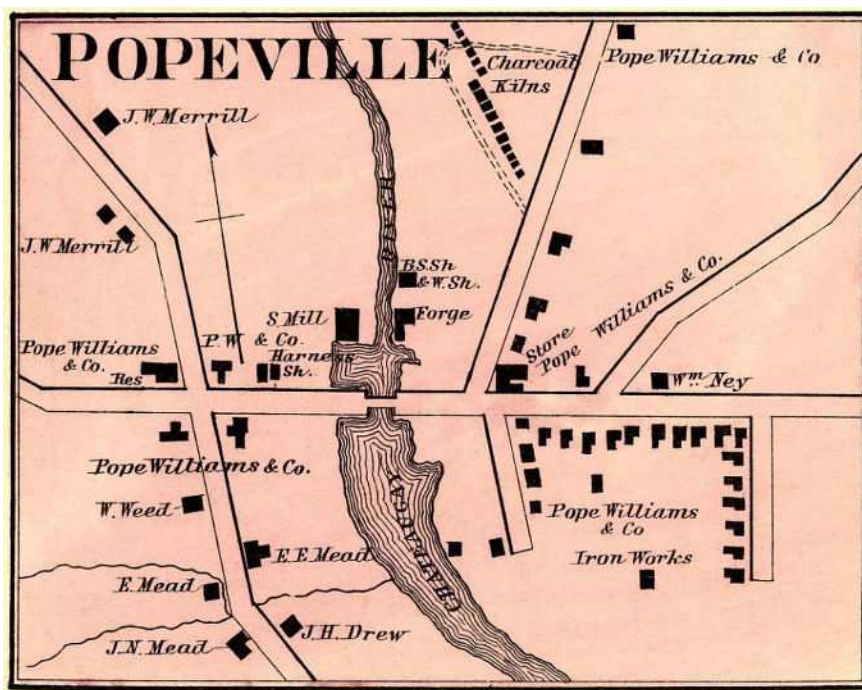


Figure 1.39. 1876 map of Popeville, later known as Bellmont. The forge is located at the center of the map (D. G. Beers & Co., *Atlas of Franklin County, New York*).

far left of the picture, three of the fourteen charcoal kilns that were at the site are visible.

The eastern side of the Bellmont forge is seen in the undated photo of Figure 1.41. The print is a modern reshoot of a photo for which there also is no record of the original photographer. A group of likely bloomers, hammersmen, and other workers are posed for the picture. A sheet metal duct for the air blast for the forges is entering the end of the building, and a total of 16 brickwork forge chimneys are seen coming through the roof. If this photo was also taken in 1884, it would refute the more-than-sixteen-fires claims that were mentioned above. Window openings on this side of the structure are more limited, and some piles of slag discarded against the outer wall seem to be evidenced, as we saw at Clintonville's forge. Barrels are seen on the roof of the structure, probably for collecting rainwater to be used in the event of a fire.

Photos of the interior of the Bellmont forge are rare, revealing examples of bloomery forges and trip hammers in operation. Several of the forges are shown in Figure 1.42, with a pile of separated ore seen between two of them. Each forge is constructed of brick, with tie rods and iron bracing on the stacks. The open hearth fireboxes are in full charge, charcoal spilling onto the fore plate. Two of the forges have long handled tongs clamped onto blooms that are being reheated in the fire, and a stack of baskets with charcoal is seen in the foreground at the right.

The stack area above the firebox contained arched iron pipes for preheating the air blast, as became standard in American bloomeries by the 1840s. Each forge has a trunk line, one of which is seen coming down to the third

forge from the left in Figure 1.42, from a larger blast duct that runs horizontally along the wall behind the forge stacks (the duct is not visible in this photo, but see Figure 1.44). After being heated in the stack, the blast enters the firebox through the looped pipe seen on the left side of the second forge from the left. Preheating the blast provided substantial savings in the amount of charcoal fuel needed to carry out the ore smelting process (Gordon 1996, 95; Pollard and Klaus 2004, 27).

The forges at Bellmont had three arched heating pipes in the stack (JUSACIW, 1881, 358). Other forge sites are known to have had as many as five, including the works at Clintonville (*Elizabethtown Post*, Nov. 14, 1901). The general configuration of the components of these types of forges is shown in the drawing of Figure 1.43, which is adapted from Egleston (1880a, plate 4). Egleston's work provides an excellent description of the entire smelting process, and illustrates several different styles of forge fires from specific sites.

The three hammers that worked the blooms from the forge at Bellmont were made of cast iron, and were atypically heavy. One weighed 7 ½ tons, and the other two 10 tons each. The one that was photographed, shown in Figure 1.44, was powered by a 20 feet diameter, undershot waterwheel, the cast iron shaft of which secured a four-armed iron cam to raise and drop the hammer head (JUSACIW, 1881, 358). The hammersman is shown working a bloom of iron that appears to be in an early stage of shaping half of it into a billet. The bloom is gripped by half-bloom tongs that are supported by a chain on a wheel that is attached to an overhead crane. Assisted by the man seen behind the hammersman, the bloom with its attached tongs could be swung to the



Figure 1.40. Bloomery forge at Belmont, 1884, showing the west side of the structure. Photographer unknown. Courtesy of the Adirondack Museum, Blue Mountain Lake, New York.

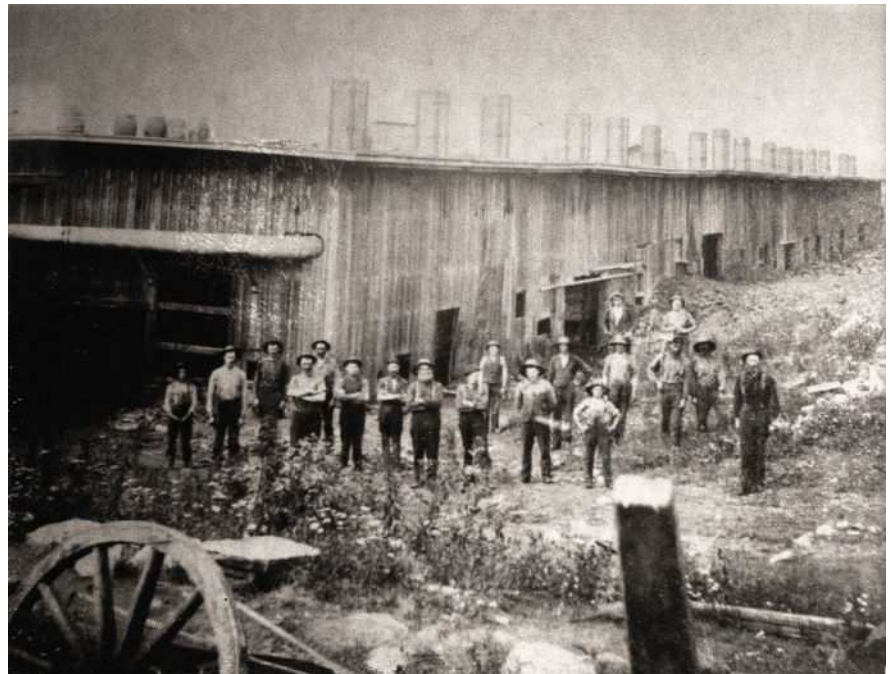


Figure 1.41. Eastern side of the Belmont forge, probably 1880s. Sixteen forge fire chimneys are visible. Photographer unknown. Courtesy of Special Collections, Feinberg Library, SUNY College at Plattsburgh.

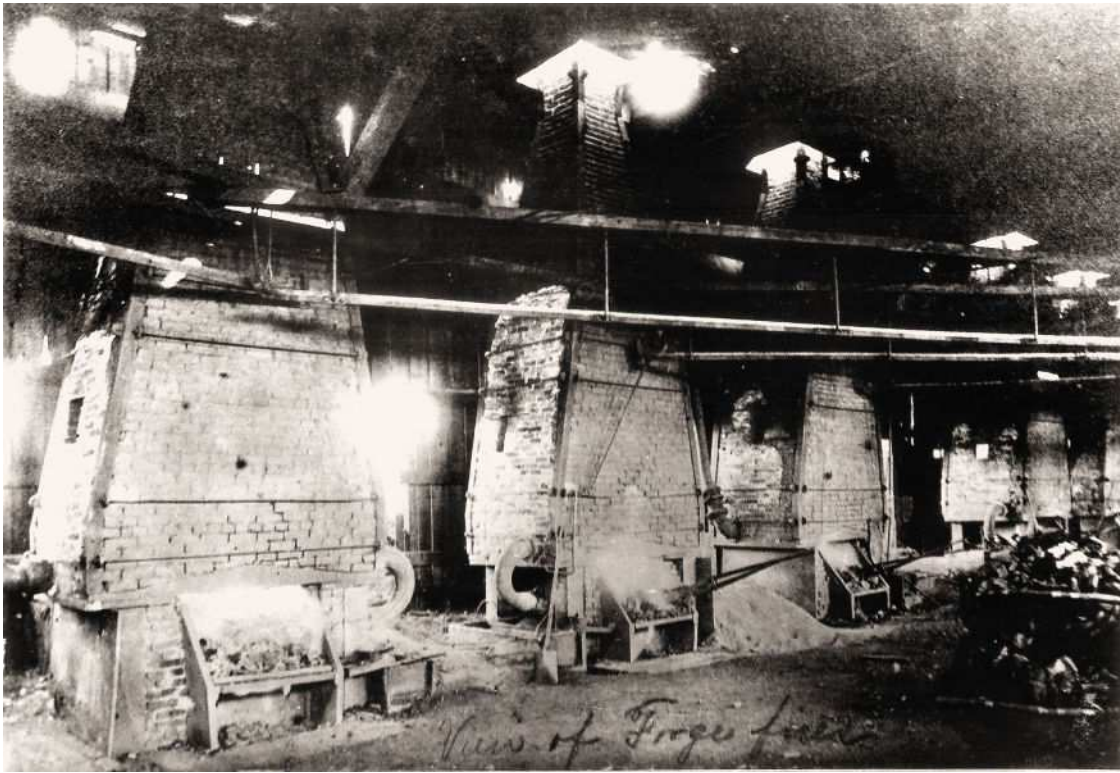


Figure 1.42. Some of the 16 bloomery forges at Bellmont, 1884. Photographer unknown. Courtesy of the Adirondack Museum, Blue Mountain Lake, N.Y.

forge behind them for reheating.

A detailed description of the hammering process is given by Egleston, based on his observation of a similar operation at the J. & J. Rogers forge at Ausable Forks ([JUSACIW](#), 1881; excerpted from Egleston [1880a](#)). That account includes measured drawings of an iron hammer at Saranac that was a close approximation of the one photographed at Bellmont. Another photo of the scene in [Figure 1.44](#), looking toward the waterwheel from behind the hammersman, is found in Pollard and Klaus ([2004](#), 32).

The photo of [Figure 1.44](#) was taken near one end of the long forge, and gives a clear view of the round air duct coming across the end wall from the bellows house, which then turns and runs behind the upper portion of the forges and provides their individual air blast. The blowing apparatus at each end of the forge involved a somewhat unique arrangement of three horizontal blast cylinders whose piston rods were connected to a crank head on the vertical shaft of a turbine. The cylinders were arranged 120° apart. Those at one end were 46 inches in diameter, had a stroke of 5 feet 6 inches, and were driven by a 44 inch turbine under a 24 feet fall. The bellows cylinders at the other end of the forge were 40 inches in diameter, had a four feet stroke, and were worked by a 48 inch turbine with a 19 feet head and fall ([JUSACIW](#), 1881, 358).

Some of the tools used in working the iron are shown

lying on and about the floor in [Figure 1.44](#). Another picture by the same photographer [[6](#)] shows a rack of such implements in the Bellmont forge ([Figure 1.45](#)). These include furgens, hooks, grampuses, bloom and billet tongs, axes and hacks. Egleston ([1880a](#), plate 5) gives measured drawings of many of these kinds of tools. Also shown in the photo is a loup or bloom cart on the right, and two charcoal baskets on the left. A number of finished iron billets are on the floor beyond the charcoal baskets, and the long row of bloomery forge fires extends down the right side of the structure. Two seated men and a stack of loaded charcoal baskets are discernable immediately behind the tool rack.

Many of the tools employed in the smelting and hammering processes are summarized here in the approximate order of their implementation, compiled from Egleston's ([1880a](#), 527-540 and plate 5) descriptive accounts:

Ore shovel four feet long. Anywhere from 15-35 shovels of ore, and 20-25 baskets of charcoal (40-50 bushels) were charged into a forge over a three hour period to produce a loupe or bloom of iron weighing 300-400 lbs.

Furgen or tempering bar a knob-handled iron rod about 5 feet long, one inch in diameter, slightly rounded end. Used as a probe to determine the

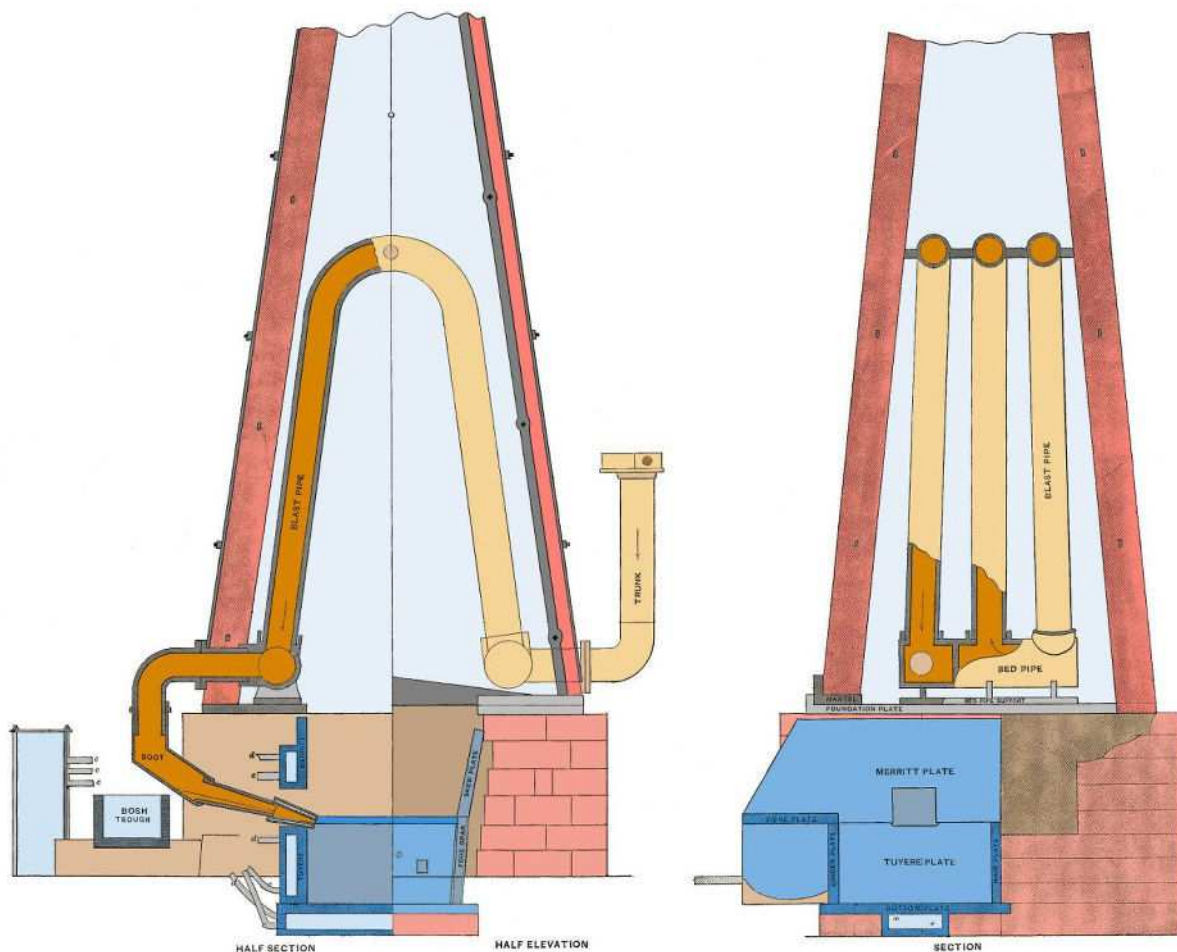


Figure 1.43. Components of a typical American bloomery forge, with three pre-heating blast pipes in the stack, and a firebox with some iron plates that are water cooled, used at Saranac, N.Y. Adapted from Egleston (1880a, plate 4). Color has been added for greater definition.

shape and position of the loupe in the forge fire box, and to test the temperature based on the size and extent of the slag "button" that sticks to the end of the rod.

Cinder bar 5 feet long iron bar, half an inch square, pointed end. Used as a pry bar, inserted through holes in the front cinder plate of the fire box to tap slag. Used in conjunction with a tapping bar that is half an inch in diameter.

Axe single or double edged. Used to cut into the rim of the iron loupe after it has been lifted out of the forge, taken to the front of the trip hammer, and turned face up using 6 feet long *foss hooks*. The axe cuts make a place for the *loupe grampuses* to grip the mass of iron.

Loupe grampuses 6 feet long. Used to grip the loupe of iron and help roll it up onto the anvil under the shingling die of the trip hammer, and hold the bloom until it has been shaped to about 7 to 10 inches

square, at which time the grampuses are replaced by *bloom tongs*.

Bloom tongs 5½ to 6 feet long with 7 inch jaws, one of which has a scoop configuration. The hammerman strides these tongs while turning and positioning the bloom under the hammer. Slightly smaller *billet tongs* are used to grip the 4 to 5 inch square billet section once it is shaped. The bloom tongs are removed and the bloom is then taken back to the forge for re-heating, and subsequently returned to the hammer for drawing out the other end of the bloom.

Hack about 4 ½ feet long, single edged. Used to lop off a 3 inch "fag end" and 5 inch "crop end," as well as the finished billets which generally are about 17 inches long and weigh 70-80 pounds each. The hack is driven half way through the hot iron under the hammer, then turned and cut off on the opposite side.

Branding iron if used, a company logo is embossed onto the middle of each billet while hot, striking the

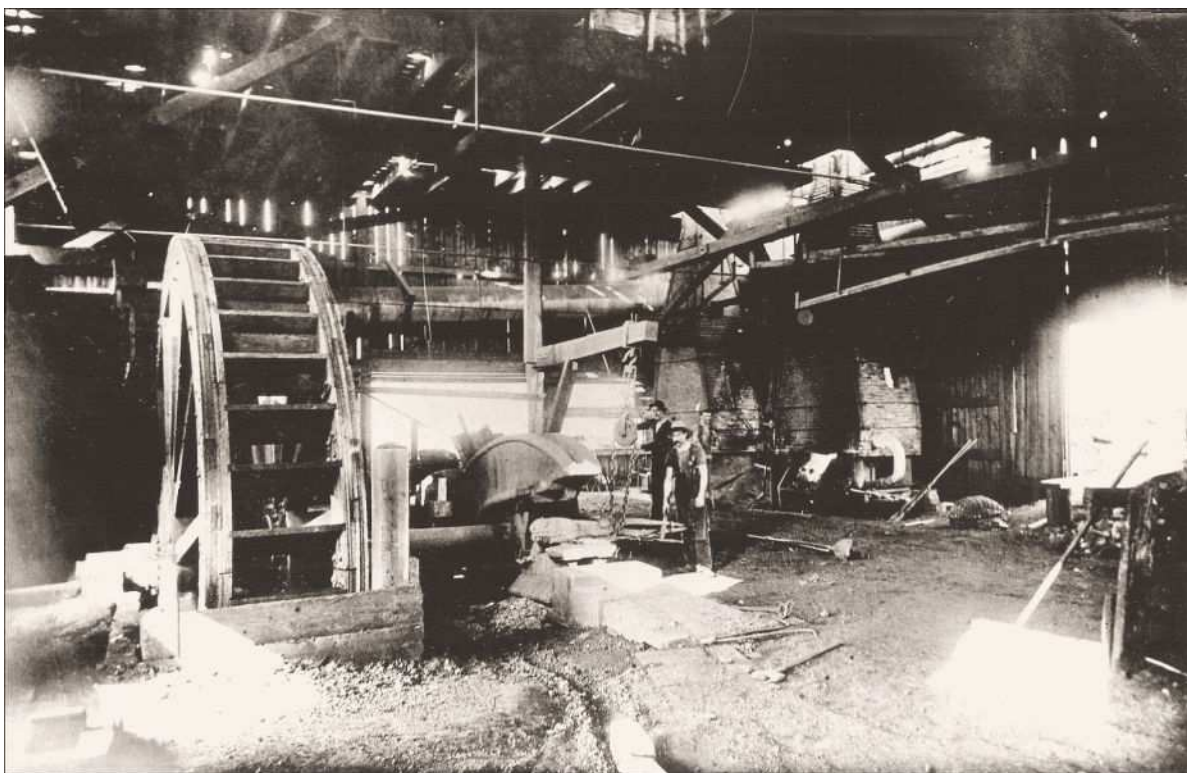


Figure 1.44. One of the trip hammers and its waterwheel in operation at the Bellmont forge, 1884. Photographer unknown. Collection of Henry G. Rogers, © Elsa Voelcker by permission.



Figure 1.45. Tools used in working iron in the Bellmont forge, 1884. Photographer unknown. Courtesy of the Adirondack Museum, Blue Mountain Lake, N.Y.

branding iron with a hammer.

Billet grampuses used to place the finished billets on a billet cart and taken outside the works.

The Peru Steel & Iron Co. at Clintonville, discussed earlier, had maintained its uniquely large scale of operation until 1870, at which time the J. & J. Rogers Co. based at Ausable Forks (Figure 1.1) had amassed a total of 22 bloomery fires in four forges at three separate locations (Ausable Forks, Jay, and two forges at Black Brook). The greatest number of forge fires in any one structure was eight, but the overall business now surpassed that of the Peru Steel & Iron Co., and included a rolling mill and nail factory at Ausable Forks. The company's four-fire forge at that location was photographed by Baldwin in 1876, the same year that he did the stereoviews of Clintonville's iron works.

The image from a stereoview of the Ausable Forks forge is shown in Figure 1.46, giving further evidence of individuality in the appearance of Adirondack iron making establishments. The brick stacks of the bloomery fires are seen rising from the slightly inclined roof of the forge, and what appears to be a pile of slag waste lies behind two men on the right, close to the structure. Open piles of charcoal are in the foreground, at which two pairs of men are carrying 10-bushel charcoal boxes like the one noticed earlier at Clintonville (Figure 1.38). The edge of a stack of finished iron billets is seen at the right.

No photographs have come to light of the interior of the Ausable Forks building, but written accounts indicate the forges utilized three air heating pipes in their stacks, as at Bellmont. The blast apparatus also appears to have been very similar to the arrangement at Bellmont. Writing around 1879, historian Duane Hurd described the setup as involving three horizontal cylinders 32 inches in diameter, with a 45 inch stroke, run by a turbine wheel, and "...ingeniously arranged so as to furnish a uniform pressure" (Hurd 1880, 255). These briefly had been mentioned 10 years earlier by another historian, Winslow Watson (1869, 442).

Thomas Egleston, to whom reference has been given several times, made extensive personal observations at this forge. His 1880 description demonstrates that the bellows had been upgraded to three cylinders that were 60 inches in diameter, with a 60 inch stroke, driven by a 56 inch turbine. The arrangement was capable of providing adequate blast for eight fires (Egleston 1880a, 522), but the Ausable Forks forge never utilized more than four. The single trip hammer in the forge was of cast iron and weighed five tons, powered by an undershot water-wheel 18 feet in diameter. In his brief treatise, Egleston (1880a) provides a detailed, scale drawing of the hammer (Egleston 1880a, plate 7), as well as a minute-by-minute description of every action taken by a bloomer

in the three hour process of making a loup (bloom) of iron in one of the forge fires (Egleston 1880a, 544-546).

As one last example, Figure 1.47 depicts what to this researcher is one of the finest photographs ever taken of the interior of a nineteenth century Adirondack bloomery forge, simply because it is given scale by including many of the bloomers and hammersmen who produced iron there. Unfortunately, the name of the photographer is unknown. The 1888 image is of the J. & J. Rogers Co. forge at Jay, six miles southwest of Ausable Forks (Figure 1.1). All six of the forge fires at this site are shown. The original forge structure here had burned down in January of 1873 (*Plattsburgh Sentinel*, Jan. 17, 1873), but was rebuilt and made operational again by the end of the following month. A woodcut illustration of the forge exterior is seen in Figure 1.48.

The Jay forge configuration is much like what we saw at Bellmont, with separated ore piled next to the forges, and a blast pipe along the wall behind the forge stacks. Prior to the 1873 fire, blast was provided by four horizontal blowing cylinders (Watson 1869, 441). Charcoal baskets, both loaded and empty, are seen about the floor, and benches for the workmen are provided, facing each pair of forges. Ira Daniels, the man reclining on several of the baskets, seems to have invented his own version of the *chaise lounge*.

The one trip hammer in the forge is not visible, and likely was centered near the wall opposite the forge fires, just out of sight in Figure 1.47. As at Ausable Forks, the hammer was of cast iron and weighed five tons (Watson 1869, 441). The wrought iron produced in all of the Rogers' forge sites was highly regarded, and received a medal for the excellent quality of the iron they exhibited at the 1876 Centennial Exhibition in Philadelphia (Hurd 1880, 256). Economic depression fell hard on nearly every Adirondack bloomery site by the 1890s, however, and a strike by the employees at the Jay forge in August of 1890 (*Plattsburgh Sentinel*, Aug. 22, 1890) led to its total closure within a few months. At Ausable Forks, the Rogers' operations were curtailed in 1892 by a fire that partially consumed the forge there, followed by a complete shutdown and dismantling of their ironworks the following year.

These descriptions and depictions of Adirondack bloomery forges portray considerable variation in the scale and structural configuration of the facilities in which iron making occurred. Features like building materials, roof styles, and placement of windows, doorways and vents could and did vary with the preferences and financial resources of individual forge owners. The large forge at Clintonville, as we have seen, was particularly unique, having been well constructed of stone and configured with arched doorways and a window adjacent to each forge fire.



Figure 1.46. The J.&J. Rogers four fire forge at Ausable Forks. Charcoal piles are in the foreground. G.W. Baldwin stereoview 1876. Courtesy of Guenther Bauer.

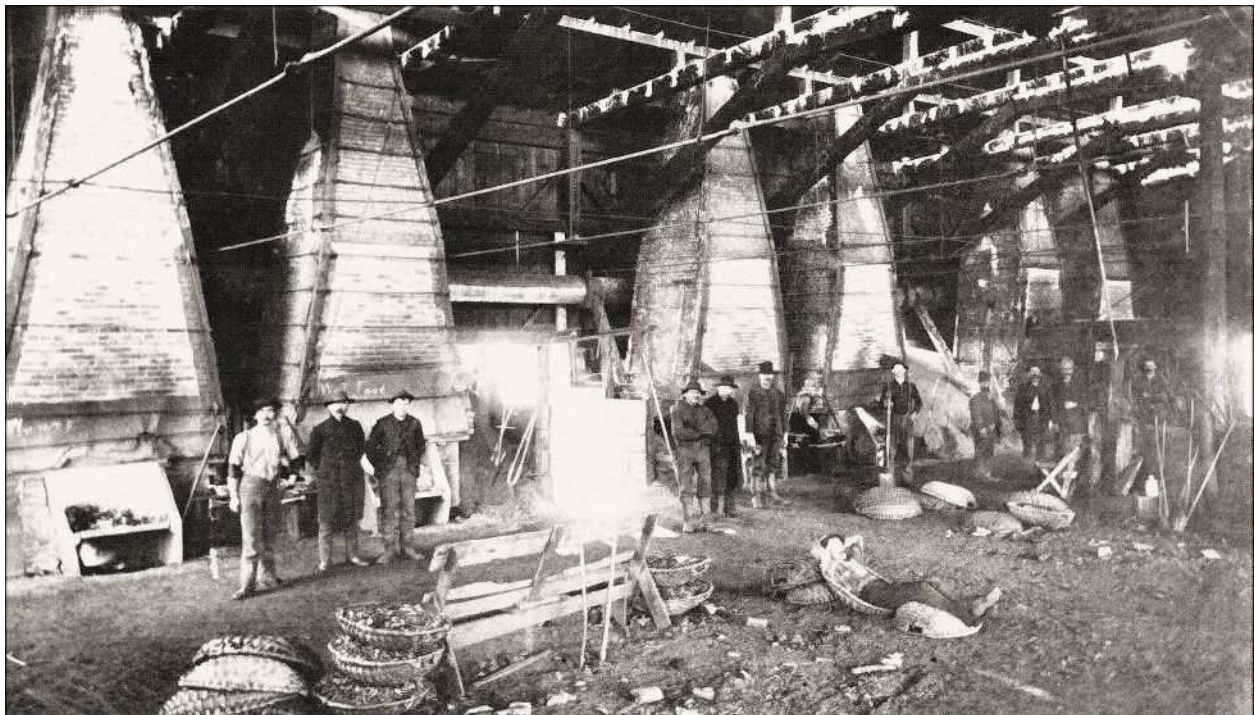


Figure 1.47. Interior of the six-fire J. & J. Rogers forge at Jay, N.Y., 1888. Photographer unknown. Collection of Henry G. Rogers, Elsa Voelcker® by permission.

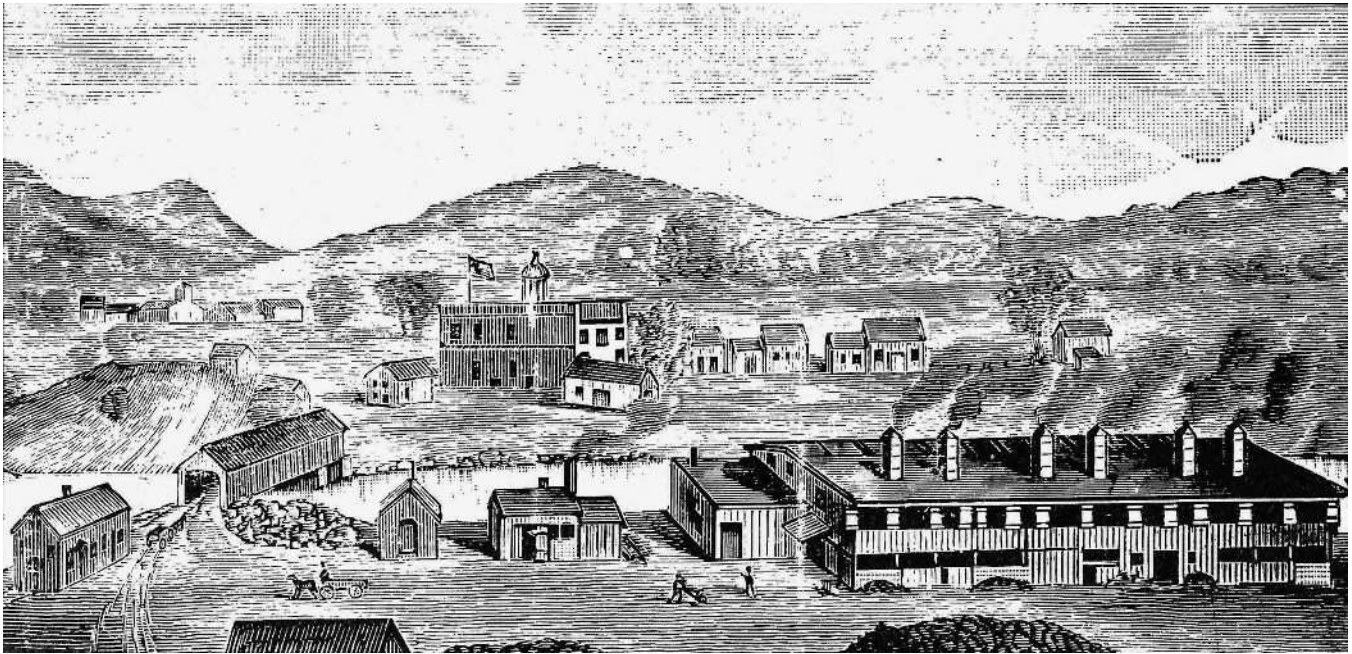


Figure 1.48. The six fire bloomery forge of the J.&J. Rogers Co. at Jay, New York. The two story brick company store and office is seen at the center. From *Adirondack Record*, Apr. 10, 1914.

The interior layout of forge buildings, however, followed a fairly common pattern based on operational efficiency, with the bloomery forges lined against an outer wall, along which ran the air blast pipe with its feeder to each fire. An open bin of separated ore typically was positioned next to each pair or set of forges, and the heavy trip hammer for working the blooms was then positioned with its long axis parallel to the face of the forges. For the operations at Bellmont, where there were 16 forge fires and only three hammers, a design feature not observed for other forges is partially seen in Figures 1.42 and 1.45. Here an overhead railway from each forge ran to one of the hammers, and could be used to help convey lumps to be worked or reheated (JUSACIW, 1881, 358).

At a more technical level, the set of elements and procedures that were utilized in making bloom iron in New York and northern New Jersey constitute what metallurgists such as Hunt (1870, 274-279) and Eggleston (1880a, 515) designated as the American bloomery process. Even though bloomeries were commonly referred to as Catalan forges locally, the method of working them clearly seems to have derived from an early German forge process that was distinct from the forges of Catalonia, Spain. American forges reflected the German pattern of using smaller hearths, and ore that was finely crushed and uniformly thrown onto the fire at intervals. With gradual improvements in ore preparation, hearth design, and the introduction of hot blast, the American bloomery process developed into a highly efficient method of producing wrought iron, as more recent met-

allurgists have shown (Gordon and Killick 1992). The forge sites we have seen here were integral to, and a direct reflection of, that development.

Charcoal Kilns

In the latter part of the nineteenth century charcoal kilns associated with bloomery forges and blast furnace operations in the Adirondacks were fairly common subjects of photography. Charcoal was a critical component of bloom iron production. Unlike mineral coal which contained sulfur that would contaminate the iron, charcoal was the best fuel to carry out the smelting process in the forges (Gordon 1996, 33). It was produced locally on a massive scale throughout the nineteenth century, and the vast forests of the Adirondacks were seen as an unlimited resource for this purpose, as well as contributing to the region's huge logging and lumber industry (Welsh 1995).

In 1879 it was estimated that in the northeastern division of the Adirondacks 30,000 tons of iron were being made annually, requiring nine million bushels of charcoal to make, which required 180,000 cords of wood. At 30 cords to an acre, this entailed stripping the timber from 6000 acres of land each year (Chahoon 1880, 427).

While charcoal could be made in meiler pits under a covering of leaves, straw, sawdust, charcoal dust, and dirt or sod (Svedelius 1875, 44-51), kiln-made charcoal was preferred by bloom iron makers. While initially more expensive to construct, kilns required less labor to operate, produced cleaner charcoal, allowed greater

burn control, and could produce 45 to 50 bushels of charcoal per cord of wood, which was a 15-20% higher yield than in meilers (Egleston 1880b, 374-375). Hard wood charcoal was favored for blast furnace use because it burned hotter and could support greater ore weight in the stack, but opinions varied as to the best choice in bloomeries. Egleston (1880b, 377) claims soft wood charcoal was preferred, while Neilson (1867, 265) suggested the *best* mixture was $\frac{1}{3}$ soft and $\frac{2}{3}$ hard wood charcoal for the direct process of making iron in forges, even though a 50/50 mix was commonly used. Hemlock, spruce, and tamarack were the primary soft woods, and maple, birch, and beech the hard. Timber to be used for making charcoal was cut in the winter (between the fall and rise of the sap), stockpiled and seasoned at kiln sites, and burned in kilns throughout the year.

Large forge operations such as the Peru Steel & Iron Co. at Clintonville had charcoal kilns scattered about in the forest lands they owned. In 1881 the ironworks owned over 21,000 acres as plotted in Figure 1.49, which is based on lists of lots in company records. On these lands the company had 15 charcoal making locations within 12 miles of Clintonville, and a total of 35 kilns. In 1884, these included 17 rectangular kilns and 18 beehive-shaped kilns. Kilns could also be made in a round shape with vertical walls and an arched roof, and with regular maintenance any of these shapes would last for many years. The PS&I company's average annual production of charcoal from 1867 to 1882 was 760,000 bushels, with a high of one million bushels in 1867, and a low of 300,000 bushels in 1878 when iron production was down (IWR, 64.3 3/3).

Figure 1.50 shows what are believed to be six rectangular kilns of the Peru Steel & Iron Co. at its "Upper South" location in Essex County, as recorded in a stereoview by G.W. Baldwin about 1876. Huge stacks of roughly four feet long timber are seen in front of and behind the kilns, having been split to a fairly uniform size. Large kilns such as these could hold 75 to 90 cords of wood, and round or beehive kilns would normally hold 35 to 50 cords. A small beehive kiln located at the forge in Clintonville held only 15 cords (IWR, 65.5 9/3, p. 234). Each rectangular kiln could take three days to fill, six days to burn, and six days to cool and discharge (Egleston 1880b, 385), and thus could see up to 20 "turns" per year. In 1883 the company produced and delivered just less than 902,000 bushels of charcoal to its forge, enough to keep 14 bloomery fires going for a year. Two wagons loaded with charcoal are seen in the photo of Figure 1.50, and each held about 250 bushels (JUSACIW, 1881, 369). At a more personal level, the man atop the near kiln is aiming a stick like a rifle. Little could he have guessed that he would be seen here, playing it up for the camera, more than 130 years later.

Kilns were almost always constructed of brick, and

a large rectangular kiln would require about 60,000 of them. By the 1870s, kilns were routinely painted on the outside with a clay wash and covered with a coating of coal tar to make them waterproof (Egleston 1880b, 377). Rectangular and circular kilns also required rigid bracing to help counteract expansion and contraction during use, and to help minimize cracking. Heavy vertical and horizontal beams tightly surround each of the kilns in Figure 1.50, and catwalks around their perimeter are splattered with the residue of reapplications of clay wash to the kiln exterior.

Prime examples of round charcoal kilns are found in the following two photographs of a single site, taken by different photographers at different times. The image of Figure 1.51 was captured by G.W. Baldwin in the late 1880s. The kilns were located near Twin Ponds (Figure 1.1) on the Chateaugay railroad, about five miles southwest of the Chateaugay ore bed at Lyon Mountain. The rail line with a spur to this location had been built in 1886 (Kudish 1996, 206,222), and the Baldwin photo likely dates soon after that year. These and other sets of kilns had been erected to serve the needs of the Chateaugay Ore & Iron Co.'s bloomery forge and charcoal blast furnace at Standish (site 6 on Figure 1.1), just two miles northeast of Twin Ponds. As noted at the beginning of this study, the Standish forge was the last bloomery in the country to finally shut down, early in the twentieth century. The forge had grown to house 18 fires, but only 8 were still operating in 1901 (*Plattsburgh Sentinel*, Aug. 23, 1901; for a photo of the forge, see Pollard and Klaus 2004, 30).

The number of charcoal kilns in the Twin Ponds photo is difficult to count, but with magnification can be seen to total ten. Building the kilns next to a hillside facilitated loading them with wood, with ramps and a platform extending from the edge of the hill to a door on the back portion of each kiln's dome. A ground-level, cast iron doorway for discharging the charcoal is on the front. Vast piles of wood are seen on the slope behind the kilns, as well as on the flats fronting them. As was common practice, the forest has been nearly clear-cut within the area closest to the kilns.

Figure 1.52, only recently recognized by this researcher as being the same set of kilns seen in the previous figure, gives a very different perspective on the site. It was photographed by Seneca Ray Stoddard, probably also in the late 1880s, and was labeled by him simply as "Charcoal kilns on the Chateaugay Railroad." Here the ramp and loading platform configuration is more easily visualized, as is the total number of kilns. Several sheds and log houses for the colliers are included in the scene, and the background shows many softwood trees still standing nearby.

Round kilns like those in Figure 1.52 normally were about 28 feet in diameter, held 50 cords of wood, and re-

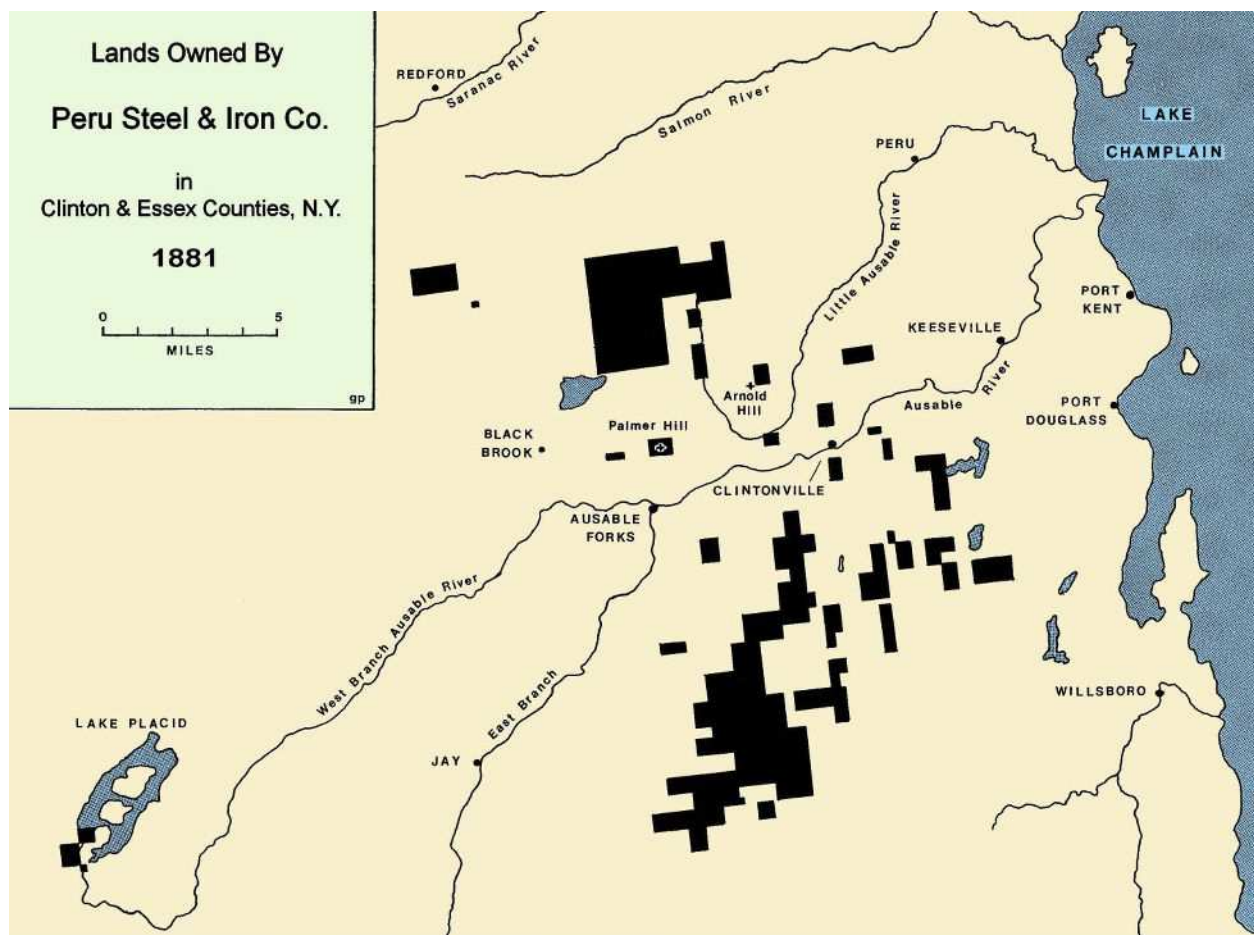


Figure 1.49. The more than 21,000 acres of timber lands owned by the Peru Steel & Iron Co., 1881. Map by Gordon Pollard based on company records.



Figure 1.50. Six rectangular charcoal kilns, c.1876, believed to be Peru Steel & Iron Co's "Upper South" location in Essex County. G.W. Baldwin stereoview from the Robert H. Dennis Collection of Stereoscopic Views, Miriam and Ira D. Wallach Division of Art, Prints, and Photographs, New York Public Library, Lenox and Tilden Foundations, by permission.



Figure 1.51. A group of ten round charcoal kilns near Twin Ponds, New York, southwest of Lyon Mountain, late 1880s. Photo by G.W. Baldwin. Courtesy of Clinton County Historical Museum, Plattsburgh, New York.



Figure 1.52. A group of "Charcoal Kilns on the Chateaugay Railroad." Photo no. 69 by S. R. Stoddard, late 1880s. Courtesy of Clinton County Historical Museum, Plattsburgh, New York.

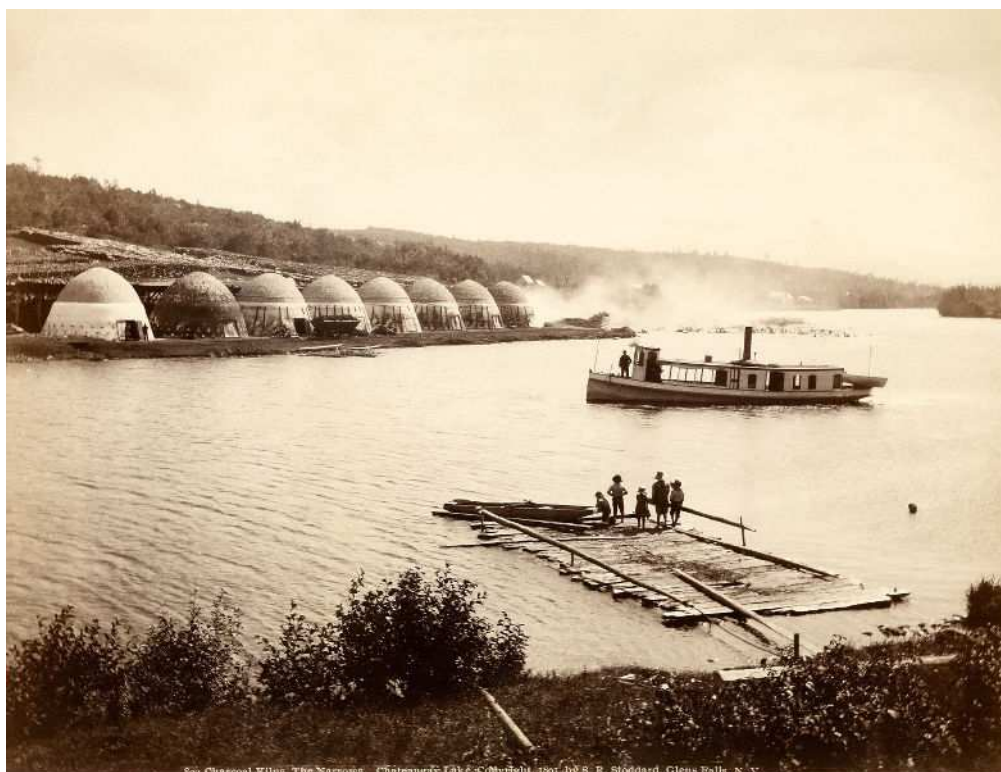


Figure 1.53. Charcoal kilns and the steamboat "Adirondack" on "The Narrows, Chateaugay Lake." Photo no. 899, copyright 1891 by Seneca Ray Stoddard. Courtesy of Special Collections, Feinberg Library, SUNY College at Plattsburgh.

quired about 31,000 bricks to construct (Egleston 1880b, 386). Each kiln is firmly braced with vertical wooden posts around its exterior, and encircled with wrought iron straps. Some of the luted vent holes around the lower perimeter are visible in the photograph. These allowed the collier to maintain control of the burn, and such kilns usually had three rows of them, often called "foot," "knee," and "shoulder" vents. In better kilns the vent openings were provided with cast iron frames, and numbered around 175. Together, the vent frames and the straps comprised about 3000 pounds of iron per kiln (Egleston 1880b, 389).

Smoke is seen coming from several of the kilns in Figure 1.52, and served as a major signal to the charcoal maker as to the progress of the burn. For the first four days thick white smoke is emitted from the upper vents as water is driven out of the wood in the form of steam (the lower rows of vents are closed soon after lighting is completed). This is followed by yellow smoke for one to four days, varying with the size of the kiln and weather. Then comes blue smoke which is a sign that the kiln is very hot and the burn nearly completed. All vents are closed off within 12 hours of the start of blue smoke emission, to bring the burn to an end (Egleston 1880b, 388).

The buildup of steam and gases within a kiln could sometimes lead to an explosion that could seriously damage the structure. The superintendent of the Peru

Steel & Iron Company at Clintonville reported two such incidents in connection with their operations, one in 1883 and this account from 1876:

One of the Poke O Moonshine kilns was exploded by gas a few days since. These explosions always seem to occur a few hours after the kilns are fired, probably caused by the condition of the wood. My own impression is that the other two kilns will work up all the wood we have or can get there, and that it will not pay to reconstruct this kiln. (letter from D. Cady to F.J. Dominick, 14 July 1876, *IWR*, 65.5 9/2)

One final example of charcoal kilns is presented in Figure 1.53, which beautifully illustrates the beehive shape that was also commonly used in many areas of the Adirondack-Lake Champlain region. This is another Stoddard photograph, taken in 1891 along the "The Narrows" between Lower and Upper Chateaugay Lake (Figure 1.1). These eight kilns helped supply charcoal to the Belmont forge, discussed earlier, at the northern end of the lower lake. A man standing next to the doorway of the first kiln on the left provides a good sense of scale. Three rows of vent holes are clearly evident on the kilns, and bracing is visible on all but the far left kiln. As at the other sites already discussed, large stacks of wood cover the hillside behind the kilns, but the surrounding

area clearly has not been denuded of timber, which at that point undoubtedly represented secondary growth.

The steamboat in Figure 1.53 was the “Adirondack,” which was a 55’ x 8’ passenger boat on the Chateaugay Lakes and the narrows between them, used for excursions and sight-seeing (Gadway 1954). A boat that began to serve these waters earlier was the “Maggie,” named after Miss Maggie Weed, daughter of Smith M. Weed who along with Andrew Williams had been one of the founders of the Chateaugay Ore & Iron Co. in 1881 (Pollard and Klaus 2004, 29). The Maggie was 28½ feet long and 11 feet wide, had a 25 horsepower engine (see photo in Pope 1968, 46), and towed an 80 feet long barge named the “Iron Age” that carried 150 tons of separated ore to the forges at Bellmont. The ore was first brought by wagon from Lyon Mountain over a plank road to a dock on Upper Chateaugay Lake. That same steamer also hauled all the charcoal and wood on the lake by barge and raft (Linney 1934, 27-31). It would pull a scow loaded with nine charcoal-laden wagons like the one seen here at the kilns, that amount being the contents of a single kiln (Gadway 1954).

As a vital component of the bloom iron industry, charcoal making clearly was a significant feature of the Adirondack landscape throughout much of the nineteenth century. Even though clear-cutting sections of the primary forest could lead to greater erosion and more frequent and destructive forest fires on secondary growth (Chahoon 1880, 427), major iron makers such as Clintonville kept detailed records on land use to better manage and maintain these resources. Despite what at the local level may have looked like a devastating use of the environment, long range impacts appear to have been minimal within the huge expanse of several million acres that encompassed the area where iron making occurred (R. F. Allen et al. 1990, 16; Gordon 1996, 39-44).

Equally if not more worrisome was the rising, poorly controlled logging of vast tracts of forest for a variety of other purposes, including lumber, fuel wood, tanning bark (hemlock), potash, and pulp, as well as clearing for farming. Forest conservation and preservation concerns, strongly voiced as early as the 1860s, resulted in the creation a state Forest Preserve in 1885, followed in 1894 by the ratification of a New York constitutional law to keep state forest lands forever wild (Welsh 1995, 150). Today the state preserve constitutes 2.6 million acres of the 6.1 million acre Adirondack Park, for which the Adirondack Park Agency, established in 1971, continues to confront and help resolve ongoing issues of conservation, land use, and development in what is the country’s largest publicly protected area (APA 2011, 2013).

CONCLUSION

We are fortunate in having at least a small corpus of photographs that provide a first-hand depiction of several aspects of the nineteenth century bloom iron industry of the Adirondack-Lake Champlain region, a number of which have been explored here. Combined with other documentary resources and archaeological investigations, they allow us to better conceptualize, understand, and appreciate the settings, activities, and accomplishments of individuals and communities that helped define an important period in U.S. industrial development. [7]

We have seen that early photographs of company stores, engine houses and ore hoists, ore separators, forge buildings, and charcoal kilns often helped clarify the placement and structural configuration of these facilities, while indirectly reflecting the scale and level of investment of the companies that erected them. As well, rare views of the interior of two forges provided details on the operational layout of both the forge fires and the trip hammers that shaped the iron, while complementing and enriching written accounts. Now such enrichment has been greatly extended to the former iron works at Clintonville, one of the few locations where industrial archaeology has been conducted. With the unusually large number of period photographic images now known, and presented here, the former setting, composition, and vitality of that industrial community is more clearly and meaningfully perceived.

Unfortunately, many of the former Adirondack iron industry sites discussed in this paper have been seriously disturbed or built over, making archaeological field study extremely difficult if not impossible. These include forge sites such as at Ausable Forks and Jay in the Ausable River valley, which have been bulldozed, filled, and leveled, along with the former brickwork company stores at those locations. At Clinton Correctional Facility in Dannemora, all of the original iron-works structures within the prison walls were torn down long ago and replaced with extensive new facilities. Only a model of the prison grounds and buildings as they appeared in the 1870s, made by inmates in the 20th century, remains under glass in the prison’s museum.

On a more positive note, some sites are known to have retained a degree of integrity, despite being reclaimed by nature. The foundations of the forge, separator and ore roasting pits at Clintonville have proven to be a notable example. As well, one can walk among the trees that densely cover the site of the former forge at Bellmont at the end of Lower Chateaugay Lake, but only with imagination can one perceive the original structure that once dominated the landscape there. Yet, looking closely one can still discern one of the stone-lined waterwheel pits, next to which are seen the tops of six iron

lugs, still deeply embedded in the ground, which once anchored one of the massive trip hammers that shaped some of America's finest iron. Only a few remnants of the stonework foundation of the forge wall along the river's edge remain intact. Just to the north of the forge, a long bluff where a line of beehive charcoal kilns once stood is apparent. Here the trees are less dense, and small bits of charcoal emerge when the ground is gently disturbed.

Our image of the former Adirondack bloom iron industry will continue to enlarge and sharpen with further research. These investigations can and should be pursued along many lines, including the discovery and interpretation of old photographs which help contextualize and enliven our other efforts. Patience is advised. You never know what might eventually turn up for auction on eBay®, or elsewhere.

ACKNOWLEDGEMENTS

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NOTES

1. (page 1) Writing in the late 1860s, metallurgist T. Sterry Hunt noted that the bloomery forge industry of northern New Jersey and adjacent areas of New York and Pennsylvania was already falling into disuse. For this, he noted several causes, including the scarcity of wood for charcoal, and the ready availability of nearby coal deposits and an excellent transportation system, all of which made it more profitable to work the ores in blast furnaces rather than in bloomery forges (Hunt 1870, 275).
2. (page 3) Published photos of Adirondack forges and related scenes are relatively rare, and almost always lack attribution to the photographer. Primary examples include the Irondale forge and charcoal shed (photo by Stoddard in Hyde 1974, 150); Bellmont forge exterior (Hyde 1974, 159; Linney 1934, 30); Chateaugay Lake charcoal kilns (actually the kilns at the Bellmont forge, see Hyde 1974, 168; Linney 1934, 5; Pollard 1991, 13); Bellmont forge trip hammer and waterwheel (Linney 1934, 32; 1943, 487); Bellmont forge trip hammer in operation (Pollard and Klaus 2004, 32), Bellmont forge tools (Linney 1934, 33); and Bellmont forge fires (R. F. Allen et al. 1990, 4; Linney 1934, 34; 1943, 484). The photographer of all of the Bellmont forge pictures is unconfirmed (see note 5).

Wendell Lansing (1897, 90-92) published three photos of the forge at Standish, one of which was of the trip hammer in operation. Linney (1934, 44, 46, 53) reprinted those same three shots without attribution, as well as an ore separator "in the Adirondacks" (Linney 1934, 166, actually the J. & J. Rogers separator on Palmer Hill), and a rolling mill "in the Adirondacks" (actually the J. & J. Rogers mill at Ausable Forks, from a stereoview taken by Baldwin Linney 1934, 168). Other images include the J. & J. Rogers Iron Co. rolling mill at Ausable Forks after being destroyed by fire late in 1874 (Gordon 1996, 71); the J. & J. Rogers Co. store at Ausable Forks (Nolan 1977, 15,17); the J. & J. Rogers Co. forge fires at Jay (Nolan 1977, 11, misidentified as being the Black Brook forge; Pollard 1991, 15; Rolando 1992, 22); an early view of the hamlet of Black Brook which includes the southernmost J. Rogers & Co. forge there (Nolan 1977, 61, although the forge is not recognized or pointed out); the bloomery forge building at Standish (Pollard and Klaus 2004, 30, photo by Rev. LaGrange); woodcut engravings of the J. & J. Rogers Co. ironworks (*Adirondack Record*, Apr. 10, 1914; also Nolan 1977, 12, 14, 16, without citing the *Adirondack Record* source); a Baldwin stereoview of six charcoal kilns believed to have been part of the Clintonville ironworks (Pollard and Klaus 2004, 27), another Baldwin stereoview of the Arnold Hill mine hoist and miners (Bauer 1999, 13; 2002-2003, 31); a Stoddard photo of eight charcoal kilns on the Chateaugay Narrows (Allan 1988, 57; R. F. Allen et al. 1990, 17; Pope 1968, 45), and another photo by Stoddard of three charcoal kilns in the Adirondacks (Horrell 1999, 116, mistakenly described as a totally different Stoddard photo).

A very limited publication by Voelcker (1976) contains other J. & J. Rogers Iron Co. forge photos, including the bloomery at Ausable Forks and the ruins of the forge at Black Brook, both of which had been photographed in 1894 by William Cheesman of Ausable Forks, New York. Voelcker (1974) also published an uncaptioned photo of the company store and office of the J. & J. Rogers Iron Co. at Ausable Forks, which was mounted on a board that identifies the photographer as Charles Derby of Morrisonville, New York (near Plattsburgh).

3. (page 4) In a letter to the vice president of the Peru Steel & Iron Co. at the home office in New York, the superintendent of the iron works at Clintonville described the contents of six boxes of iron specimens he was sending him for display at the Centennial Exhibition. These included a raw loup of 300 lbs, a shingled loup of 300 lbs., three nice billets with one planed on one side, a loup shingled and hammered down with the first billet cut off (300 lbs.), one large billet 3 feet long and 5 inches square (300 lbs.), two pieces of twisted 2 x ½ bars weighing 300 lbs, and a box of ore from the Winter iron mine. All were to be sold at the end of the exhibition (D. Cady to F.J. Dominick, February 28, 1876, *IWR*, 65.5 9/1)

4. (page 4) All of the images in this study have been digitally enhanced by the author for contrast and clarity. No image may be reproduced without written permission from the author and the original cited source. Additional notes on some of the 1876 G.W. Baldwin stereoviews of Figures 1.3 to 1.16 on pages 6–9:

- 1.3&1.4: None of these structures seen in these views have survived to the present. The new hotel seen in 1.3 stood until destroyed by fire in 1941. Collection of Ronald Allen.
 - 1.5: To the right are seen several of the 40 houses at Clintonville that were owned by the Peru Steel & Iron Co. An iron bridge across the Ausable River is barely visible in the distance. Collection of Ronald Allen.
 - 1.10: The grist mill and saw mill at this location had burned in June of 1875. The stone walls of the grist mill survived and the interior was rebuilt, but the saw mill was a total loss. The new saw mill is seen here, having been completed in August of 1875. Collection of Gordon Pollard.
 - 1.11: Viewed from left to right, the rolling mill is partly visible in this photo, along with the nail factory, grist mill, saw mill, and part of the upper dam across the Ausable. Nail making had ended here around 1856, with the factory building subsequently used for storage. Collection of Gordon Pollard.
 - 1.12: The foundry and blacksmith shop are in the long, stone-walled building to the right. The rolling mill is seen in the distance. Collection of Gordon Pollard.
 - 1.13: The horse barn shown here was relatively new. A large fire in May of 1872 had destroyed eight barns of the company, 40-50 tons of hay, 32 pairs of sleighs, a house, and other items, along with a dog and a cat (*Plattsburgh Sentinel*, May 17, 1872). Collection of Gordon Pollard.
 - 1.14, 1.15, 1.16 three views show the PS&I Co.'s stone-walled engine house on Palmer Hill. The steam engine here ran a hoist that raised ore from the main mine, as well as pumps that drew water from several mine shafts. In Figure 1.16 mine openings in the foreground are mostly covered with planking. Collection of Gordon Pollard.
5. (page 4) Steelmaking was a very small part of the operations at Clintonville, and only for a brief period. During the Peru Iron Co. era, a furnace for making blister steel was erected near the rolling mill in 1852 at a cost of \$2657.20 ("Inventory" ledger IWR, 64.3 1/1). Neilson

(1867, 267) implies the use of this furnace was discontinued shortly after 1860, and was still standing, in ruins, in 1866. It had produced an average of 150 tons of blister steel per year up to 1859, and only 50 tons in 1860. Thus, the "Peru Steel and Iron Company" (1865-1886) is a bit of a misnomer. They did not actually make steel, but sold and shipped most of their bloom iron to ironworks in Pennsylvania for conversion to steel.

6. (page 27) The identity of the person who took the Bellmont forge photos in Figures 1.34, 1.36, 1.38, and 1.39 is an intriguing mystery. All four of these pictures were undoubtedly taken by the same photographer in 1884 (one of them had the date handwritten in the negative). The photo of Figure 1.39, in the collection of the Adirondack Museum in Blue Mountain Lake, New York, is the only one that is intact on a mounting board which bears a photographer's embossing. That photographer is D.S. Brush of Plattsburgh, New York. However, Brush is not known to have been in this region prior to 1888 (*Plattsburgh Republican*, May 5, 1888), and he became successor to the George T. Woodward photo studio in Plattsburgh in 1912, after having worked for Woodward there for a number of years (*Plattsburgh Republican*, May 11, 1912).

Since the photo of Figure 1.39 has "Forge Tools" handwritten in the negative, it is most likely that sometime after 1912 Brush simply reissued older photos, made from negatives that had been in Woodward's stock. But since Woodward himself did not begin business in Plattsburgh until 1892, he also is unlikely to have taken the photos. G.W. Baldwin, who had taken the Clintonville and Ausable Forks photographs in the 1870s, and who is known to have taken pictures of other Adirondack iron works in the 1880s, had his photography studio in Plattsburgh from 1882 to 1892. It is the belief of this researcher that some of Baldwin's stock was sold to Woodward in 1892, including the Bellmont forge negatives, when Baldwin moved his art studio to Saranac Lake that very same year.

7. (page 37) Many of the photographers who contributed to this form of documentation, such as George W. Baldwin, worked on a relatively local scale and received little notoriety. As they continue to come to light, the images captured by such artists will nevertheless remain an important source of potentially new and significant visual revelations. Seneca Ray Stoddard, on the other hand, was prolific in his work and widely recognized for his literary, artistic and cartographic contributions, much of which focused on the Adirondacks (Adler 1997; Crowley 1982; DeSormo 1972; Horrell 1999). Besides his acclaimed photographic achievements, one of his most successful publications was a guidebook titled *The Adirondacks, Illustrated*, which was published and revised numerous times between 1874 and 1914.

Here it is interesting to note that in this work Stoddard wrote a lengthy, anecdotal account of a trip he made in

1873 from Port Kent on the shore of Lake Champlain, up the Ausable River valley to Lake Placid and beyond. He even stopped at Baldwin's photo studio in Keeseville on that trip (Bauer 2002–2003, 28–30). In his trip account, Stoddard's only mention of the ironworks at Clintonville, which as we have seen were to be beautifully photographed by G.W. Baldwin in 1876, was the following: "Clintonville, with its said-to-be largest forge on the continent, and decayed, ashy, sooty look, was passed, as was 'Point-of-Rocks,' the southern terminus of the Plattsburgh Railroad" (Stoddard 1874, 54).

Thus it seems that Stoddard rather dismissively passed on the opportunity to photographically capture any aspect of this community, as well as that of Ausable Forks five miles beyond. We are fortunate, indeed, that G.W. Baldwin was around to counter these omissions.

REFERENCES

- APA (Adirondack Park Agency). 2011. "Annual Report for 2011." Adirondack Park Agency. Accessed Aug. 2, 2013. <http://apa.ny.gov/Documents/Reports/ADAnnualReport-20120315-KPM-F-AR2011c.pdf>. (Cited on page 37).
- . 2013. "New York State Adirondack Park Agency." Adirondack Park Agency. Accessed Aug. 2, 2013. <http://www.apa.ny.gov/>. (Cited on page 37).
- Adirondack Record* (Ausable Forks, NY). 1914. "Collage of drawings of the iron works of the J. & J. Rogers Iron Co. in Ausable Forks, Jay, and Black Brook, published in conjunction with a 'Historical Sketch of Au Sable Forks.'" Apr. 10, section 1. (Cited on pages 32, 38).
- Adler, W. 1997. *Early Days in the Adirondacks, the Photographs of Seneca Ray Stoddard*. New York: Harry N. Abrams. (Cited on page 39).
- Allan, H. W. 1988. *Clinton County: A Pictorial History*. Norfolk, Virginia: Donning Company. (Cited on page 38).
- Allen, R. S. 1967. *Separation and Inspiration: Concerning the First Industrial Application of Electricity in America*. Historical Publication 1. Crown Point, New York: Penfield Foundation. (Cited on page 11).
- Allen, R. F., J. C. Dawson, M. F. Glenn, R. B. Gordon, D. J. Killick, and R. W. Ward. 1990. "An Archeological Survey of Bloomery Forges in the Adirondacks." *The Journal of the Society for Industrial Archeology*: 3–20. (Cited on pages 1, 3, 37, 38).
- AI&SA. *Directory to the Iron and Steel Works of the United States*. 1886–1898. American Iron and Steel Association, Philadelphia. (Cited on page 1).
- Bailey, J. B. 1830–1850. Papers, 1830–1850. Collection 85.34.1. A collection of original documents of Jerome B. Bailey, Manager of the Peru Iron Company, Clintonville, N.Y. Clinton County Historical Museum, Plattsburgh, NY. (cited on page 3).
- Bauer, G. 1999. "George W. Baldwin, Adirondack Photographer." *The Antiquarian* (Plattsburgh, NY), no. 1, 8–18. (Cited on page 38).
- . 2002–. 2003. "George W. Baldwin's 'Gems of the Adirondacks.'" *Stereo World*, no. 4, 22–32/37. (Cited on pages 38, 40).
- . 2007a. *Seneca Ray Stoddard's New York State "Crystal" Stereoviews*. View List Series 25. National Stereoscopic Association. (Cited on pages 3, 18).
- . 2007b. *The Stereoviews of George W. Baldwin, Keeseville, New York*. View List Series 39. National Stereoscopic Association. (Cited on page 3).
- Chahoon, G. 1875. "Iron Making in Northern New York Catalan Forges." Edited by American Iron & Steel Association. *The Bulletin* (Philadelphia, PA), Aug. 20, 250. (Cited on page 1).
- . 1880. "Report on the Iron Deposits of the North Eastern Division (with Industrial Memoranda)." In *Seventh Annual Report on the Progress of the Topographical Survey of the Adirondack Region of New York to the Year 1879*, edited by V. Colvin, 413–428. Weed, Parson & Co. (Cited on pages 1, 3, 15, 32, 37).
- Cook, R. 1843. Reply of R. Cook, Esq. to the Ausable memorial, in relation to convict labor, &c., Apr. 4. State of New York, No. 155, In Assembly. The Legislature, Albany, New York. (Cited on pages 17, 20).
- Crowley, W. 1982. *Seneca Ray Stoddard: Adirondack Illustrator*. Exhibition catalog. Adirondack Museum, Blue Mountain Lake, New York, June 15–October 15, 1981 & 1982. Adirondack Museum and Canterbury Press, Rome, New York. (Cited on page 39).
- D. G. Beers & Co. 1876. *Atlas of Franklin County, New York*. Philadelphia: D. G. Beers & Co. (Cited on page 25).
- David, J. F., ed. 1949. *Clinton State Prison, Dannemora, N.Y. Its History, Purpose, Makeup and Program*. New York State Department of Correction, New York State Vocational Institution. (Cited on page 17).
- Dawson, J. C., J. R. Moravek, M. F. Glenn, and G. C. Pollard. 1988. "Iron Industry of the Eastern Adirondack Region." In *Field Trip Guidebook*, edited by J. F. Olmstead, 149–174. Plattsburgh, New York: State University College. (Cited on page 3).
- DeSormo, M. 1972. *Seneca Ray Stoddard: Versatile Camera Artist*. Saranac Lake, New York: Adirondack Yesteryears. (Cited on page 39).
- Egleston, T. 1880a. "The American Bloomery Process for Making Iron Direct from the Ore." *Transactions of the American Institute of Mining Engineers* VIII:515–550. (Cited on pages 1, 15, 20, 25, 27, 28, 30, 32).
- . 1880b. "The Manufacture of Charcoal in Kilns." *Transactions of the American Institute of Mining Engineering* VIII:373–397. (Cited on pages 1, 33, 36).

- Elizabethtown Post* (Elizabethtown, New York). 1901. "The Largest Charcoal Iron Forge in the World Located at Clintonville on the Ausable River." Nov. 14. (Cited on page 25).
- Essex County Republican* (Port Henry, New York). 1890. "Libelous Attacks." Northern New York Historical Newspapers, Northern New York Library Network, Feb. 20. Accessed Aug. 13, 2013. <http://news.nynln.net>. (Cited on page 5).
- Evening World* (New York, NY). 1890. "Legal Weekly Pay Days. Proposed Laws to Protect Corporation Employees from Robbery. Evils of the 'Truck System' as Portrayed at Ausable Forks." National Endowment for the Humanities, Chronicling America, Historic American Newspapers, Jan. 20. Accessed Aug. 13, 2013. <http://chroniclingamerica.loc.gov/>. (Cited on page 5).
- . 1890. "Lyon Mountain, N.Y., Feb. 2." National Endowment for the Humanities, Chronicling America, Historic American Newspapers, Jan. 20. Accessed Aug. 13, 2013. <http://chroniclingamerica.loc.gov/>. (Cited on page 5).
- F. W. Beers & Co. 1869. *Atlas of Clinton County, New York*. Philadelphia: F. W. Beers & Co. (Cited on pages 4, 19).
- Farrell, P. 1996. *Through the Light Hole, a Saga of Adirondack Mines and Men*. Utica, New York: North Country Books. (Cited on page 1).
- Gadway, R. 1954. "Early Steamboats on Chateaugay Lake." *Chateaugay Record* (Chateaugay, New York), Jan. 15. (Cited on page 37).
- Gordon, R. B. 1996. *American Iron 1607-1900*. Baltimore: Johns Hopkins University Press. (Cited on pages 1, 11, 25, 32, 37, 38).
- Gordon, R. B., and D. J. Killick. 1992. "The Metallurgy of the American Bloomery Process." *Archaeomaterials* 6 (2): 141-167. (Cited on pages 1, 3, 32).
- Hardy, P. J. 1985. "The Iron Age Community of the J. & J. Rogers Iron Company, Au Sable Valley, New York: 1825-1900." Ph.D. Dissertation, Bowling Green State University. (Cited on page 5).
- Horrell, J. L. 1999. *Seneca Ray Stoddard. Transforming the Adirondack Wilderness in Text and Images*. Syracuse: Syracuse University Press. (Cited on pages 38, 39).
- Hunt, T. S. 1870. *Notes on Iron and Iron Ores*. Report of Progress from 1866-1869. Montreal: Geological Survey of Canada. (Cited on pages 1, 32, 38).
- Hurd, D. H. 1880. *History of Clinton and Franklin Counties, New York*. Philadelphia: J. W. Lewis & Co. (Cited on pages 5, 17, 30).
- Hyde, F. S. 1974. *Adirondack Forests, Fields, and Mines*. Lakemont, New York: North Country Books. (Cited on page 38).
- IWR. *Clintonville, N.Y., Iron Works Records, 1825-1890*. Original documents of the Peru Iron Co., the Peru Steel & Iron Co., and the Peru Iron Ore Co. Includes collections 64.3, 65.5, and 65.10. State University of New York, College at Plattsburgh, Special Collections of Feinberg Library. (Cited on pages 4, 5, 11, 15, 20, 33, 36, 38, 39).
- Journal of the U.S. Association of Charcoal Iron Workers*. 1881. "A Charcoal Iron Works in the Adirondack Mountains." No. 6, 355-360. (Cited on pages 22, 24, 25, 27, 32, 33).
- . 1881. "Forge Hammers and their Operation." No. 3, 140-151. (Cited on page 27).
- Kemp, J. F., and H. L. Alling. 1925. *Geology of the Ausable Quadrangle*. New York State Museum Bulletin 261. Albany: The University of the State of New York. (Cited on pages 5, 11, 12).
- Kudish, M. 1996. *Railroads of the Adirondacks, a History*. Fleischmanns, New York: Purple Mountain Press. (Cited on page 33).
- Landon, D., P. Martin, A. Sewell, P. White, T. Tumberg, and J. Menard. 2003. "'... A Monument to Misguided Enterprise': The Carp River Bloomery Iron Forge." *IA: The Journal of the Society for Industrial Archeology* 27 (2): 05. (Cited on page 3).
- Lansing, W. 1897. *Souvenir Industrial Edition, The Press*. Edited and published by W. Lansing & Son, Plattsburgh, New York. Facsimile reprint 1978 with the title *The Souvenir Industrial Edition of Plattsburgh, 1897*. The Corner-Stone Bookshop, Plattsburgh, New York. (Cited on page 38).
- Lesley, J. P. 1866. *The Iron Manufacturer's Guide to the Furnaces, Forges and Rolling Mills of the United States*. New York: John Wiley. (Cited on page 1).
- Linney, R. J. 1934. *A History of the Chateaugay Ore and Iron Company*. Albany: Delaware & Hudson Railroad Co. (Cited on pages 1, 24, 37, 38).
- . 1943. "A Century and A Half of Development Behind the Adirondack Iron Mining Industry." *Mining and Metallurgy* 24 (443): 480-487. (Cited on page 38).
- Malone Paladium* (Malone, New York). 1893. "Business Changes and Politics." Northern New York Historical Newspapers, Northern New York Library Network, June 8. Accessed Aug. 12, 2010. <http://news.nynln.net/>. (Cited on page 24).
- Moravek, J. R. 1976. "The Iron Industry as a Geographic Force in the Adirondack-Champlain Region of New York State 1800-1971." Ph.D. Dissertation, University of Tennessee. (Cited on page 1).
- Neilson, W. G. 1867. *The Charcoal Blast Furnaces, Rolling Mills, Forges, and Steel Works in New York in 1867*. Philadelphia: American Iron & Steel Association. (Cited on pages 1, 33, 39).

- Newland, D. H. 1908. *Geology of the Adirondack Magnetic Iron Ores, with a Report on the Mineville-Port Henry Mine Group by James F. Kemp*. New York State Museum Bulletin 119. Albany: The University of the State of New York. (Cited on page 5).
- Nolan, M., ed. 1977. *Yesterday, Today, Tomorrow: Black Brook, Ausable Forks*. Elizabethtown, New York: Denton Publications. (Cited on page 38).
- Palmer, L. G. 1921. "Reminiscences of Clintonville, New York." NYGenWeb Project. Accessed July 18, 2010. <http://www.rootsweb.ancestry.com/~nycclinto/areahist/cltville.html>. (Cited on pages 3, 22).
- Plattsburgh Daily Press* (Plattsburgh, New York). 1898. "This is Good News; Works at Lyon Mountain to be Started at Once." Mar. 12. (Cited on page 24).
- Plattsburgh Republican* (Plattsburgh, New York). 1873. "Home Enterprises – No. 5. J. & J. Rogers Iron Works at Ausable Forks, Black Brook and Jay." Aug. 9. (Cited on page 11).
- . 1875. "Home Enterprises – No.22. Peru Steel & Iron Company at Clintonville." Apr. 17. (Cited on pages 11, 22).
- . 1876. "Home Enterprises – No. 30. Clinton Prison." Apr. 29. (Cited on page 18).
- . 1880. "Some Things New and Old at Ausable Forks." Feb. 21. (Cited on page 11).
- Plattsburgh Republican* (Plattsburgh, New York). 1883. "Editorial Notes: Development of a Gigantic Iron Interest." May 5. (Cited on page 24).
- . 1888. "Elizabethtown. Daniel S. Brush has recently purchased..." May 5. (Cited on page 39).
- . 1890. "Closure of the Bellmont Forge." July 19. (Cited on page 24).
- . 1912. "Brief. D.S. Brush has purchased..." May 11. (Cited on page 39).
- Plattsburgh Sentinel* (Plattsburgh, New York). 1871. "The Forges of the Wilderness. From the New York Times, Dec. 7th." Dec. 22. (Cited on page 24).
- . 1872. "Clintonville. A fire broke out..." May 17. (Cited on page 39).
- . 1873. "Jay – Forge Burned." Jan. 17. (Cited on page 30).
- . 1874. "Visit to the Iron Works of J. & J. Rogers Iron Co." Feb. 27. (Cited on page 11).
- . 1881. "The Largest Catalan Forge in the World." Aug. 19. (Cited on page 24).
- . 1890. "Iron Works Shut Down." Aug. 22. (Cited on page 30).
- . 1900. "Lyon Mountain Boom. Extensive Repairs Being Made by the Chateaugay Ore & Iron Co." Feb. 16. (Cited on page 24).
- . 1901. "Will Abandon Charcoal. C.O.& I. Co. to Discontinue Catalan System of Manufacturing Iron." Aug. 23. (Cited on pages 1, 33).
- Pollard, G. C. 1991. "The Company Store of "S.P. Bowen & Co." at Clayburgh, N.Y., 1869." *The Antiquarian* 7 (1): 10–16. (Cited on page 38).
- . 1998. "Experimentation in 19th Century Bloomery Iron Production: Evidence from the Adirondacks of New York." *Journal of the Historical Metallurgy Society* 27 (1): 33–40. (Cited on page 20).
- Pollard, G. C., and H. D. Klaus. 2004. "A Large Business: the Clintonville Site, Scale, and Resources at Adirondack Bloomery Forges." *IA, The Journal of the Society for Industrial Archeology* 30 (1): 19–46. (Cited on pages 2–5, 18, 20, 21, 25, 27, 33, 37, 38).
- Pope, C. C. 1968. "Popeville, Franklin County Ghost Town." *York State Tradition* 22 (4): 38–49. (Cited on pages 37, 38).
- Prison Report. 1857. *Annual Report of the Inspectors of State Prisons of the State of New York*. Charles van Benthuyssen & Sons. Albany, NY. (cited on page 17).
- . 1859. *Annual Report of the Inspectors of State Prisons of the State of New York*. Charles van Benthuyssen & Sons. Albany, NY. (cited on page 17).
- . 1860. *Annual Report of the Inspectors of State Prisons of the State of New York*. Charles van Benthuyse & Sons. Albany, NY. (cited on page 17).
- . 1862. *Annual Report of the Inspectors of State Prisons of the State of New York*. Charles van Benthuyssen & Sons. Albany, NY. (cited on page 17).
- . 1869. *Annual Report of the Inspectors of State Prisons of the State of New York*. Charles van Benthuyssen & Sons. Albany, NY. (cited on pages 17, 19).
- . 1877. *Annual Report of the Inspectors of State Prisons of the State of New York*. Charles van Benthuyssen & Sons. Albany, NY. (cited on page 17).
- Prison Select Committee. 1869. *Report of the Select Committee of the Assembly, appointed May 6, 1868, to Examine into the Conduct of our State Prisons and to Make Such Recommendations as Might be Suggested by Such Examination*. Charles Van Benthuyssen & Sons. Appendix to Annual Report of the Inspectors of State Prisons of the State of New York. Transmitted to the Legislature, Albany, NY, Feb. 10. (Cited on page 17).
- Putnam, B. T. 1886. "Notes on the Samples of Iron Ores Collected in New York." In *Report on the Mining Industries of the United States (Exclusive of the Precious Metals), with Special Investigations into the Iron Resources of the Republic and into the Cretaceous Coals of the Northwest*, edited by R. Pumpelly, 15:89–144. United States Census for 1880. Washington: U.S. Department of the Interior, Census Office. (Cited on pages 11, 13).

- Report of the Commissioners Appointed to Investigate the Pecuniary Affairs of the Several State Prisons*. 1855. Charles van Benthuyzen & Sons. State of New York, No. 60, in Assembly, Albany, NY, Jan. 29. (Cited on page 17).
- Rolando, V. R. 1992. *200 Years of Soot and Sweat: the history and archeology of Vermont's Iron, Charcoal, and Lime Industries*. Burlington, VT: Vermont Archaeological Society. (Cited on page 38).
- Smock, J. C. 1889. *First Report on the Iron Mines and Iron-ore Districts in the State of New York*. Bulletin 7. Albany: New York State Museum of Natural History. (Cited on pages 5, 11).
- Stoddard, S. R. 1874. *The Adirondacks, Illustrated*. Albany: Weed, Parsons & Co. (Cited on pages 39, 40).
- . 1968. "Wilderness Prison (Clinton Prison), text and photos by Seneca Ray Stoddard." *York State Tradition* 22 (3): 42–50. (Cited on page 18).
- Svedelius, G. 1875. *Hand-book for Charcoal Burners*. New York: John Wiley & Son. (Cited on page 32).
- Voelcker, E. C. 1974. *A Heritage*. Rochester, New York and Toronto: Visual Studies Workshop & Coach House Press. (Cited on page 38).
- . 1976. *An Industrial History of Ausable Forks, New York*. Rochester, New York: Visual Studies Workshop. (Cited on page 38).
- Watson, W. C. 1869. *The Military and Civil History of the County of Essex, New York*. New York: J. Munsell. (Cited on pages 5, 30).
- Welsh, P. C. 1995. *Jacks, Jobbers and Kings: Logging the Adirondacks 1850-1950*. Utica: North Country Books. (Cited on pages 32, 37).
- Witherbee, F. S. 1907. "History of the iron industry of Essex County, New York." *Essex County Republican* (Keeseville, NY), Mar. 8–Apr. 5. (Cited on page 3).

AN HISTORICAL–ECONOMIC DESCRIPTION OF SEVERAL IRON DEPOSITS FROM THE ADIRONDACK REGION OF NEW YORK

Marian V. Lupulescu

The iron deposits from New York State were an important source for the iron industry of the USA during the nineteenth and twentieth centuries. The iron deposits were localized in rocks metamorphosed at high temperature and medium pressure during the Grenville orogeny. The main component of the ore was magnetite; it was accompanied in some deposits by by-products such as fluorapatite. The medium- to high-grade magnetite ore was mined underground. This paper presents an historical-economic evaluation of the low Ti-Fe oxide and Ti-Fe oxide deposits from the Adirondack Mountains (Adirondack Highlands) based on their mining history, mineralogical form, ore grade, by-products, texture, and harmful substances.

Iron mining in New York State has a long history. There are two main regions where iron mining was developed, the Hudson Highlands in the south and the Adirondack Mountains in the north. Smock (1889) completed the first report on the iron ores of New York State and the first classification based on a “geologico-geographical arrangement.” His classification included almost all the iron occurrences known at that time and all the major ore types (magnetic iron, hematite, limonite, and carbonates).

This study presents an historical and economic evaluation of the iron ore from some of the Adirondack iron deposits, both as main commodity and by-product, in terms of ore-grade, production, and deleterious substances.

The most significant regions with iron deposits in the Adirondack Mountains (Figure 2.1) are the northwestern area that includes the Jayville deposit (St. Lawrence County); the central region with the Benson mines (St. Lawrence County) and Tahawus (Essex County); and the eastern and northeastern region with the Mineville-Port Henry group of mines (Essex County) and Ausable and Lyon Mountain mines (Clinton County). The earliest discoveries and mining operations of iron ores in the Adirondack Mountains were in the eastern part (Linney 1943).

GEOLOGICAL SETTING

For many years, geologists debated the origin of the iron deposits in the Grenville geological province of New York. Alling (1925) wrote that those who read about the “...genesis of these important ore bodies in Northern New York may reach the conclusion that there is a hopeless disagreement among those who have studied these deposits.” This statement is still true today and probably will be for many years to come. The origin of these iron deposits was related to contact replacement by highly heated igneous solutions (Kemp 1897), igneous emplacement (Kemp 1890), basic segregation due to differentiation (Kemp and Ruedemann 1910), replacement of the country rock by igneously-derived iron-rich solutions (Alling 1925), or possibly metamorphism of sedimentary sequences (Nason 1922). Buddington (1939), Baker and Buddington (1970), and Foose and McLelland (1995) leaned toward a hydrothermal or hydrothermal-metasomatic origin.

The Adirondack Mountains are part of the Grenville Province of Precambrian age, which lasted from 1.3 to 1.0 billion years (Ga) ago. Three distinct periods of mountain building, or orogenies, were recognized in the Grenville province (Rivers 2008) including the Adirondacks. These are the Elzevirian, which lasted from 1245 to 1225 million years (Ma) ago, Shawinigan (1190–1140 Ma), and Grenvillian, which included the Ottawan (1090–1020 Ma) and Rigolet (1000–980 Ma) pulses. A large deformation zone called the Carthage-Colton Shear Zone (Geraghty, Isachsen, and Wright. 1981; Streepey et al. 2001) separates two domains in the Adirondacks, the Central Metasedimentary Belt or Adirondack Lowlands (AL) and Central Granulite Terrain or Adirondack Highlands (AH). These two realms differ by their lithologic content and metamorphic grade.

The uplifted region of the Adirondack Highlands (AH) has a dome-like shape. This region contains supracrustal (rocks deposited on a preexisting basement) and igneous rocks that were metamorphosed at high temperature and medium pressure (granulite facies conditions) during the Shawinigan orogeny and the Ottawan pulse of the Grenville orogeny. The oldest rocks are arc-related tonalites (rocks containing plagioclase, quartz, and less potassium feldspar) emplaced between

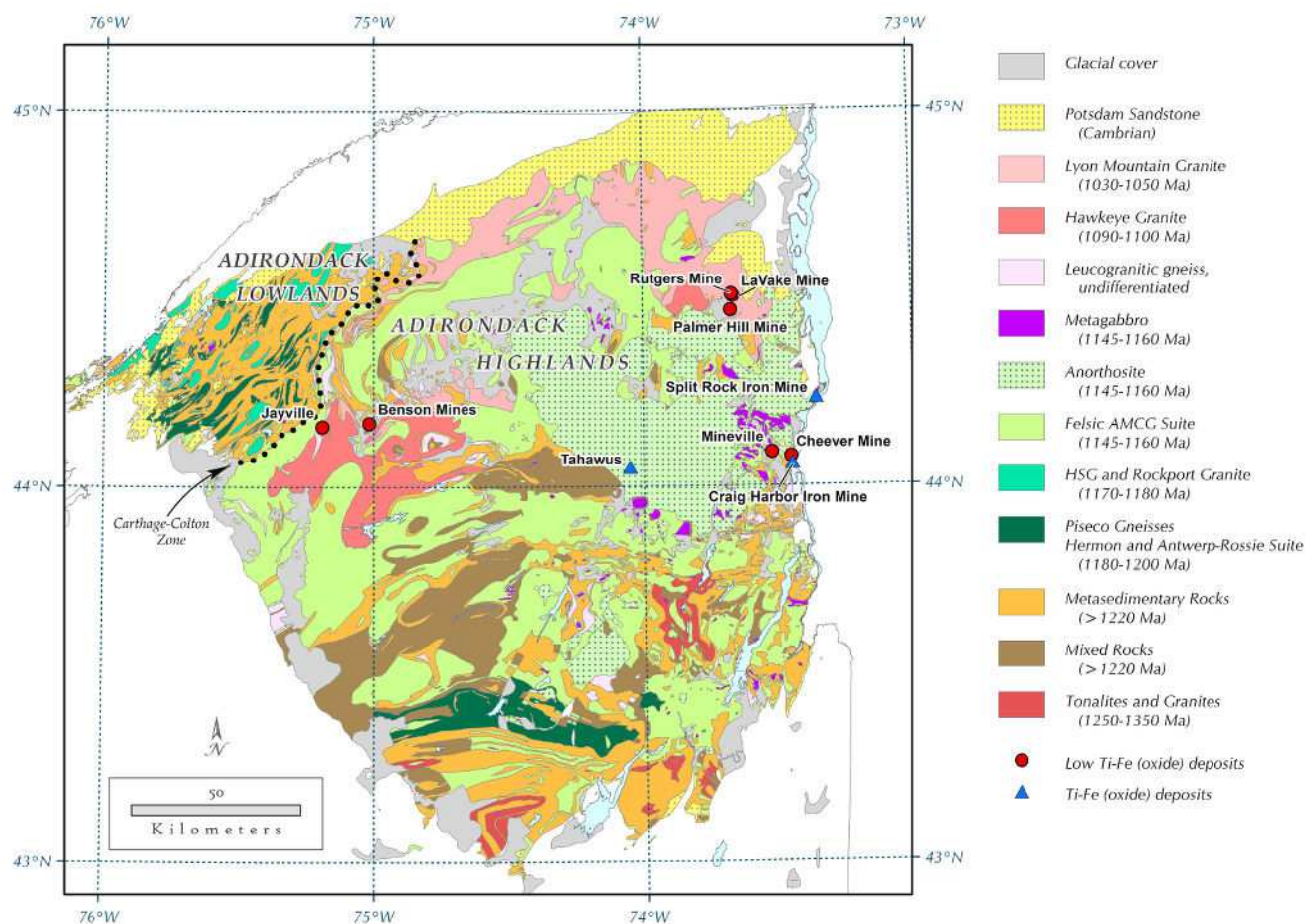


Figure 2.1. Simplified geological map of the Adirondack Mountains showing the age of the different rock units and the location of the low Ti-Fe oxide and Ti-Fe oxide deposits.

1330 and 1307 Ma (McLelland and Chiarenzelli 1990b). The AMCG suite (anorthosite – mangerite – charnockite – granite) was intruded around 1155 Ma (McLelland et al. 2004; McLelland and Chiarenzelli 1990a) followed by younger igneous rocks such as A-type Hawkeye granite (1100–1090 Ma), the mangerites from the northern Highlands (1080 Ma), and the A-type Lyon Mountain granite (1070–1040 Ma) (McLelland and Daly 1996).

Uplifting and erosion of the sedimentary blanket that covers the basement rocks (unroofing) is probably responsible for the morphology of the Adirondack Highlands. The oldest apatite fission-track thermochronology data (168–135 Ma) showed that the uplifting and unroofing of the Adirondacks started in the High Peak area and continued later on the northern, northwestern, and southwestern edges of the Adirondacks (146–114 Ma). Younger ages (112–83 Ma) were obtained on the southeastern margin of the mountains (Roden-Tice, Tice, and Schofield 2000).

Taylor and Fitzgerald (2011) suggested that the present relief of the eastern part of the AH was developed during the Late Cretaceous to Cenozoic. Zircon fission-track thermochronology on a sample from a

small pegmatite body cutting the wollastonite skarn at the Lewis quarry in the eastern Adirondacks yielded 513 ± 30 Ma (Montario, Garver, and Marsellos 2008). This fission-track age could represent an older start of the unroofing on the eastern side of the Highlands or the result of another previously unknown thermal event.

Some of these AH rocks (e.g. the A-type Lyon Mountain granite) are the hosts of some of the iron deposits that were significantly mined over the nineteenth and twentieth centuries.

CLASSIFICATION

The classification of ore deposits in Geology is important, as it provides a method to group ore bodies or deposits that have common properties. Classification makes the comparison of the different ore deposits easy. A good classification of ore deposits is generally one that does not make any reference to origin, because any discussion of origins could bring difficulties and debates (Evans 1993). In accordance with this assumption, the following classification of the iron deposits of the Adirondacks will be based on the mineral composition,

commodities extracted from the ore, and host-rock without reference to origins.

- **Mineral Composition:**

1. Low Ti-Fe oxide:
 - a) Low Ti-Fe oxide (magnetite) - P (fluorapatite) – REE (monazite-Ce, fluorapatite) deposits: Mineville (Old Bed);
 - b) Low Ti-Fe oxide (magnetite): Mineville-Port Henry district, Ausable Forks district, Lyon Mountain district, Benson Mines;
 - c) Low Ti-Fe oxide (magnetite) – B (vonsenite): Jayville;
2. Ti-Fe oxide deposits (ilmenite, magnetite): Tahawus, Craig Harbor, Split Rock mines.

- **Commodities:**

1. Fe-P-REE: Mineville (Old Bed);
2. Fe: Mineville, Cheever, Ausable Forks, Lyon Mountain, Benson Mines, Jayville;
3. Ti-Fe: Tahawus, Craig Harbor, Split Rock.

- **Host rock:**

1. Granite-hosted low Ti-Fe oxide deposits: Mineville, Cheever, Ausable Forks, Lyon Mountain;
2. Gneiss-hosted low Ti-Fe oxide deposits: Benson Mines, Jayville;
3. Anorthosite - hosted Ti-Fe oxide deposits: Tahawus;
4. Gabbro-hosted Ti-Fe deposits: Tahawus, Craig Harbor, Split Rock mines.

GENERAL FACTORS IN THE ECONOMY OF THE IRON DEPOSITS

The characterization and evaluation of an industrial ore body or deposit must consider the following factors: ore grade, by-products, mineralogical form, undesirable substances, and texture (grain size, mineral relations). The location factor is not discussed here because the history section contains references to it.

Mineralogical Form The mineralogical composition of the ore is very important for ore processing. The main minerals that are common for both low Ti-Fe oxide and Ti-Fe oxide deposits from the Adirondack Highlands are magnetite, hematite (martite), hemo-ilmenite, and ilmenite.

Ore Grade In Geochemistry, the relative amount of an element in the Earth's crust is known as abundance, in general terms, how common the element is. For the formation of an economic ore body an element must be concentrated at a much higher level than its crustal abundance. The degree of enrichment is called the concentration factor. Iron's abundance in the crust is 5.63% (Handbook of Chemistry and Physics, 77th edition).

The lowest average grade for an iron ore to become exploitable is 25% Fe (Evans 1993). The concentration factor necessary to form an iron deposit that can be mined with a small profit is about five. Table 2.1 presents a comparison of the ore-grade data and production of the iron deposits from the AH.

By-products In some ores, one or several metals or industrial minerals are present in low amounts, and can be processed and sold to help finance the main commodity. These are called by-products. Calcium phosphate (fluorapatite) was an important component of the iron ore from Mineville. Also, significant concentrations of rare earth elements (REE) were identified and reported as possible by-products from the same Mineville mines (McKeown and Klemic 1956).

Grain Size, Shape, Mineral Relationships Grain size, the morphology of the crystals, and their relations are important factors in ore beneficiation. Most of the important iron ores from the Adirondacks were easy to crush because of the size of the metallic mineral components and their relation with the gangue minerals. In general, the size of magnetite, hematite, and ilmenite grains is more than 1 mm. Some of the magnetite crystals associated with the pegmatitic separations in the ore from Mineville display a very coarse size up to 5 cm in length. These magnetite specimens were not mined for industrial milling and separation but collected for their esthetic value.

Undesirable Substances Harmful minerals or elements may be present in different amounts both in metallic and gangue minerals or as mineral phases associated with the principal minerals. The existence of such elements in ore concentrate may bring financial penalties. For the iron ores some of the deleterious elements are titanium, phosphorus and sulfur.

Titanium, present in titanite, ilmenite, anatase, and rutile in association with magnetite or as exsolution in magnetite and hematite inhibits the smelting process.

Phosphorus comes from the mineral fluorapatite or from elemental impurities in magnetite. It increases the hardness and strength, lowers solidus temperature, increases fluidity and cold shortness. When phosphorus concentration is higher than 0.2%, iron becomes brittle at low temperatures. Most of the iron deposits from the

Table 2.1. Main iron deposits from the Adirondack Highlands.

Deposit/Group	Year of discovery	Production (t)	Grade	Commodity	By-product
Mineville ^a	(1775) 1804	>400,000,000	61-68% Fe	Fe	Fluorapatite REE
Arnold Mine ^b		600,000	62% Fe	Fe	
Palmer Hill ^b	1809	1,000,000	33-35% Fe	Fe	
Chateaugay Mine ^c	(1798) 1850	15,000,000 (35,000,000)	26% Fe	Fe	
81 Mine ^b	(1798) 1850		35-40% Fe	Fe	
Benson Mines ^d	1810	16,600,813*	61.08% Fe	Fe	
Jayville ^e	1854	25,000-200,000	40-60% Fe	Fe	B (not used)
Tahawus ^f	1826		9.55-30% Ti	Ti	Fe

^a Birkinbine (1890), Nason (1922), Kemp (1890), and Farrell (1996)

^b Postel (1952)

^c Postel (1952) and Cavallerano and Zimmer (2008)

^d Crump and Beutner (1970)

^e Tyler and Wilcox (1942)

^f Gross (1970)

* until 1965

Adirondack Highlands contained fluorapatite, but the quality of the ore was still good because the processing method allowed the phosphate to be easily separated from magnetite.

Sulfur dissolves easily in both liquid and solid iron at the temperatures that characterize the smelting process and makes the iron brittle. It comes from sulfides; some sulfides were found in many of the deposits from the Adirondack Highlands (Table 2.2), but generally they were quantitatively insignificant.

CHARACTERIZATION OF THE IRON ORE: LOW TI-FE OXIDE DEPOSITS

Mineville – Port Henry mining district

History The most important iron mining district in the eastern part of the Adirondacks was located in the Mineville-Port Henry region. A very interesting and well documented history of mining in the Mineville area has been written by Farrell (1996); the following brief listing of historical mining events is based upon and compiled from Farrell's book.

The presence of iron ore in this region has been known since 1775. The first significant operating mine in the Mineville district was the Cheever Mine, located north of Port Henry, which was discovered in 1804 (Linney 1943) and opened in 1820 by Charles Fisher. Soon thereafter, the same owner started the works for the Fisher Hill Mine that was worked intermittently until 1893.

Two distinct varieties of iron ore were produced by these mines (Birkinbine 1890): magnetite-apatite and magnetite-silicate ore. The magnetite-apatite ore was produced from what was called the "Old Bed" and the magnetite-silicate ore came from the "New Bed". The name "Old Bed" was derived from an opening made in 1824. In 1829 the "Old Bed" was mined by the Ore Bed Company at the Sanford Pit and the 21 Mine. It was

thought to represent a series of lenses "lying en echelon, or nearly parallel, of varying thickness and dip" (Birkinbine 1890). New mine works were made northwest of the "Old Bed" and produced magnetite-silicate ore. These works opened the "New Bed" along a large area. The "New Bed" was apparently a continuous vein, but was separated in different sub-layers and complicated by faults.

Prior to 1840, the Barton Hill Mine began as a series of openings on a magnetite body that seemed to be the northern continuation of the New Bed. The extensive development of iron mining in the area took place after 1849 when the properties came into the possession of the Witherbee and the Sherman interests that were later incorporated into Witherbee, Sherman & Co (Farrell 1996).

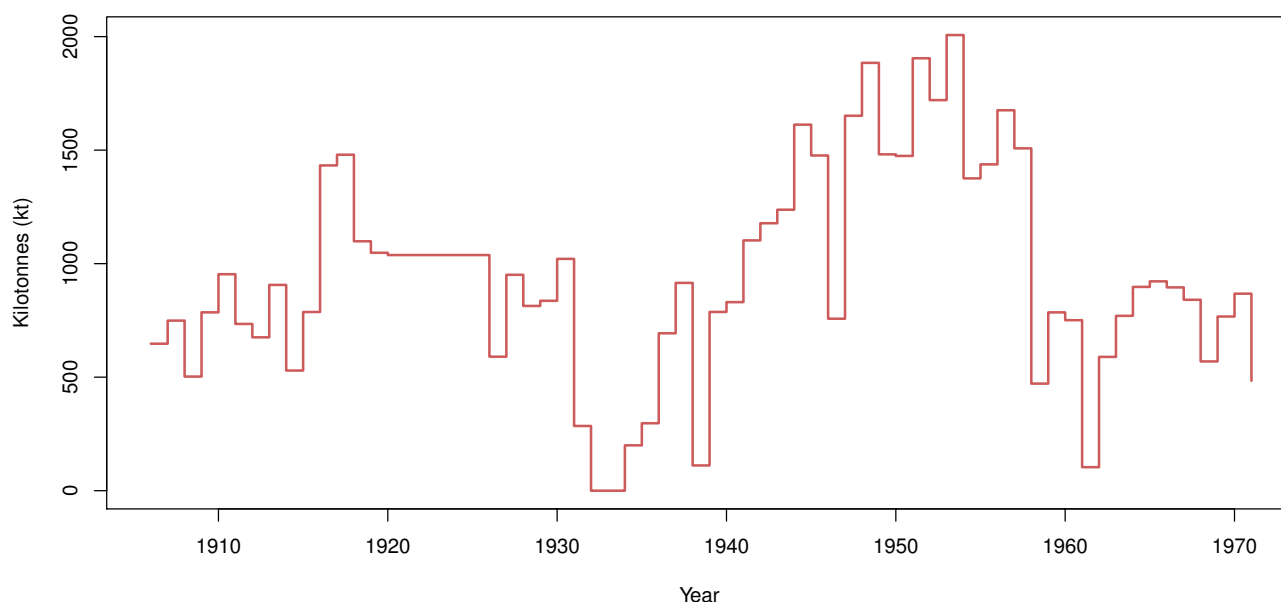
The Mineville-Port Henry Iron Mining District had a cyclical pattern of boom and bust in its long mining history that spanned over 150 years. The various mines were repeatedly opened and then shut down only to be reopened later depending on world events, economic changes, and ownership's interests (Figure 2.2).

Between 1858 and 1900, due to the pressure of economic factors, some of the mines were sold to different groups of investors or the "old" companies changed their names. The decline of the Mineville mining district started around 1875 when only a few mines were operating. The main economic factor that led to this decline was competition from the newly found large and low-cost iron deposits in Minnesota and Michigan. Despite this competition, however, the mining at Mineville experienced a boom around 1900 and it became the largest operating iron district east of Mississippi River (Farrell 1996).

After 1920, the mining activity collapsed again in the Mineville region; a few mines operated until 1932–1933 when they were completely shut down. After 1935, there was an attempt to revitalize the mining, with a small

Table 2.2. Harmful minerals and elements from some iron deposits from the Adirondack Highlands.

Sulfide	Benson Mines	Jayville	Craig Harbor	Tahawus	Chateaugay Mine
Pyrite	•	•	•	•	—
Chalcopyrite	•	—	•	—	•
Pyrrhotite	•	•	•	•	—
Marcasite	•	—	•	—	—
Bornite	•	—	—	—	•
Chalcocite	•	—	—	—	—
Covellite	•	—	—	—	—
Molybdenite	•	•	—	—	—
Pentlandite	—	—	•	—	—
TiO_2	0.37-1.28%	0.54%	—	—	—
P_2O_5	—	—	—	0.45%	0.025%

Fe Production at Mineville, Essex Co. (1906–1971)**Figure 2.2.** Iron production at Mineville, Essex County in the 20th century until 1971 when the mines closed (data from Farrell 1996).

spurt of production in 1936–1937. The Republic Steel Corporation, founded in 1938, leased all the Witherbee Sherman and Company’s properties. Production and mining interest in the area again started to decline, however. The mines were repeatedly shut down and re-opened for short periods until they closed permanently in 1971 (Farrell 1996).

Mineralogical Form Fluorapatite, stillwellite-(Ce), allanite-(Ce), monazite-(Ce), edenite, actinolite, ferro-actinolite, titanite, microcline, albite, and zircon were found in various proportions in the low Ti-Fe oxide (magnetite) ore from the Mineville – Port Henry mines. The ore also contained minor secondary mineral phases of thorite, allanite-(Ce), parisite-(Ce), and monazite-(Ce)

as recognized under the polarizing microscope and by SEM – EDAX in thin/polished sections. A probable lanthanite-(Ce) occurrence, mentioned by Blake (1858), was detected based upon the electron microprobe data. Due to their scarce distribution within the iron ore, these minerals did not affect the ore processing methods; however, some are REE-bearing minerals (lanthanite-Ce, parisite-Ce, allanite-Ce and others) and could be of potential use.

Magnetite is the essential ore mineral of the Mineville – Port Henry iron ore. At Mineville, Beck (1842) described the magnetite crystals as “cuneiform octahedron...but with some edges truncated” and 3 cm in length. The crystallography of magnetite is an important factor especially for the milling process when the min-

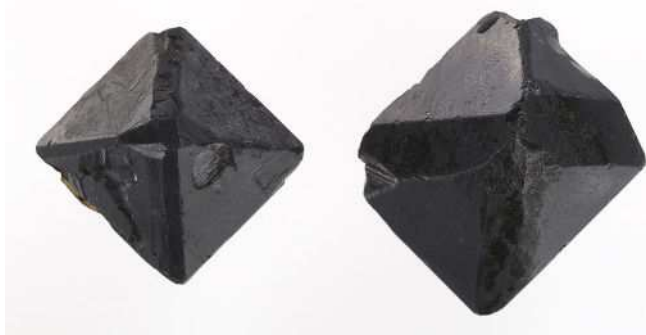


Figure 2.3. Octahedron crystals of magnetite. NYSM 12495. Crystal size: 3.5 x 2.5 x 2.5 cm.



Figure 2.4. Unusual morphology of magnetite crystals (4.7 x 1 x 1.5 cm) resulting from parting along octahedral faces (NYSM 12258).

eral breaks along the mechanical discontinuities such as cleavages and parting planes. This requires, a crystallographic evaluation of magnetite. The principal crystallographic form of the magnetite crystals found in the ore from the Lover's Pit, Barton mine, Mineville was the octahedron (Figure 2.3). Birkinbine (1890) mentioned combinations of octahedron with rhombic dodecahedron, pentagonal dodecahedron, cube, and icositetrahedron.

Some magnetite crystals display "rhombohedral" appearance due to parting of the distorted octahedrons (Figure 2.4). The parting planes (pseudocleavages) are covered with stilpnomelane. Kemp (1890) reported magnetite crystals displaying combinations of octahedron and rhombic dodecahedra with striations parallel to the octahedron faces and interpreted them as pressure-generated pseudocleavages. An average chemical com-

position of magnetite from Mineville shows some variation in the oxides amount: FeO 88.17 – 91.98%; Al_2O_3 0.13 - 0.54%; TiO_2 0.52 – 0.88%; MnO 0.04%, but SiO_2 , MgO, and Cr_2O_3 are very low (Figure 2.5). Titanite, with low amount of vanadium and fluorine, rims magnetite (Figure 2.6).

Ore Grade The iron ore grade from the Adirondack Highlands deposits fits into a large range of values (Table 2.1). The ore from the Mineville mines had the highest grade if compared with the other deposits.

By-products Fluorapatite, monazite (Ce), allanite (Ce), stillwellite (Ce), lanthanite (Ce), and bastnaesite (Ce) host the REE from the Mineville ore. Fluorapatite locally forms almost 50% of the ore in some magnetite bodies. Apatite was first mined in 1852 by the Moriah Phosphate Company with the intention of producing fertilizers. The mine initially exploited the outcrop (Figure 2.8), and the amount of apatite from the surface was greater than it was from the underground works (Maynard 1889). This phosphate came to the attention of Professor Ebenezer Emmons who supervised the American Mineral Company formed in 1853. The company mined mainly apatite for fertilizers and iron as by-product, but it stopped production after short time (Farrell 1996).

A new era for fluorapatite began in 1940 when a U. S. Geological Survey report showed that the phosphate was very rich in rare earth elements. Molycorp, an REE producing company, leased the mineral rights and started recovery of the REE from the tailings, but the feasibility studies were unfavorable and they did not acquire the property. Interest in the REE-bearing fluorapatite was renewed in 1983 when Williams Strategic Metals of Colorado purchased the fluorapatite-rich tailings in 1986 to resell them to Rhone-Poulenc, Inc. a French state-owned company (Farrell 1996). Solvay, a Belgian company, presently has the surface and mineral ownership.

Fluorapatite was found mostly in the ore from the "Old Bed." It has an unusually high thorium concentration of up to 0.15% and total REE concentrations sometimes exceeding 11.14 wt. % (percent by weight) (McKeown and Klemic 1956).

Monazite-(Ce) is another REE-bearing mineral and a possible important by-product at Mineville. Mineville is the unique occurrence of stillwellite-(Ce). in New York. It was found in a sample from the "Old Bed" collected near a fault at the 640 m (2100 ft) level (Mei et al. 1979). Under the electron microprobe, the author of the present study detected some very tiny inclusions in stillwellite-(Ce) that contained 27.05 wt. % Ce_2O_3 , 18.02 wt. % La_2O_3 , 6.44 wt. % Nd_2O_3 , 1.71 wt. % Pr_2O_3 and 1.50 wt.

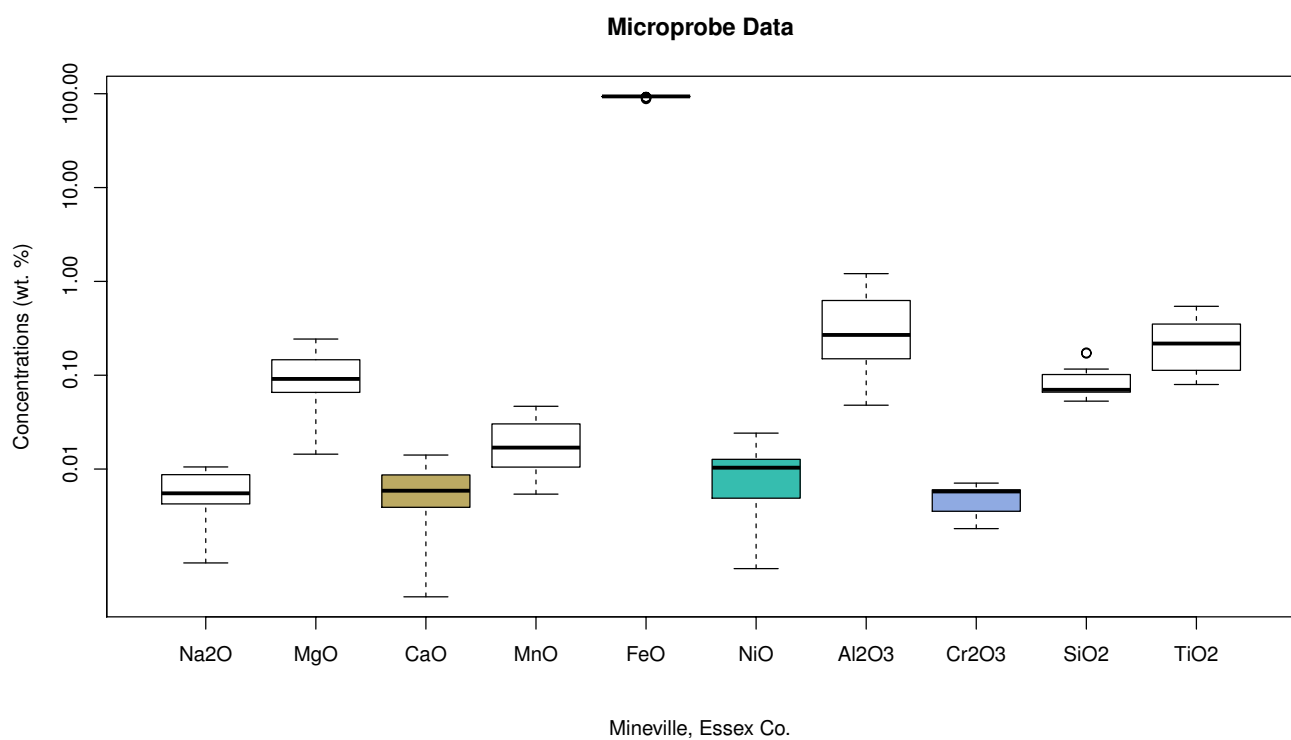


Figure 2.5. Chemical composition of magnetite from Mineville, Essex County (electron microprobe data)

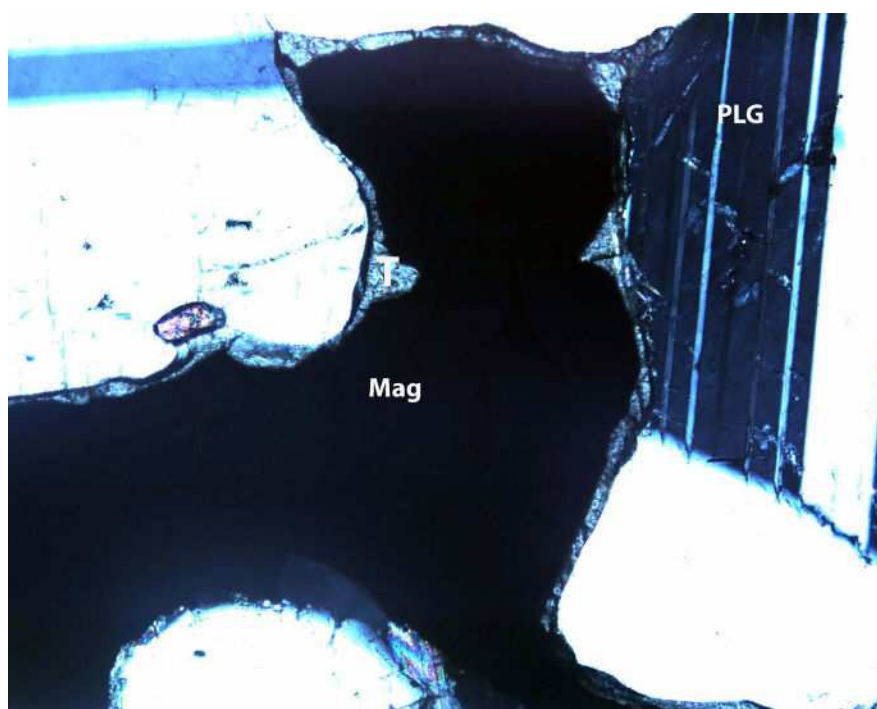


Figure 2.6. Magnetite (Mag) with titanite rim (T) and plagioclase (PLG) in the iron ore from Mineville (cross polars, transmitted light). Field of view 4.5 mm across.



Figure 2.7. Tailings containing REE-bearing fluorapatite at Mineville, Essex County.



Figure 2.8. The historic outcrop of magnetite and apatite ore, Mineville, Essex County.

% Sm_2O_3 . These small grains are probably lanthanite-(Ce).

Undesirable Substances The deleterious minerals and elements in the iron deposits from the Mineville – Port Henry district do not occur in significant amount; the iron ores from this district are generally sulfide-free and titanium minerals such as ilmenite and titanite are very scarce and were easily separated by milling from the magnetite.

Ausable Forks Mining District

History The mines from Arnold Hill and Palmer Hill in the Ausable Forks region were small and not significant competitors for the Mineville – Port Henry district. Arnold Hill was operated by the Arnold Ore Co. shortly after 1806 (Postel 1952). More intense activity was reported by Smock (1889) after 1830. Palmer Hill opened in 1825 according to Newland (1908) or 1844 according to Smock (1889). The production of the district can be estimated only from the data from the old literature.

Smock (1889) mentioned that the total ore extracted from the Arnold Hill mine from its initial opening until 1890 was 400,000 tons, while Newland (1908) stated ca. 600,000 tons. Two companies, the J. & J. Rogers Iron Co. and the Peru Steel Ore Co., shared the mining works and benefits. Both Arnold Hill and Palmer Hill mines lasted until 1890 (Newland 1908). Before 1952, the Republic Steel Corp. acquired the mineral rights for the district from the Witherbee Sherman Co. (Postel 1952).

Mineralogical Form Arnold Hill mine was the main iron ore producer from this mining district. The ore was classified as the “gray”, “black”, and “blue” after the color it presented due to its mineral composition (Postel 1952). The “gray” and “black” ores contain magnetite and the “blue” ore hematite. Magnetite is equigranular, with millimeter-size grains. It is partially replaced by hematite along the contacts and fractures; in the “blue” ore magnetite is completely replaced by hematite. The hematitic composition and the replacement textures could be an important factor in abandoning the mining in this district.

The second important mine from the district is the Palmer Hill mine. Here, magnetite is disseminated in granitic-gneiss and associated with quartz, plagioclase, biotite, and pyroxene.

Ore Grade The ore from the Arnold Hill mine has high grade comparable with that from the Mineville district (Table 2.1). All other mines from Ausable Forks district such as Palmer Hill, Rutgers, and LaVake had low-grade ore.

By-products The iron ore from this district does not have any reported by-products. Fluorapatite is present, in places in significant amount, but the REE content is very low.

Grain Size, Shape, and Mineral Relationships Magnetite grains were equant, display straight contacts with gangue minerals, and a triple junction of 120°. Hematite (Figure 2.9) partial or total, replaced magnetite (martite).

Undesirable Substances The Ausable Forks mines are sulfide-free as all the low Ti-Fe iron oxide deposits from the eastern Adirondacks. Ilmenite and titanite are scarce and phosphorus was in low amount.

Lyon Mountain district

History The iron ore from the Lyon Mountain region was discovered around 1823 at what would later become the Chateaugay mine (Linney 1943), but some preliminary works were reported in 1798 when the first Catalan forge was operated at Plattsburg (Cavallerano and Zimmer 2008; Linney 1943). In 1803, the Baileys’ new Catalan forge processed the iron ore from the Pratt vein of what would later be known as the 81 mine (Linney 1943).

Large scale operations started in 1867, but they did not become significant until 1871. In 1881 the Chateaugay Ore and Iron Co. was organized and it operated the mine until 1902 when the firm became a subsidiary of the Hudson Coal Co., a subsidiary of the Delaware and Hudson Railroad (Gallagher 1937). The mine closed temporarily from 1926 to 1929 because of a recession. Republic Steel Co. leased the mine in 1939. Mining activity in the region stopped definitively in 1968 (Cavallerano and Zimmer 2008).

Mineralogical Form Magnetite is the only ore mineral in the Lyon Mountains mines. Minor ilmenite accompanied magnetite in the ore. Apatite content is quite variable. The rock-forming minerals (gangue) are quartz, microcline, albite, pyroxene, titanite, and amphiboles.

Ore Grade Two types of ore, based on the grade, were mined at the Lyon Mountain mines: high-grade ore (60–70% iron) and low-grade ore (30–40% iron). Most of the ore fits into the second category, but there were some very rich parts of the ore that were smelted without milling (Gallagher 1937).

By-products No by-products were reported from the Lyon Mountains mines.

Grain Size, Shape, and Mineral Relationships Magnetite occurs in two forms: crystals with crystallographic faces (euhedral) and irregular grains and aggregates. The grain size of the magnetite grains generally ranges between 1 and 2 mm. Magnetite size is less than 1 mm when it is disseminated through the host-rock in the low-grade ore and can be around 3 mm in the high-grade ore (Gallagher 1937).

Undesirable Substances Cavallerano and Zimmer (2008) disclosed for the first time the occurrence of a 1 m-wide vein with chalcopyrite and bornite in the magnetite ore from the Lyon Mountain mines. The vein was found in the early 1940s, but the management team of the mine did not allow the discovery to be made public because of the fear that it could “degrade the ore’s quality in comparison to other New York mining ventures” (Cavallerano and Zimmer 2008).

Jayville and Benson Mines

History In the central-western Adirondacks, the Jayville iron deposit opened in 1854 and was operated by Z. H. Benson. The B. D. Benson interests leased the property in 1886 and operated it as the Magnetic Iron Ore Co., but stopped the activity in 1888 when they moved the mining equipment to the Little River iron deposit, now known as the Benson mines (Leonard and Buddington 1964).

The magnetic anomaly at the future Benson mines location was discovered in 1810 when engineers working on a military road from Albany to Ogdensburg found a magnetic disturbance as they crossed over the magnetite deposit (Crump and Beutner 1970). The Magnetic Iron Ore Co. explored the deposit in 1889 after abandoning the Jayville mine, but only a small production was reported.

The mining works stopped in 1893 because of the depression and market competition from the low-cost Lake Superior region ore. Benson Mines Co. started to operate an open pit at the site in 1907 but abandoned it in 1919. Years later in 1941, because of increased demand for wartime production, the Jones and Laughlin Co. leased the property. They operated it until 1978 when the mine was definitively closed (Crump and Beutner 1970).

Mineralogical Form Magnetite and hematite are the principal ore constituents at the Benson mines; here, magnetite occurs as disseminations or compact bands in association with sillimanite, garnet, quartz, and plagioclase. Palmer (1970) reported the following composition for the magnetite ore: SiO_2 49.45%; FeO (total Fe) 28.44%; MgO 1.45%; TiO_2 0.83%; P_2O_5 0.3%.

Hematite (specularite) from the Benson mines displays good basal cleavage, and polysynthetic twinning.

In some parts of the ore it replaces magnetite (martite) along the octahedron parting (Crump and Beutner 1970). Titanium minerals such as ilmenite, anatase, rutile, titanite, and leucoxene are special correlated with hematite ore (Hagni 1968).

Ore Grade At the Benson mines the iron ore is divided into magnetic (magnetite) and non-magnetic (hematite) ore based on the mineral composition and processing characteristics. The reported ore grade was under or similar to the actual lower average, but some uncommon values of more than 50% were mentioned (Crump and Beutner 1970).

By-products Magnetite from Jayville is intimately associated with vonsenite, an iron borate that has not been taken into consideration as a by-product even though it forms in places ca. 40% to 60% of the ore (Leonard and Buddington 1964). The major uses of boron compounds are in sodium perborate bleaches, and the borax component of fiberglass insulation. Boron compounds play specialized roles as high-strength lightweight structural and refractory materials. They are used in glass and ceramics to give them resistance to thermal shock.

Grain Size, Shape, and Mineral Relationships Magnetite (> 1 mm in size) is associated with vonsenite (same size as magnetite) at Jayville. Replacement textures such as bornite on chalcopyrite, chalcocite on bornite, and covellite on chalcocite were found at the Benson Mines. Hagni (1968) described from the Benson mines ilmenite exsolution as patches of 1 to 10 microns wide in hematite, anatase laths accompanying ilmenite exsolution in hematite, and rutile as exsolution in magnetite.

Undesirable Substances The sulfides (Table 2.2), pyrite, chalcopyrite, bornite, and chalcocite, were common at the Benson mines and preferentially localized in some of the ore bodies (Crump and Beutner 1970).

CHARACTERIZATION OF THE IRON ORE: TI-FE DEPOSITS

Tahawus, Split Rock, and Craig Harbor Mines

History Tahawus (Sandford Lake) is the most economically significant Ti-Fe oxide deposit in the Adirondacks. It was found in 1826 when a Native American showed Euro-Americans the ore outcrop. A blast furnace was built in 1838 and another one in 1854, but recession, impure ore, and other circumstances led to abandonment of the deposit. A new attempt to restart the mining operations was made in 1894. The National Lead Company acquired the deposit and production was in full activity

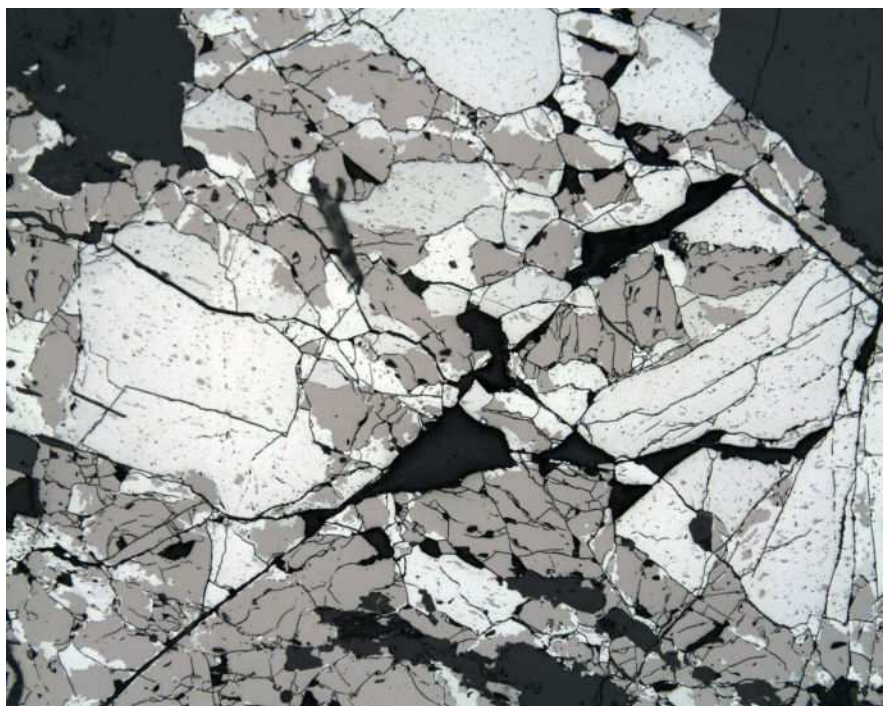
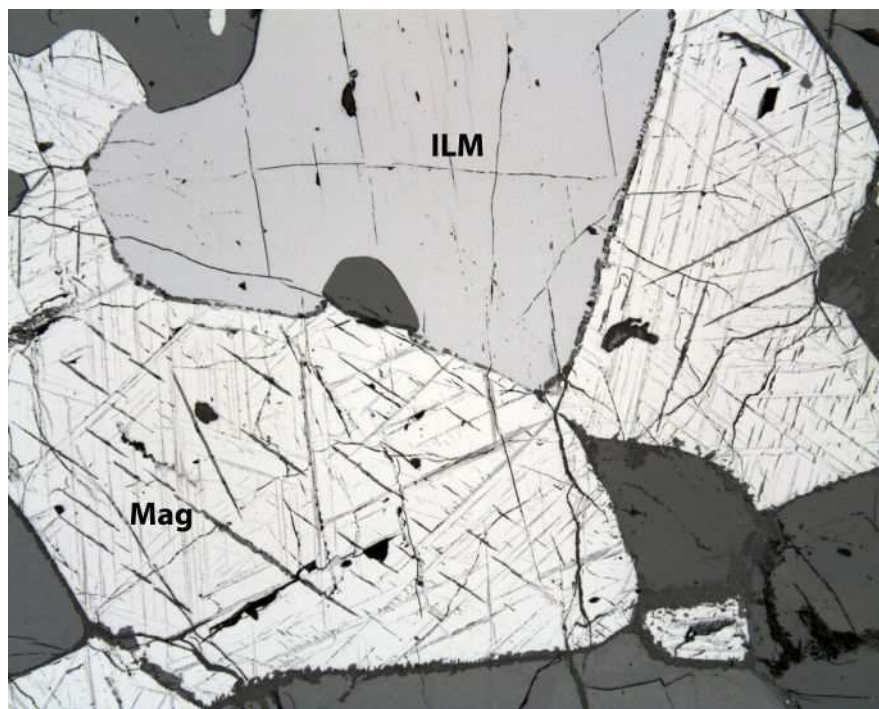


Figure 2.9. Hematite (white and very light gray) replacing magnetite (brown-gray), Arnold Hill, Clinton County (one polar, reflected light); field of view: 3.9 mm across.

Figure 2.10. Magnetite (Mag) with spinel exsolutions along {111} and {100} (spindle-like gray crystals) and ilmenite (ILM), Craig Harbor mine, Essex County (one polar, reflected light); field of view 3.5 mm across.



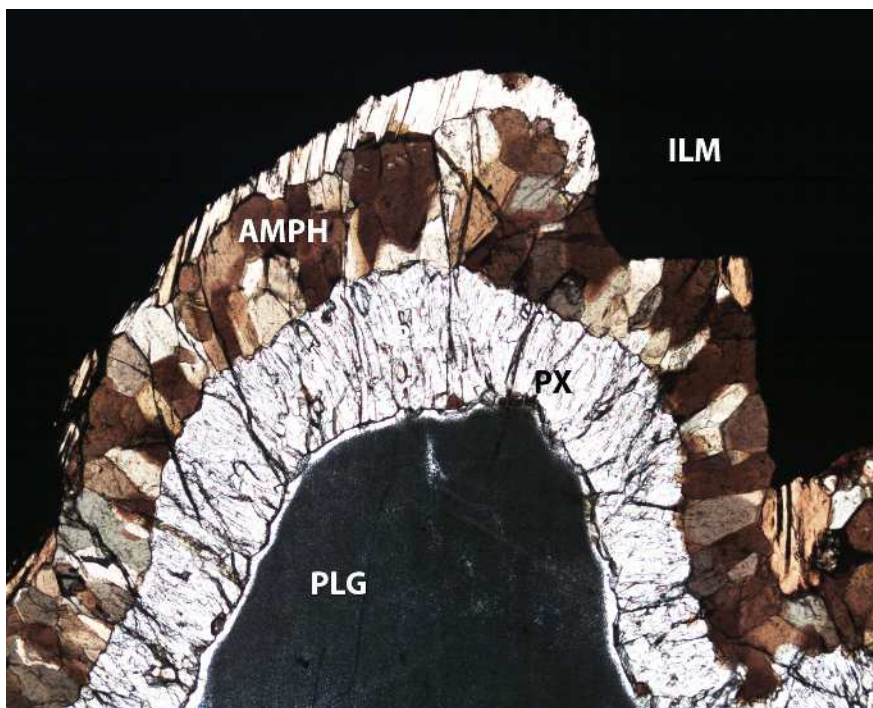


Figure 2.11. “Cloudy” plagioclase (PLG) rimmed by pyroxene (PX), amphibole (AMPH) and ilmenite (ILM). The plagioclase is “cloudy” due to multiple grains of spinel. Photograph taken with cross polars in reflected light, Split Rock mine, Essex County.

in 1942. The mine closed for good in 1982 (Kelly and Darling 2002).

There are no detailed data on the history of discovery and production of the Split Rock and Craig Harbor mines. According to information obtained from the Smock (1889) and Newland (1908) reports, the Split Rock mine probably opened in 1874 and lasted until 1889.

The Craig Harbor mine situated above the Lake Champlain shore in Port Henry was not an important mining operation. It was mentioned by Emmons (1842) as a small mining development, but was not cited by subsequent researchers.

Mineralogical Form The titaniferous magnetite from Tahawus contains a magnetite-spinel solid solution with the following composition; magnetite 81% and ulvospinel 19% (Kelly 1979). Vanadium is mentioned in the composition of magnetite, but no vanadium mineral was found (Gross 1970).

The ore from the Craig Harbor and Split Rock small mines contains magnetite and ilmenite associated with amphibole, pyroxene, plagioclase, and olivine. The host-rock from the Split Rock mine is “cumberlandite”, a variety of the igneous rock dunite; it contains ilmenite, magnetite, olivine, rare plagioclase, and spinel.

The hemo-ilmenite from Tahawus is a solid solution between hematite and ilmenite and contains 94% ilmenite and 6% hematite (Kelly 1979). Ilmenite occurs in small grains in equigranular aggregates with or rimming magnetite.

By-products When the Tahawus deposit came into production magnetite was not considered the main commodity because the first owners were not aware of the occurrence of ilmenite in the ore (Kelly and Darling 2002). Ilmenite by itself is not profitable for the iron ore as the titanium inhibits the smelting process. Thus, the presence of titanium was one of the main reasons that contributed to the decision to close the mine before 1894.

Since 1942 ilmenite has become the main commodity. Ilmenite is used in the manufacture of titanium dioxide for paint pigments, for a wide variety of metal parts where light weight and very high strength parts are needed such as aircraft parts, artificial joints for humans and sporting equipment such as bicycle frames and in a number of high-performance alloys. According to Kelly and Darling (2002) 12,000,000 tons of ilmenite and 17,000,000 tons of magnetite were processed and 32,000,000 tons of ilmenite and 21,000,000 tons of magnetite are still in the deposit.

Ore Grade We do not have any information about the ore grade at the Craig Harbor and Split Rock mines. The Tahawus massive ore shows the following chemical composition 4.59% SiO_2 , 18.58% TiO_2 , 5.48% Al_2O_3 , 66.37% FeO , 0.01% P_2O_5 , and 0.45% V_2O_5 (Kelly and Darling 2002). The ratio Fe/TiO_2 differs with the ore-type. The anorthosite ore shows 2:1 and the gabbroic ore a less than 2:1 Fe/TiO_2 ratio (Gross 1970).

Grain Size, Shape, and Mineral Relationships Exsolution textures between oxides, oxide – silicate, and sulfides are common in many of the Ti - Fe oxide deposits.

Spinel exsolution along the {111} and {100} faces of magnetite (Figure 2.10) were found in thin/polished sections at the Tahawus, Craig Harbor, and Split Rock mines. Spinel exsolution in plagioclase (“cloudy” plagioclase), a characteristic of the Grenville coronitic gabbros and anorthosites, were identified from Tahawus and Split Rock mine (Figure 2.11).

Undesirable Substances Sulfides were common enough at the Craig Harbor, and to a lesser extent at Tahawus. The sulfides generally form narrow veinlets cutting the ore or disseminations within it. At the Craig Harbor mine the sulfides are part of the entire ore. At Tahawus, sulfides occurred between the ilmenite-magnetite ore and the anorthosite or the gabbroic ore and anorthosite (Gross 1970).

CONCLUSIONS

1. Iron was historically an important commodity for New York and New York State was one of the main iron suppliers of the USA during the nineteenth century;
2. The New York main iron deposits were located in rocks formed during Grenville Orogeny and their origin is still controversial;
3. Magnetite was the principal component of the ore. The magnetite ore occurred as lens-like, sheets, and dikes in granites, gneisses, anorthosites, and gabbros;
4. Magnetite was associated with by-products such as fluorapatite and vonsenite. If fluorapatite was used as fertilizer-producing material and thought of as a potential rare earth element ore, vonsenite was never considered of interest for its boron component;
5. The deleterious substances and elements (sulfides, phosphorus, and titanium) did not influence significantly the iron ore processing. The ore grade, texture, and gangue minerals were also favorable to the designated processing recipes;
6. The decline of the iron industry in New York was related not to the quality of the ore, but to the discovery of the new low-cost iron deposits from Minnesota and Michigan;
7. The iron deposits of New York were significant not only from an industrial point of view, but also as a museum-quality producing specimen sites. They offer an important hint to the origin of the iron deposits located in the granulite facies rocks.

ACKNOWLEDGMENTS

Sincere thanks to Marty Pickands for inviting me to write a paper for this volume and for his effort to edit it, Janet Manchester for the map drafting, and to the reviewers for their useful comments.

REFERENCES

- Alling, H. L. 1925. “Genesis of the Adirondack magnetites.” *Economic Geology* 20:335–363. (Cited on page 43).
- Baker, D. R., and A. F. Buddington. 1970. *Geology and Magnetite Deposits of the Franklin Quadrangle and Part of the Hamburg Quadrangle, New Jersey*. Professional Paper 638. Washington, D. C.: U.S. Geological Survey. (Cited on page 43).
- Beck, L. C. 1842. *Mineralogy of New York*. Albany, New York: W. & A. White / J. Visscher. (Cited on page 47).
- Birkinbine, J. 1890. “Crystalline Magnetite in the Port Henry, New York Mines.” *Transactions of the American Institute of Mining Engineering* 18:747–762. (Cited on pages 46, 48).
- Buddington, A. F. 1939. “Adirondack Igneous Rocks and Their Metamorphism.” *Geological Society of America Memoirs* 7:1–343. (Cited on page 43).
- Cavallerano, E. J., and P. W. Zimmer. 2008. “History and Geology of the Chateaugay Mine, Lyon Mountain, New York, With a Discussion of Previously Unreported Minerals.” *Rocks & Minerals* 84:446–453. (Cited on pages 46, 51, 52).
- Crump, R. M., and E. L. Beutner. 1970. “The Benson Mines Iron Ore Deposit, St. Lawrence County, New York.” In *Ore Deposits in the United States 1933/1967*, edited by J. D. Ridge, 2:49–71. The Graton Sales. Englewood, Colorado: American Institute of Mining, Metallurgical, / Petroleum Engineers. (Cited on pages 46, 52).
- Emmons, E. 1842. *Geology of New York, Part II: Survey of the Second Geological District*. Albany, New York: W. & A. White & J. Visscher. (Cited on page 54).
- Evans, A. M. 1993. *Ore Geology and Industrial Minerals: An Introduction*. Malden, Massachusetts: Blackwell Science, Ltd. (Cited on pages 44, 45).
- Farrell, P. 1996. *Through the Light Hole, a Saga of Adirondack Mines and Men*. Utica, New York: North Country Books. (Cited on pages 46–48).
- Foose, M. P., and J. M. McLelland. 1995. “Proterozoic Low-Ti Iron-Oxide Deposits in New York and New Jersey: Relation to Fe-oxide (Cu-U-Au- rare element) Deposits and Tectonic Implications.” *Geology* 23:665–668. (Cited on page 43).
- Gallagher, D. 1937. *Origin of the Magnetite Deposits at Lyon Mountain, N.Y.*. New York State Museum Bulletin 311. Albany: The University of the State of New York. (Cited on pages 51, 52).

- Geraghty, E. P., Y. W. Isachsen, and S. F. Wright. 1981. *Extent and Character of the Carthage-Colton Mylonite Zone, Northwest Adirondacks, New York*. Submitted to the U.S. Nuclear Regulatory Commission. Albany, New York: New York State Geological Survey. (Cited on page 43).
- Gross, S. O. 1970. "Titaniferous Ores of the Sanford Lake District, New York." In *Ore Deposits of the United States, 1933-1967*, edited by J. D. Ridge, 2:141–153. The Graton Sales. Englewood, Colorado.: American Institute of Mining, Metallurgical, / Petroleum Engineers. (Cited on pages 46, 54, 55).
- Hagni, R. D. 1968. "Titanium Occurrence and Distribution in the Magnetite—Hematite Deposit at Benson Mines, New York." *Economic Geology* 63:151–155. (Cited on page 52).
- Kelly, W. M. 1979. "Chemistry and Genesis of Titaniferous Magnetite and Related Ferromagnesian Silicates, Sanford Lake Deposits, Tahawus, New York." Unpublished Ph.D dissertation, University of Massachusetts, Amherst. (Cited on page 54).
- Kelly, W. M., and R. Darling. 2002. "Geology and Mining History of the Barton Garnet Mine, Gore Mt. and the NL Ilmenite Mine, Tahawus, NY with a Temporal Excursion to the Macintyre Iron Plantation of 1857." In *Guidebook*, edited by J. McLelland and P. Karabinos, B3-1–B3-14. New York State Geological Association. (Cited on page 54).
- Kemp, J. F. 1890. "Notes on the Minerals Occurring Near Port Henry, N. Y.." *American Journal of Science* 40:62–64. (Cited on pages 43, 46, 48).
- . 1897. "The Geology of the Magnetites Near Port Henry, N. Y. and Especially Those of Mineville." *Transactions of the American Institute of Mining Engineers* 27:147–203. (Cited on page 43).
- Kemp, J. F., and R. Ruedemann. 1910. *Geology of the Elizabethtown and Port Henry Quadrangles*. New York State Museum Bulletin 138. Albany: The University of the State of New York. (Cited on page 43).
- Leonard, B. F., and A. F. Buddington. 1964. *Ore Deposits of the St. Lawrence County Magnetite District, Northwest Adirondacks, New York*. Professional Paper 377. Washington, D.C.: U.S. Geological Survey. (Cited on page 52).
- Linney, R. J. 1943. "A Century and A Half of Development Behind the Adirondack Iron Mining Industry." *Mining and Metallurgy* 24 (443): 480–487. (Cited on pages 43, 46, 51).
- Maynard, G. W. 1889. "The Iron Ores of Lake Champlaine." *Journal of British Iron and Steel Institute* v i:114. (Cited on page 48).
- McKeown, F. A., and H. Klemic. 1956. *Rare-Earth-Bearing Apatite at Mineville, Essex County, New York*. Bulletin 1046. Washington, D.C: U. S. Geological Survey. (Cited on pages 45, 48).
- McLelland, J. M., M. E. Bickford, B. M. Hill, C. C. Clechenko, J. W. Valley, and M. A. Hamilton. 2004. "Direct Dating of Adirondack Massif Anorthosite by U-Pb SHRIMP Analysis of Igneous Zircon: Implications for AMCG Complexes." *Geological Society of America Bulletin* 116:1299–1317. (Cited on page 44).
- McLelland, J. M., and J. R. Chiarenzelli. 1990a. "Geochronological Studies of the Adirondack Mountains, and the Implications of a Middle Proterozoic Tonalite suite." In *Mid-Proterozoic Laurentia-Baltica*, edited by C. F. Gower, A. B. Ryan, and T. Rivers, 175–194. Special Paper 38. St. John's, Newfoundland: Geological Association of Canada. (Cited on page 44).
- . 1990b. "Geochronology and Geochemistry of 1.3 Ga Tonalitic Gneisses of the Adirondack Highlands and Their Implications for the Tectonic Evolution of the Grenville Province." In *Middle Proterozoic Crustal Evolution of the North American and Baltic Shields*, edited by A. B. Ryan, T. Rivers, and C. . Gower, 175–196. Special Paper 38. St. John's Newfoundland: Geological Association of Canada. (Cited on page 44).
- McLelland, J. M., and J. S. Daly. 1996. "The Grenville Orogenic Cycle (ca. 1350-1000 Ma): An Adirondack Perspective." *Tectonophysics* 265:1–28. (Cited on page 44).
- Mei, L., R. R. Larson, P. J. Loferski, and H. Klemic. 1979. *Analyses and Description of a Concentrate of Stilwellite from Mineville, Essex County, New York*. Open File Report 79-847. Washington, D. C.: U. S. Geological Survey. (Cited on page 48).
- Montario, M. J., J. I. Garver, and A. Marsellos. 2008. "Annealing of Radiation Damage in a Grenville Zircon from the Eastern Adirondacks, NY State." In *Proceedings from the 11th International Conference on Thermochronometry*, edited by J. I. Garver and M. J. Montario, 174–176. Anchorage, Alaska. (Cited on page 44).
- Nason, F. L. 1922. "The Sedimentary Phases of the Adirondack Magnetic Iron Ores." *Economic Geology* 17:633–654. (Cited on pages 43, 46).
- Newland, D. H. 1908. *Geology of the Adirondack Magnetic Iron Ores, with a Report on the Mineville-Port Henry Mine Group by James F. Kemp*. New York State Museum Bulletin 119. Albany: The University of the State of New York. (Cited on pages 51, 54).
- Palmer, D. F. 1970. "Geology and Ore Deposits Near Benson Mines, New York." *Economic Geology* 65. (Cited on page 52).
- Postel, A. W. 1952. *Geology of Clinton County Magnetite District, New York*. Professional Paper 237. U.S. Geological Survey. (Cited on pages 46, 51).
- Rivers, T. 2008. "Assembly and Preservation of Lower, Mid, and Upper Orogenic Crust in the Grenville Province - Implications for the Evolution of Large Hot

- Long-duration Orogens." *Precambrian Research* 167:237–259. (Cited on page 43).
- Roden-Tice, M., S. Tice, and I. S. Schofield. 2000. "Evidence for Differential Unroofing in the Adirondack Mountains, New York State, Determined by Apatite Fission-Track Thermochronology." *Journal of Geology* 108:155–169. (Cited on page 44).
- Smock, J. C. 1889. *First Report on the Iron Mines and Iron-ore Districts in the State of New York*. Bulletin 7. Albany: New York State Museum of Natural History. (Cited on pages 43, 51, 54).
- Streepey, M. M., E. L. Johnson, K. Mezger, and B. A. van der Pluijm. 2001. "Early History of the Carthage-Colton Shear Zone, Grenville Province, Northwest Adirondacks, New York (U.S.A.)." *Journal of Geology* 109:479–492. (Cited on page 43).
- Taylor, J. P., and P. G. Fitzgerald. 2011. "Low-Temperature Thermal History and Landscape Development of the Eastern Adirondack Mountains, New York: Constraints from Apatite Fission-Track Thermochronology and Apatite (U - Th)/He Dating." *Geological Society of America Bulletin* 123:412–426. (Cited on page 44).
- Tyler, S. A., and R. E. Wilcox. 1942. *Geological report on the Jayville area. Pitcairn Township, St. Lawrence County, New York*. Private rept. to Jones & Laughlin Steel Corp. (Cited on page 46).

IRON-RICH SEDIMENTARY DEPOSITS OF NEW YORK: AN OVERVIEW

Charles A. Ver Straeten

Iron (Fe) is a minor component of most sediments and sedimentary rocks. However, under some conditions and at certain times in the geologic past, iron-rich sedimentary deposits (>15% Fe) have formed. This paper summarizes the characteristics and formation of nine different types of iron-rich sediments and sedimentary rocks, which may form through processes of chemical weathering, physical concentration, or chemical precipitation of Fe. Eight of these occur in New York State. They include residual limonite masses, iron sand placers, Clinton hematite ores, bog iron, iron-manganese nodules, siderite (+/- ankerite), and iron pyrite. From colonial times into the 1800s, five of these were utilized as sources of iron by local and regional foundries to produce goods for local to distant trade. One type, the Clinton ironstones, continued to be an important economic resource into the early 1900s, when it was replaced by iron deposits in the Great Lakes region of the northern Midwest.

Iron (Fe) is one of the most common elements on Earth, comprising about 7 to 8% of the crust by mass (Faure 1998). Iron generally occurs in small amounts in sedimentary rocks, comprising <1% of total sedimentary rocks (Boggs 1995). The average iron concentration for common sedimentary rocks such as sandstone, shale and limestone is 2-4%, 4-6% and less than 1%, respectively (Prothero and Schwab 1996).

While iron is generally uncommon in sediments and sedimentary rocks, under certain conditions and during specific times in the geologic past, relatively concentrated iron-rich deposits have been formed. Sometimes termed "ironstones," they can be of significant economic importance. Such iron-rich sedimentary rocks contain 15% or more [iron](#).

The Fe mineralogy found in iron-rich sediments and sedimentary rocks includes the oxide minerals hematite (Fe_2O_3) and magnetite (Fe_3O_4), the iron carbonate minerals siderite (FeCO_3) or ankerite ($(\text{Fe,Ca,Mg})(\text{CO}_3)_2$), the oxyhydroxide mineral goethite ($\text{FeO}(\text{OH})$) and associated iron oxyhydroxides generally lumped together under the term "limonite" (generic formula $\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$, see Bridge and Demicco 2008, Table 4.4). Other iron-rich minerals found in sedimentary

rocks include the sulfide minerals pyrite and marcasite, and iron silicates such as chamosite and glauconite.

Various types of iron-rich sediments and sedimentary rocks form through different geologic processes:

1. residual deposits formed by weathering processes (e.g., laterite soils and limonites);
2. placer deposits formed by sedimentary concentration of relatively denser mineral grains (e.g., Fe-rich "iron sands");
3. deposits formed by precipitation of various iron minerals (e.g., "banded iron formations," Clinton-type hematites, bog iron, iron-manganese nodules); and
4. deposits that may originate as precipitated sediments, or as diagenetic (unmetamorphosed) deposits formed in the sediments or rocks long after their burial (e.g., siderite and iron pyrite).

The iron in sediments and sedimentary rocks may occur as masses of iron-rich materials, as discrete clastic grains weathered from older rocks, as chemical precipitates which may occur as discrete grains (e.g., nodules/concretions/ooids) or as a fine matrix which fills in between and may cement together larger sediment grains (e.g., sand).

Iron-rich sediments and sedimentary rocks have been and continue to be significant economic resources. In pre-industrial times, iron was primarily sourced from deposits of goethite/limonite (including "bog ore") and laterite. With the rise of local and regional iron foundries, for example in New York from the 1700s to early 1900s, various sources of iron were utilized, depending on what was available in the area (e.g., bog iron, limonite, magnetite, hematite, siderite). With the rise of global-scale industrialization, hematite and magnetite became the dominant sources of iron.

The purpose of this article is to examine the different types of iron-rich sediments and sedimentary rocks and their occurrence in New York State (Figure 3.1). To this end, literature from geological, historical and archaeological sources was utilized, as well as discussions with numerous historians, archaeologists and geologists. Much of what is found herein is a summary of those findings. However, some new preliminary research by the author into the occurrence and history of

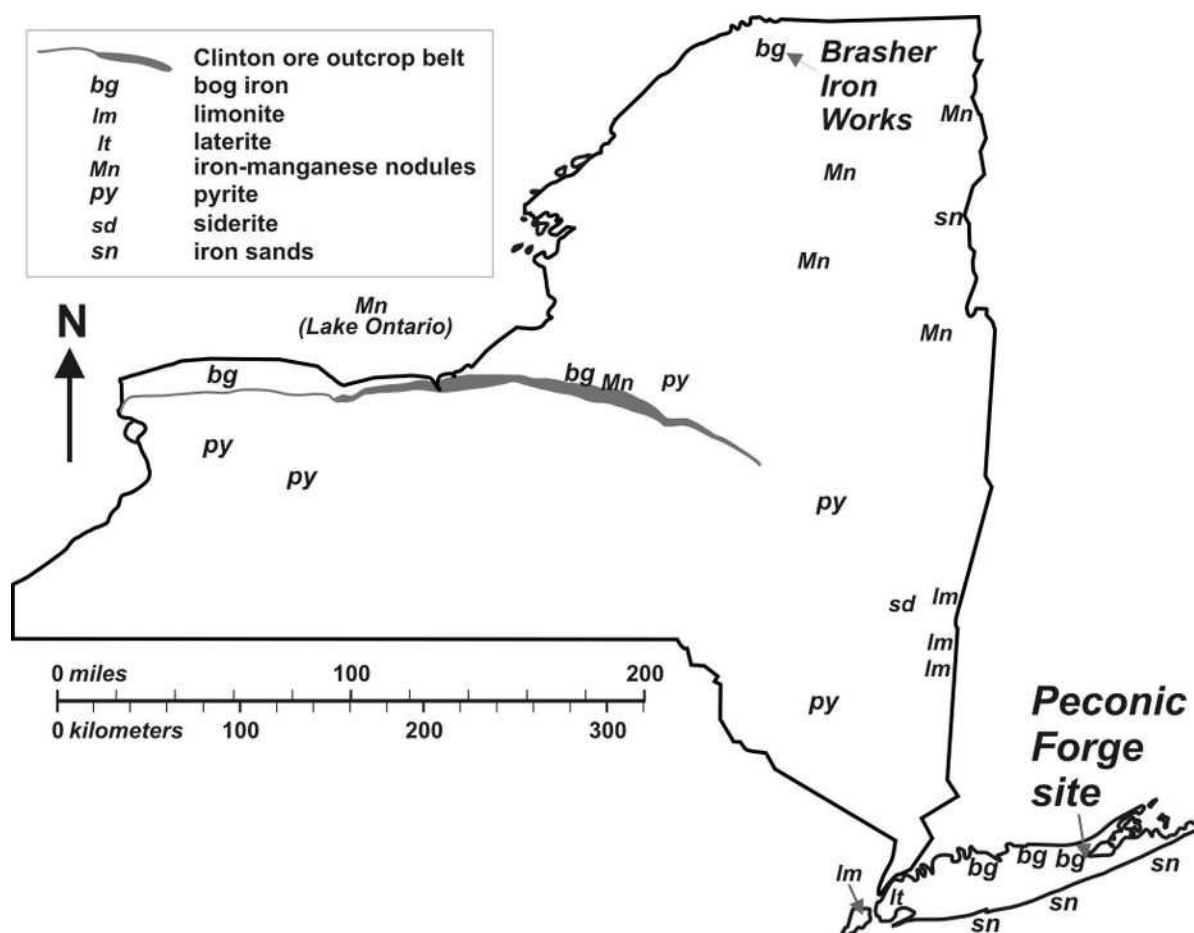


Figure 3.1. Map of select New York State iron deposits, discussed in chapter. The band of dark gray across central to western New York demarcates the outcrop belt of the Clinton iron ore. Abbreviations: Pec = site of the Peconic Iron Forge site, eastern Long Island; Br = site of the Brasher Iron Works, northeast St. Lawrence Co. For other abbreviations, see key.

use at New York localities is also included. The intent of this paper is to provide an overview of these sedimentary sources of iron for sedimentary and economic geologists, historians and archaeologists and to provide information on little known but potential iron sources for traditional/artisan blacksmiths.

Note that in this paper, the word “deposit” is used in the geological sense of a sedimentary layer or layers deposited by physical or chemical processes rather than in the economic sense of an “ore deposit,” for which the concentration or grade of an ore would then be provided.

SEDIMENTARY IRON ORES: TYPES AND OCCURRENCES IN NEW YORK

Iron-rich sediments and sedimentary rocks are divided here into four chief categories: residual weathering deposits, placer deposits, those that form initially as precipitated sediments, and those which may form as post-burial diagenetic (unmetamorphosed) minerals. Any of these categories of sediment may later become

sedimentary rocks. For each category, an overview is presented followed by a discussion of various types and their occurrence and history in New York State.

Fe-rich Residual Weathering Deposits

Some iron-rich sedimentary deposits (Figure 3.2) form from weathering of older iron-rich rocks. These “residual-type” iron sediments and sedimentary rocks generally form over long periods of exposure and weathering of bedrock and/or soils, often at major erosional surfaces (unconformities). They may occur as goethite/limonite deposits, or as laterite soils and can form in at least two ways: 1) through the *in situ* weathering of iron-rich deposits at and near the Earth’s surface; or 2) through the accumulation from broad regions of weathered iron-rich deposits transported in solution or as clastic material and deposited in low areas (Newland 1936; Robb 2005).

Laterites

Laterites are soil-type sedimentary deposits rich in iron and aluminum. They form through long-term weathering and leaching of silicate minerals in well-drained, acidic soils in the tropics (Bridge and Demicco 2008; Leeder 1999; Prothero and Schwab 1996). The resultant lateritic soils, rich in iron oxides, aluminum oxides and clays, were important pre-industrial sources of iron and aluminum.

Blank (1978) describes Precambrian-age gneisses at a site Brooklyn, overlain locally by an upward progressively more deeply-weathered residuum of the gneiss, succeeded by a sandy, clay-rich layer with concretions. He interpreted the latter to be a laterite soil. The laterite, or in its absence the gneiss, is variously overlain by Cretaceous- or Pleistocene-age sediments.

Limonites

Significant limonite (iron oxyhydroxide; 'rust')-rich deposits occur locally in the area east of the Hudson River in New York and western New England, including the Taconic Mountains (Figures 3.1 and 3.2). These were formerly important economic sources of iron in New York (Newland 1936; Smock 1889). Field and petrographic evidence led Newland (1936) to conclude that many of the Taconic iron ore deposits fit the *in situ* weathering model outlined above. Surface to near-surface Taconic limonite deposits can be seen to transition laterally and at depth to unweathered, deformed layers of siderite-rich rocks within stratified, somewhat metamorphosed limestones and shales. These limonites formed through in-situ, post-glacial surficial weathering of sedimentary rocks over the last ca. 18,000 years.

In the eastern belt of the Taconics, in easternmost New York and western New England, limonitization can reach over 60 meters deep; laterally, however, the same seams occur as unweathered siderite ore. Newland (1936) interpreted at least some of this deep weathering to have occurred over a longer stretch of time that he termed "pre-glacial".

Additional residual-type limonite deposits derived from sedimentary limestones have been reported from Westchester and Orange counties by Smock (1889, 62).

On Staten Island, Britton (1882, 175-7), Hunt (1886, 268-9), Smock (1889, 61-2), and Fettke (especially 1912) documented residual-type limonite deposits. These limonites, which were formerly mined on Staten Island, are derived from the weathering of underlying serpentine deposits, which in turn originally formed from metamorphosed oceanic crust (peridotite). Hunt reported that the limonite, which occurs locally, can be as much as 3.7 meters (12 feet) thick. Fettke interpreted these deposits to be laterite soils; Marian Lupulescu (personal communication 2011) states that this is unlikely.

Fe-Rich Sedimentary Placer Deposits

Placer deposits are concentrations of relatively dense sediment grains, separated from less dense grains by the action of water and wind. Placers may concentrate economically important minerals like gold, diamonds, magnetite, ilmenite and others in stream, beach and dune environments. Further concentration and separation of preferred minerals is achieved by modern technologies, making placer mining profitable in some places. Detailed discussion of the natural mechanics involved in concentrating heavy minerals on beaches is provided by Komar and Wang (1984) and Komar (2007), and in stream/fluvial settings and via wind processes by Robb (2005).

Iron Sands

Iron sands are sediment deposits rich in dense mineral grains including magnetite, hematite, ilmenite and other metals, as well as minerals such as garnets and zircons (Komar and Wang 1984). These are commonly seen along beaches as dark streaks or patches in the swash zone. Such so-called "black sands," with abundant iron-rich heavy minerals, are well known in areas of Florida, Australia, New Zealand, India and South Africa (Robb 2005), where they may be mined.

Relatively iron-rich sands occur in New York (Figures 3.1, 3.3), such as on the south shore beaches of Long Island, in rivers and deltas draining the Adirondacks, and on the shores of other lakes and rivers through the state (Beck 1842, 22; Merrill 1895, 542; Smock 1889; Thompson 1839, 29-30). Historically, some of these placers have on occasion been mined and separated for smelting (e.g., New York Times 1884). Thomas Edison's recognition of iron-rich sands on the south shore of Long Island led to his invention of early types of mechanical magnetic separators and his involvement in iron mining ventures (Anderson 1980; Baldwin 2001, 213-4, 471-2; Welland 2009). Michael McCarthy, a New York artisan blacksmith and pioneer in the redevelopment of traditional iron smelting technology, collected and utilized iron sands from Lake Champlain for an iron smelting demonstration during the "Iron In New York" symposium held at the New York State Museum in October 2010.

A newspaper article in the mid-1880s reported on the work of a primitive, small-scale (three men, one horse) iron sand mining and separation operation on the beach of Fire Island, on the south shore of Long Island. The following excerpt from the article describes the separating technique and mechanism used, and their yield.

The mechanism consists of a long oblique trough, a wooden cylinder studded with magnets, and a brush attachment. The load of

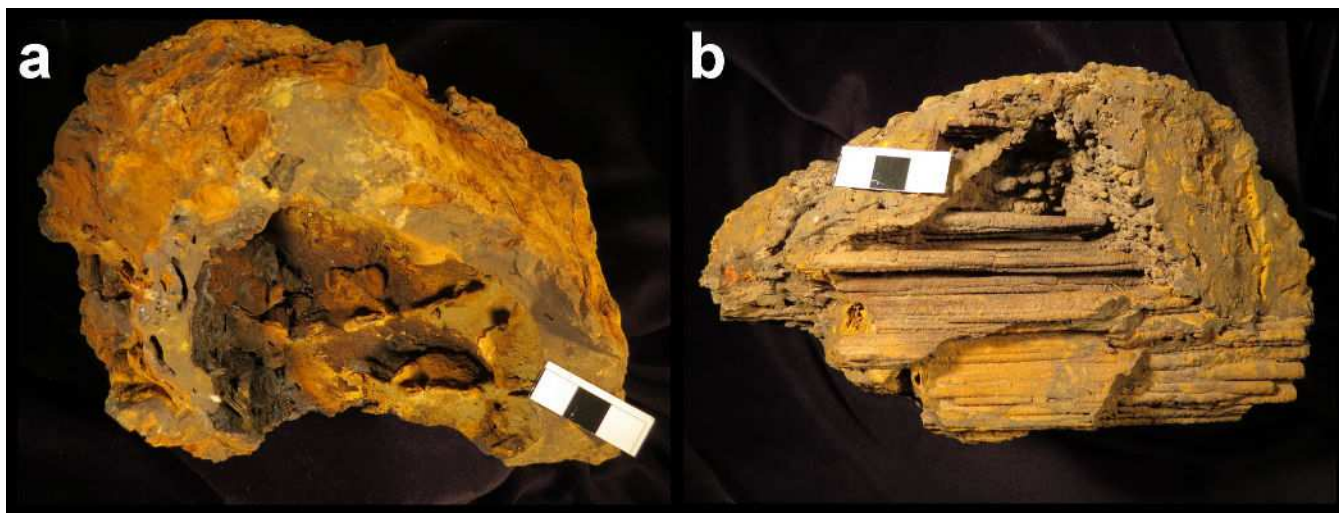


Figure 3.2. Iron-rich residual weathering deposits: Limonite. Samples from Taconic limonite deposits, Dutchess Co., eastern NY. Black bars at left of ruler = 1 cm. (a) hollow limonite rock, Amenia Mine, Amenia Township, Dutchess County; NYSM Geology Collection no. 71.3.0-20. (b) stalactitic limonite, Dutchess Co., NYSM Geology Collection no. 7.1.3.0-34.



Figure 3.3. Iron-rich placer deposits: Iron sand. Sample of “iron sand” from Quogue Beach, Suffolk County, south shore of Long Island. (a) macro photo of sample; (b) auto-montage syncroscopy image of sand grains from the same sample. Visual examination by Marian Lupulescu (personal communication, May 4, 2011) identified abundant garnets of different types, opaque minerals (probably magnetite), quartz and an amphibole or pyroxene.

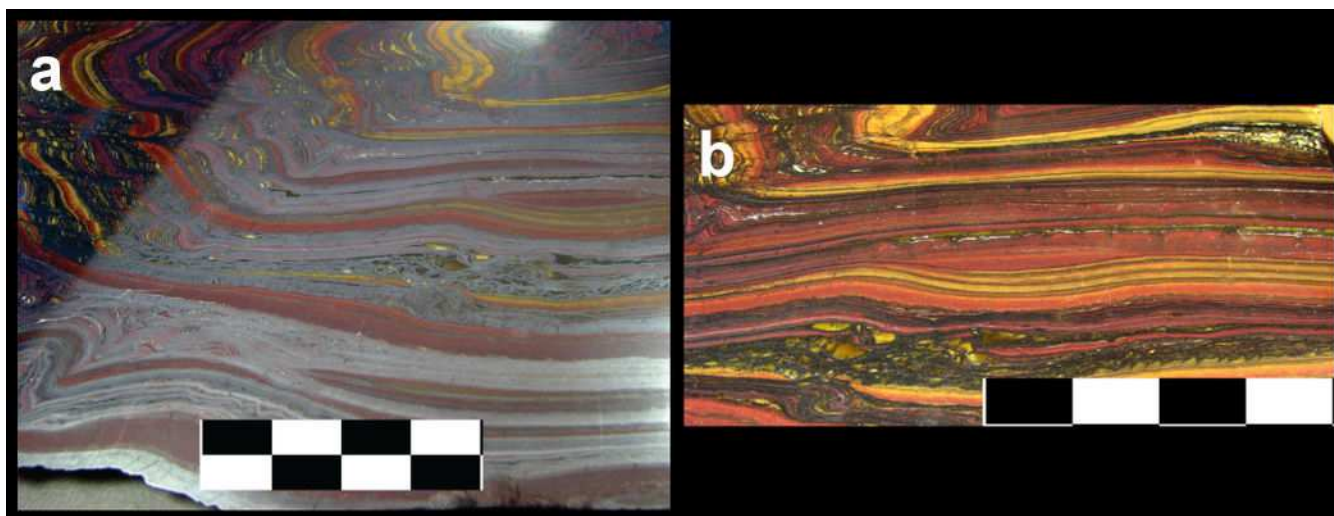


Figure 3.4. Precipitated iron-rich sedimentary rocks: Precambrian-age Banded Iron Formation. Two photos of the same sample under different lighting conditions; black bar in each photo = 1 cm. Image (b) is visible in the upper right of image (a).

sand is dumped into one end of the trough, the horse is cursed... until the cylinder is properly started in revolution, the magnets plow through the sand, picking out the particles of ore as they move for the brushes to knock it off in turn... a small stream of iron sand and a large one of common sand fell from the mill. ...“With two men and a horse I take out a ton a day; some days when we strike a very good bed, we get two tons, and once I got three.” (*New York Times*, Aug. 5, 1884)

Daily yields of one to two tons using such a basic, low-technology approach may seem high. However, a reading of the article by Dr. William Kelly, retired New York State Geologist, yielded the following observations :

Such yields would be possible. A ton of normal sand and gravel is about $\frac{2}{3}$ of a cubic yard, perhaps slightly less (~ 3850 lbs/yd³). Magnetite sand has a density about double normal sand if the magnetite sand is relatively pure, which in fact it is in bands on Long Island. I’ve seen areas of heavy mineral sand 100 feet long, 10 to 20 feet wide, and up to a foot thick that were pretty much red (garnet) and black (magnetite/ilmenite) sand. The separatory technique described above would be much more efficient at gathering magnetite than it would be at collecting ilmenite, due to the poor ferromagnetic behavior of the mineral ilmenite compared to magnetite. So, given the tenor of magnetite in the sand, you’d need to process just couple of yards of black sand to get 2000 lbs of magnetite. (Kelly, personal communication 2011)

The magnetite in these iron-rich sands forms as a result of physical weathering of pre-existing rocks, which breaks the rock into fragments, ultimately into discrete mineral grains of sand size ($\frac{1}{16}$ to 2 mm diameter). In locations adjacent to source areas (e.g., Lake Champlain and rivers draining the Adirondacks), the sand will have been transported largely by stream action. Iron-rich sands on Long Island beaches, however, probably represent sands transported there by both fluvial and glacial ice processes, and then sorted by oceanic wave and storm, and possibly eolian (wind-driven) processes.

Precipitated Fe-rich Sediments and Sedimentary Rocks

The precipitation of Fe out of solution in surface to near-surface waters over time, via chemical sedimentation, is the chief source of iron in the world (Robb 2005, 266). This includes iron-rich sediments or sedimentary rocks known as banded iron formations, Clinton-type ironstones, bog iron, iron-manganese nodules and, at least in some cases, siderite.

The geochemical processes involved in the precipitation of iron-rich sediments are complex, controlled by the interaction of many physical, biological and chemical factors. The following overview is based on discussions in Boggs (1995), Bridge and Demicco (2008), Prothero and Schwab (1996), Robb (2005), and Tucker (2001).

Fe ions occur in two forms, ferric iron (Fe^{3+}) and ferrous iron (Fe^{2+}). In oxygenated conditions, and under pH conditions of 4-8, ferric iron is essentially insoluble, while ferrous iron is relatively soluble. Upon exposure to oxygen, abundant in most sedimentary environments, Fe^{2+} oxidizes (“rusts”) to Fe^{3+} . In environments with no oxygen, as may occur in bogs and wetlands, some lakes

and oceanic settings, or within sediments, iron may go into solution as Fe^{2+} ions.

Precipitation and settling of iron-rich sediment particles may occur through crystallization of iron minerals, or through flocculation of and/or adherence of iron to clays or organic matter. The precipitation of iron and Fe-rich sediments is affected by various chemical factors in natural waters and within sediments themselves (e.g., oxidation-reduction, pH, concentration of oxygen and of CO_2 and salinity), and by various physical or geological factors (e.g., climate, paleolatitudes, weathering, volcanism, sediment source, sedimentation rate, hydrodynamics). Precipitation of Fe-rich sediments may also directly involve biogeochemical processes, via direct bacterial activity or, less directly, the activity of animals and macrophytic algae and plants (e.g., sediment burrowing, oxygen consumption or production) that may influence chemical conditions such as oxygen availability.

Precambrian Iron Formations

Pre-Cambrian iron formations, generally termed “banded iron formations” (BIFs), are iron-rich deposits formed during the Precambrian Era from approximately 3.5 to 2.0 Ga (billion years ago) when the evolution of photosynthetic bacteria first released oxygen into the earth’s essentially oxygen-free waters as a byproduct of photosynthesis. As these bacteria released oxygen into their aquatic environment, it quickly bonded with free iron ions, allowing the deposition of iron oxide minerals. BIFs commonly consist of thin, alternating bands of iron-rich and chert-rich strata (Figure 3.4). Iron minerals present are typically hematite or magnetite, or sometimes siderite or pyrite. In addition to chert or jasper (red-colored microcrystalline quartz), layers of calcium carbonate (CaCO_3) or other minerals may occur (Bridge and Demicco 2008; Cloud 1972; Robb 2005).

BIF deposits occur widely in Archean to early Proterozoic rocks around the world. In the eastern United States, they are found primarily in northern Minnesota and northern Michigan. Sometimes termed “taconite,” they are now the predominant source of iron ore in the eastern United States. No BIF deposits, however, occur at or near the surface in New York State. Key references on BIFs and their origin include Bridge and Demicco (2008), Gross (1980, 1995), and Robb (2005).

Phanerozoic Ironstones, including Clinton Iron Ores

Some hematite-rich sedimentary deposits, formed over the last 540 million years, occur as distinctive layers or discontinuous lenses of iron-rich sediments. The iron-rich sediment grains commonly occur as small, spherical to flattened “flax seed” like grains, termed “ooids,” or iron-impregnated fossil shell fragments. Geographically,

Clinton-type iron ore layers (Figures 3.1 and 3.5) commonly change laterally into thin phosphate-rich layers, which formed at the same time under different chemical conditions in deeper, more offshore environments. Individual layers of iron range from a few centimeters to at least five meters in thickness.

New York’s Clinton iron deposits are a part of a much greater belt of oolitic ironstones in the eastern U.S., formed in shallow marine environments during the Silurian Period approximately 430–435 million years ago. Multiple hematite-rich layers formed in a shallow sea between New York, Alabama and Wisconsin during times of rising sea level during the Silurian Period. They were important economic sources of iron ore in the past for iron and steel, and for paint pigments. The famous Birmingham, Alabama steel industry mined and processed Clinton iron ores until 1971. In New York, thicker layers of the Clinton iron ores were mined from the late 1700s through the mid-1960s. Thicker layers in central to western New York were mined, chiefly in Oneida, Cayuga and Wayne counties, and formed the basis of a regional iron ore and paint pigments industry. However, the iron and steel industry based on Clinton-type iron deposits largely declined with the rise of iron ore mining of the “banded iron formations” in the Great Lakes region in the late 1800s.

Clinton-type iron ore beds formed in shallow marine environments during distinct intervals over the last 540 million years of the Phanerozoic Eon. These intervals represent times of global greenhouse climates, during the Ordovician to Devonian geological periods (ca. 488–360 million years ago) and the Jurassic Period through the early part of the Cenozoic Era (ca. 200–34 million years ago). The Clinton-type ironstones were deposited in shallow seas, in association with times of very low rates of sedimentation (“condensation”) especially during times of sea level rise (Brett et al. 1998; Cotter 1992; Cotter and Link 1993; Earle 1914; McLaughlin, Brett, and Wilson 2008; Taylor and Macquaker 2000; Van Houten 1990; Van Houten and Bhattacharyya 1982).

The iron-rich minerals chamosite or hematite caused filling, impregnation or replacement of fossils or the formation of “ooids” (small grains with concentric layers of iron, calcium carbonate, etc. surrounding a central sediment grain), probably in the upper few centimeters of sediment at the sea floor. These were commonly later eroded out and concentrated by storm action and currents at the sea floor. This happened multiple times, forming iron-rich beds of ooids and/or iron-impregnated fossils. Under mildly reducing conditions, the iron-rich clays chamosite or berthierine also formed shallowly in these sediments. These clays were often later transformed into hematite or goethite. These ironstone beds commonly exhibit cross-bedding, ripples, erosive bases, and sparry cements indicative of agita-

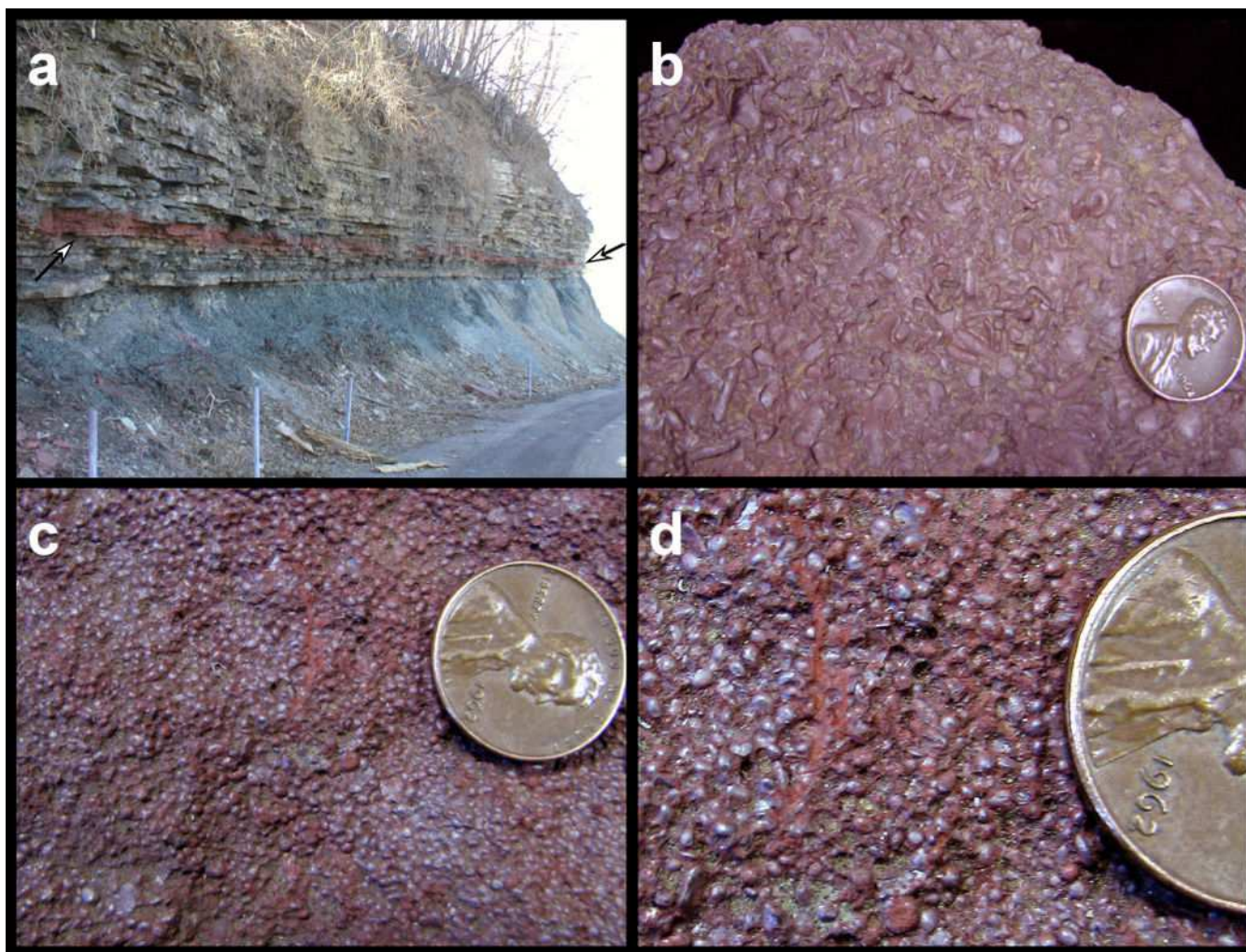


Figure 3.5. Precipitated Fe-rich sedimentary rocks: Silurian-age Clinton-type ironstones. (a) Outcrop of the Seneca Park hematite bed (arrow points to red band), Furnaceville Member, Reynales Limestone Formation, from the Rochester Gorge, Rochester, Monroe County, NY. Bed is approximately 30 cm-thick; (b) “fossiliferous” Clinton hematite bed, from Clinton Township, Oneida Co. NYSM Geology Collection no. 12751; (c) Oolitic Clinton hematite bed, from Clinton Township, Oneida County. NYSM Geology Collection no.5295; (d) closeup of ooid grains from previous photo.

tion of the sea floor, and concentration of iron-rich grains by currents or waves during high energy events in near shore environments, especially storms (Brett et al. 1998).

A number of distinct, widely recognizable and correlatable layers of Silurian-age Clinton iron ore are known. These include the Westmoreland, Furnaceville, Kirkland and other hematite beds in New York, the Irondale, Kidney, Ida, and additional iron ore beds in the area of Birmingham, Alabama and others in between (Brett et al. 1998). Because of their formation during global periods of sea level rise, layers from New York to Alabama are correlatable, and recognized as having formed at the same time.

Historically, the Silurian-age Clinton iron ore beds have been the most economically important sedimentary ironstone in New York (Figures 3.1 and 3.5). The Clinton iron ores in New York occur as multiple, widespread thin layers or as locally-occurring lenses

that thin and disappear laterally (Alling 1947; Brett et al. 1998; Gillette 1947). In some cases, such as the Westmoreland iron ore bed, the beds may occur as a thicker complex unit with several decimeter-scale hematite layers interbedded with shales and dolostones (Brett et al. 1998, 106). Their character commonly changes geographically along the outcrop belt. Brett et al. (1998, 101) describe the Furnaceville Iron Ore bed as a thin (10-30 cm), intraclast-bearing, fossil fragment-rich, hematite to hematitic limestone to the west and a sandy oolitic ironstone toward central New York.

Key sources on the Clinton Iron ore in New York include Beck (1842), Brett, Goodman, and LoDuca (1990), Gillette (1947), McLaughlin, Brett, and Wilson (2008), Newland (1908), Smock (1889), and Smyth (1919). Local histories of Clinton iron ore and manufacturing are available on the web (Williams 1998; Shilling 2002).

Bog Iron

Bog iron (Figures 3.6 and 3.7) is a sedimentary deposit composed of various iron oxyhydroxide minerals generally termed “limonite,” commonly goethite ($\text{FeO}(\text{OH})$). It often forms in bog or swamp-type or lake environments, where oxidation of free iron ions and their resulting precipitation may occur through chemical or biological (bacterial) processes. Bog iron commonly precipitates at an interface of oxygenated groundwater and acidic bog or lake waters rich in free iron ions (Robb 2005). Rates of precipitation are greatly enhanced by the action of Fe-fixing bacteria (Crerar, Knox, and Means 1979).

In many places, bog iron was the main source of iron before the industrial revolution, including during the war of the American Revolution. Methods of collection varied, including digging or raking it out of muddy sediments, or poking poles from a boat down into bog, lake or river sediments to find larger nodules, and then retrieving them. Furthermore, in areas of active precipitation, it was recognized that bog iron could be harvested two or three times in a century (French 1860, 25).

In New York, bog iron was reported by Hall (1838) to be “scattered widely across the state.” This was echoed by Smock (1889, 3), who mentioned “...bog iron ores, which are scattered in all of the great divisions of the state.” Beck (1842), in *Mineralogy of New York*, noted key bog iron deposits in St. Lawrence Co. with lesser workings in Jefferson Co. and western New York. He also discussed numerous other local occurrences around the state (e.g., Long Island, Manhattan, and Westchester, Orange, Dutchess, Columbia, Albany, Saratoga, Essex, Clinton, Franklin, St. Lawrence, Jefferson and Herkimer counties), as did French (1860).

Between geological and local historical sources available on the web, bog iron deposits and their historical use in New York are discussed for various areas (Figure 3.1), such as the Brasher Iron Works in St. Lawrence Co. (Helena Historical Society, n.d.), the Peconic River in Suffolk Co., eastern Long Island (Harmond 2006; Amon 2000); near Ridgeway in western Orleans Co. (Hall 1843, 437-8); and at Costantia, on the north shore of Oneida Lake, in Oneida Co. (Gordon 1836, 615; Vanuxem and Hall 1842, 228). Other sites include Watson and other localities in Jefferson Co., whose iron was transported to the Carthage furnace, and from Morris, in western Otsego Co. This is only a portion of what was an early, more widespread local industry in parts of New York. In some areas, such as at the Brasher Iron Works, the bog iron was largely utilized to make pig iron bars, or to make various tools and implements to be used locally (Helena Historical Society, n.d.). Alternatively, bog iron from the Peconic River forge on eastern Long Island is reported to have produced chains and anchors (some over 3,000 lbs.) for the shipbuilding industry in the late

eighteenth century, and that the area also provided bog iron for the famous iron-clad Civil War ship, the U.S.S. Monitor (Harmond 2006).

The accuracy of some of these accounts has sometimes been called into question, however, when there are no contemporaneous reports available. Statements in the informal literature since the 1980s about the utilization of local bog iron at forges such as the Townsend/Petty forge, along the Peconic River west of Riverhead, Suffolk Co., Long Island (Figure 3.1, “Pec”) in the late 1700s to 1800s (Townsend-Petty Forge 1995; Harmond 2006), are not supported in other recent historical literature (e.g., Yeager 1965). Suffolk County historians Edward H.L. (Ned) Smith III and Mary Cummings (personal communications 2010), in preliminary searches, found no historical reports prior to the 1980s of bog iron along the Peconic River, nor of its usage in the forge or forges there. That raises questions about whether that knowledge is lost, or not found yet, buried deep in some local or state archives; or that bog iron was never found, extracted and utilized there.

However, there are informal reports, observations, and other older information that support the presence and potential use of local bog iron at the Peconic River iron forge. Martin Pickands (personal communication 2010) collected bog iron samples while working at an archeological site on north-central Long Island (Betsey Prince site, Rocky Point State Pine Barrens Preserve; Figure 3.6). He also found bog iron in Coram, Long Island. Thompson (1839, 31) reports that nodular masses of “brown oxide of iron or hematite” were not uncommon on Long Island, and were especially abundant at Lloyd Neck, on the north shore of western Long Island. Further informal reports include the occurrence of “bog iron” closer to the Peconic River iron forge site. Daniel Mazeau (personal communication 2011) stated he found apparent bog iron at Wildwood State Park, on the north shore of Long Island, approximately nine kilometers northwest of the Peconic forge site. Thompson (1839, 31) further notes “sandstones, conglomerates and brown iron ore” at Iron Point, eight kilometers east of the Peconic River iron forge, in which he seems to imply that the rocks are cemented by iron deposits. All combined, these reports do not constitute a thorough, systematic search. However, they indicate that bog iron may occur in many areas on Long Island, including near the forge site.

Numerous wetlands and bogs do occur on the south side of the Peconic River, in the vicinity of the Peconic iron forge (i.e., Peconic Bog County Park, Cranberry Bog County Preserve). These may have been local primary sources of iron that have been lost to the historical record. In fact, recent informal reports (Michael Lenardi personal communication 2011; geologist Steven Englebright quoted in *Newsday* 2000) do indicate the appar-

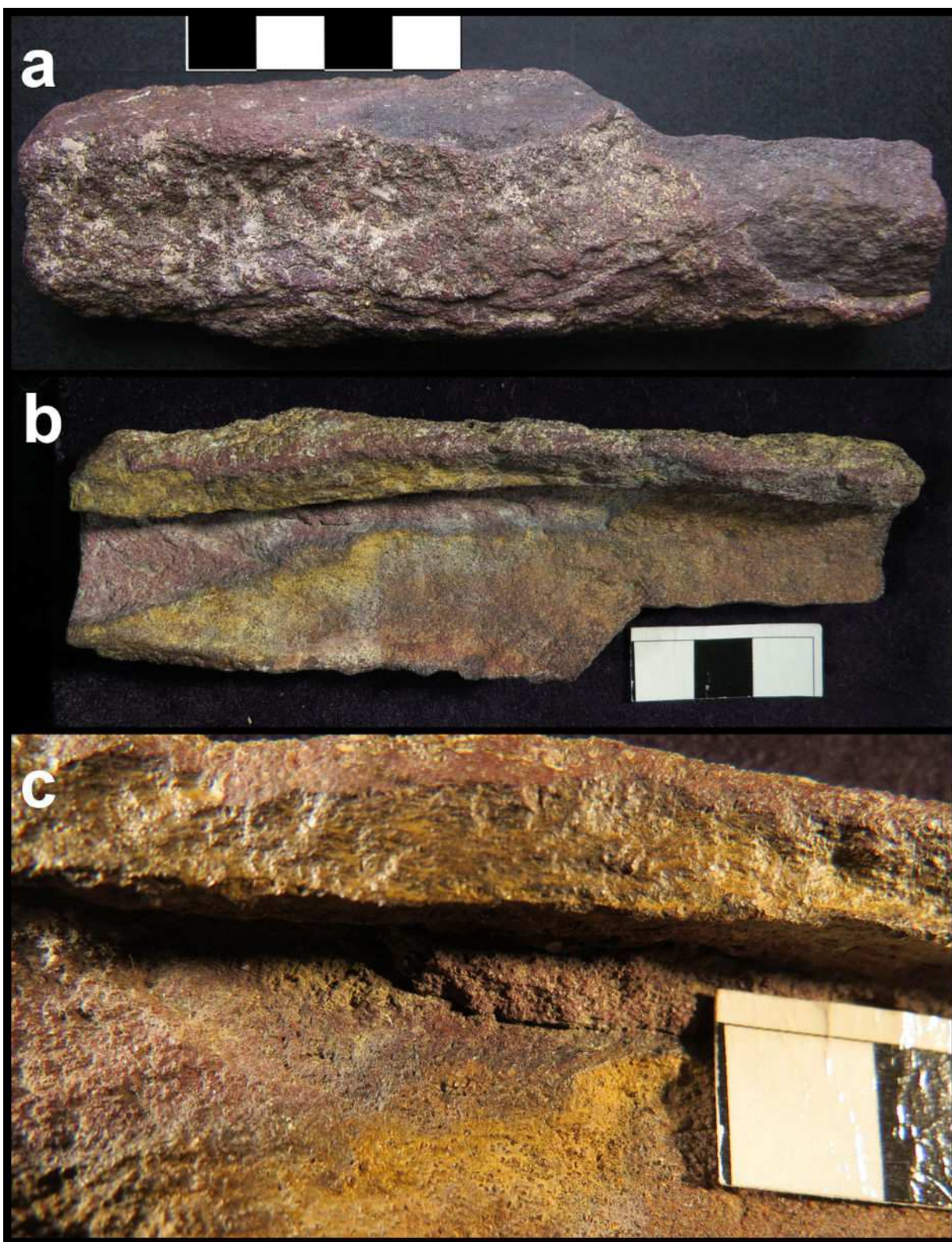


Figure 3.6. Precipitated iron-rich sedimentary rocks: Bog iron. Photos of hard, elongate, well lithified “bog iron” from near Rocky Point, Long Island, NY. The sample formed since the retreat of continental glaciation about 18,000 years ago. Iron-rich matrix cements together loosely packed sand grains. Elongate shape of sample appears to be possibly part of a hollow-centered nodule that formed around an elongate feature at center (e.g., woody stick?). Views: (a) = exterior view; (b) = interior view; (c) = close up view of upper right corner of image (b), at 90° angle.

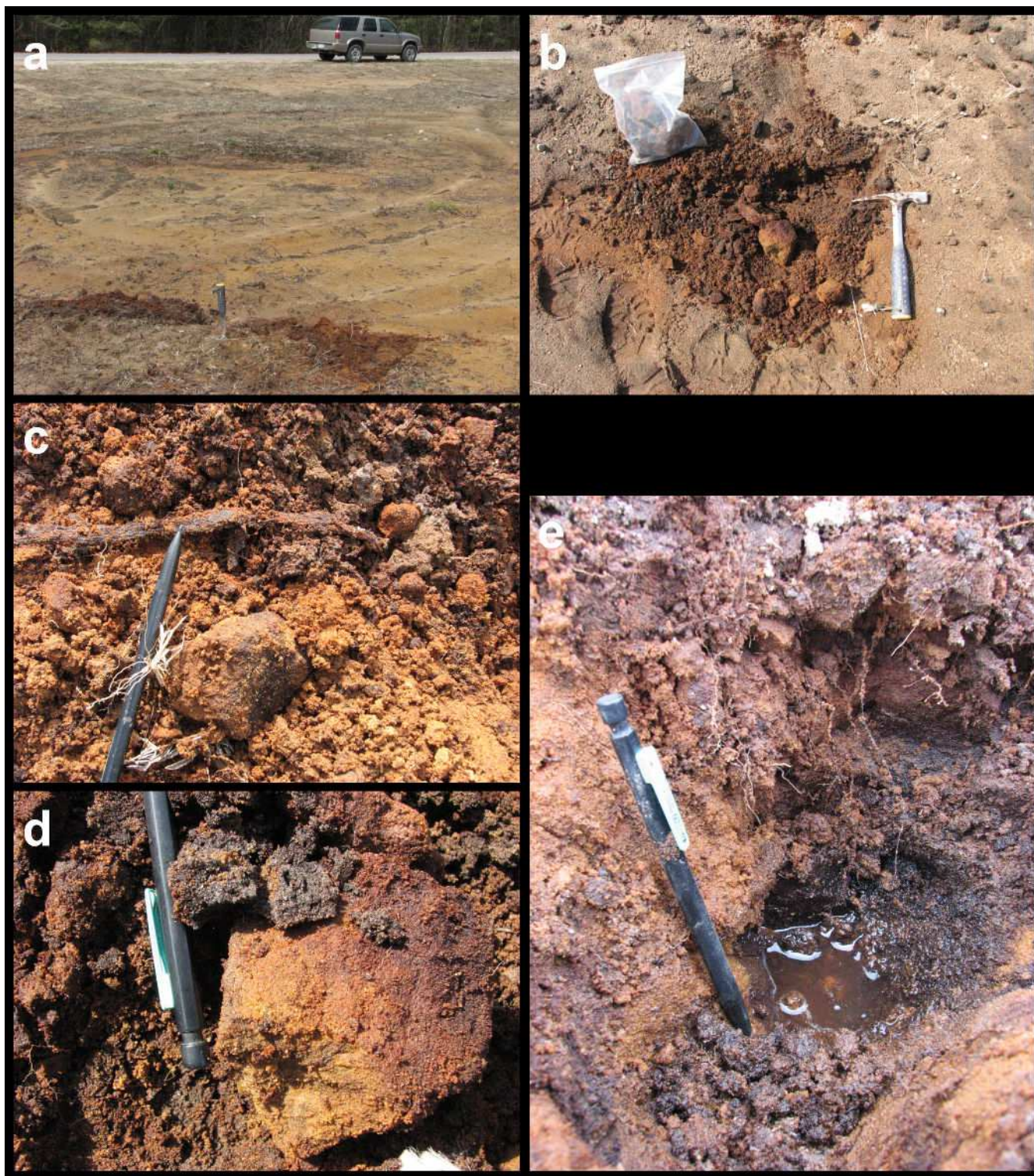


Figure 3.7. Precipitated Fe-rich rocks and sediments: Bog iron. Orange-brown to dark gray, poorly lithified sandstone nodules, which are weakly cemented by limonite. The nodules have formed in recent times. Surrounding sands are colored by a fine matrix of clays and limonite. From vicinity of Brasher Iron Works, St. Lawrence Co., NY. (a) Sandy surficial deposits typical of the area between wetlands; (b) nodules from below surface, dug out of a shallow pit; (c),(d) Close-up of small- to medium-size, poorly cemented nodules dug from shallow pit in photo “e”; (e) shallow pit, ca. 20 cm deep, with succession of (from top down) light brown sands; sand with medium-size orangish-brown nodules; sand with smaller orange-brown nodules. Note dark gray matrix of sand and sandy nodules low in pit. Water fills base of pit.

ent presence of bog iron in the vicinity of the Peconic River forge.

Alternative potential sources of iron for the Peconic River forge could have included iron retrieved from shipwrecks (as projected by Yeager 1965), or from “iron sands” along the shores of Long Island (e.g., Beck 1842, 22; *New York Times*, Aug. 5, 1884). However, iron from either source would have to have been transported by water around the eastern tip of Long Island, through Great Peconic Bay and then approximately eight kilometers upriver; or overland from the south and/or north shores for 14.5 or 6.5 kilometers, respectively. This seems unlikely, especially through the hilly and boggy lands south of the Peconic River. Considering the transport issues, why would a forge in the late 1700s be sited so far from sources of iron? It seems plausible that an abundant, primary source of iron for the Peconic River forges was local bog iron. Further geological and/or archaeological research may help resolve this issue.

In contrast, the presence of bog iron in St. Lawrence County (north of the Adirondack Mountains) is well documented. It was the resource base of an important iron industry in the area through a significant portion of the 1800s, including the Brasher Iron Works in the town of Brasher (Figure 3.1). The Brasher Iron Works furnace was active from 1836 through 1857, after which the business stopped making iron and concentrated on foundry work until it closed in 1887. The bog iron utilized was termed “loam ore,” with a composition of approximately 20% iron; extensive processing was needed to yield iron for making stoves and other castings (information courtesy of Bill Lewis of the Helena Historical Society and the Helena Historical Society webpage Helena Historical Society, n.d.). Lesley (1859) reports three iron operations in the Brasher area at that time, all of which used bog iron. These were the Brasher Hot-blast Charcoal Furnace, owned by I.W. Skinner, which produced about 400 tons of foundry iron during half of 1855; the Brasher Bloomery Forge, owned by J.W. Skinner, which produced about 75 tons of merchant bars in 1856 along with some scrap; and the Brasher Centre Bloomery Forge, owned by J. Crapser, which was reported by Lesley (1859) to produce about 35 tons of merchant bars per year.

Preliminary fieldwork by the author in sands between wetlands in the Brasher area yielded what appear to be iron-rich nodules and unlithified iron-rich matrix within the sands (Figures 3.1 and 3.7). A few shallow pits (ca. 20 cm maximum depth) produced both iron-cemented sand nodules and loose sand with brown to black fine matrix in between, as if iron minerals were present but not lithified into nodular masses yet.

There were no doubt a number of local forges and furnaces using bog iron around New York from the 1700s into the 1800s. The records of many of these are

likely lost, but more investigation would undoubtedly uncover a greater record of their occurrence in New York State.

Iron-Manganese (Fe-Mn) Nodules

Iron-manganese, or “ferromanganese” nodules are concretions of metals formed by slow precipitation in aquatic environments. They generally occur as ovoid, spherical or flattened, pancake-like nodules, with alternating onion-like rings of iron and manganese, commonly with lesser amounts of other metals such as copper, nickel, cobalt and zinc (Figure 3.8). They typically occur in highest concentrations on the floor of the abyssal plains of the oceans, at depths of approximately four to six kilometers, in areas of very low sedimentation rates. They may also be found in freshwater lakes. The formation of Fe-Mn nodules is not well understood; multiple processes have been hypothesized for their development (Robb 2005, 282-5).

Potential technologies for mining and extracting these economically valuable nodules from the deep ocean floor were explored in the 1970s and 1980s (Glasby 2002). However, the cost of mining from great depths relative to market values and other factors leaves these resources untapped.

Several studies report the presence of iron-manganese nodules on the floors of lakes in New York State (Figures 1, 8), including Lake Champlain (Johnson 1969), Lake Erie (Harriss and Troup 1970), Lake Ontario (Cronan and Thomas 1970, 1972), Oneida Lake (Dean, Moore, and Nealson 1981; Moore 1981), Lake George (Schoettl and Friedman 1971), the Saranac Lakes (Cook and Felix 1975), and Bisbee, Sagamore, Blue Mountain and Massawepie Lakes in the Adirondacks (Dean and Ghosh 1980).

Ferromanganese nodules from Lake George, reported by Schoettl and Friedman (1971), variously appear as spherical, discoidal or lumpy nodules. They sometimes occur as scattered nodules in the top of glacial clay deposits, or carpeting current-scoured areas of the lake bottom. Schoettl and Friedman report average composition of metals from seven Lake George nodules as Fe = 33.52%, Mn = 3.57%, and traces (ca. 0.1% or less) of Cu, Co, Ni and Zn; iron concentrations within the seven nodules range between 18.80 and 43.70%.

In Lake Ontario, ferromanganese deposits occur as nodules or as oxide coatings (Cronan and Thomas 1972). Dean and Ghosh (1980) discuss the occurrence and formation of Fe-Mn nodules in Oneida Lake, New York. They report that the nodules largely occur within shallow oxygenated central areas of the lake, sometimes nearly covering the lake floor. They range in form from pancake- to saucer-like (locally termed “Oneida Lake Pancakes”) to smaller, spherical shapes. Saucers have

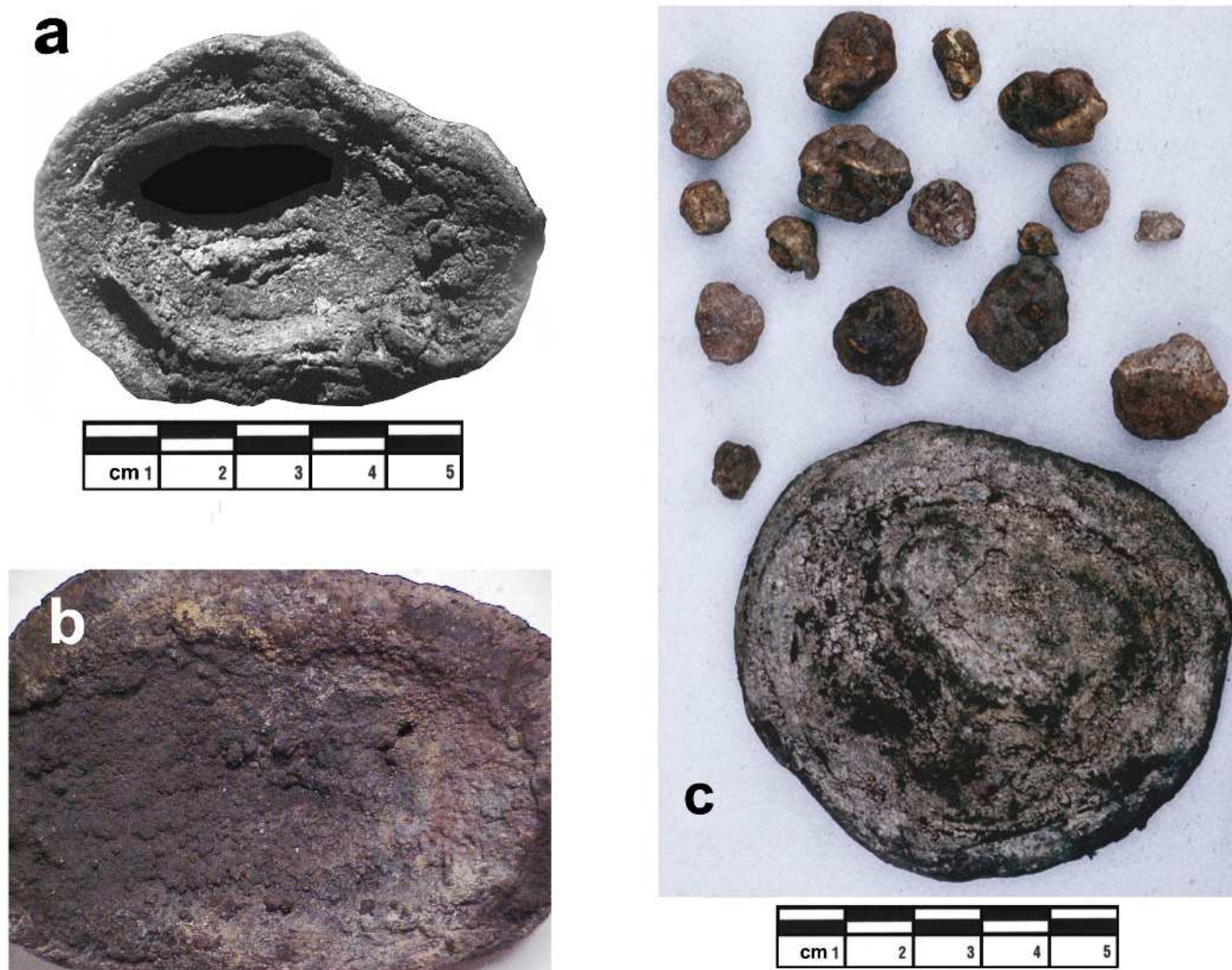


Figure 3.8. Precipitated Fe-rich sedimentary rocks: Iron-Manganese (Fe-Mn) Nodules. Fe-Mn nodules, from Oneida Lake, Oneida or Oswego County, central New York. The nodules have formed in recent times. (a) black and white photo of Fe-Mn nodule. Photo courtesy of Walt Dean; (b) Color photo of another nodule, with no scale, courtesy of Carmen Aguilar-Diaz; (c) small to large nodules, courtesy of Walt Dean.

an average size of approximately 15 cm in diameter and 5 cm-thick. Unlike Fe-Mn nodules from most freshwater lakes, Oneida Lake nodules are enriched in Mn. Dry weight geochemical analysis of 132 nodules from the lake yield mean elemental compositions on the order of 27.4% (+/-12.9%) Mn and 14.6% (+/-5.7%) Fe, with lesser amounts of Zn, Pb, Cr, Cu, Ni and Co. Dean and Ghosh (1980) conservatively estimated that deposits on the order of 10^6 tons of ferromanganese nodules could occur on the floor of Oneida Lake.

The relatively recent discovery of these Fe-Mn nodules in New York's lakes means that they likely had no historical use as an iron resource. Amateur blacksmiths who are interested in these nodules as a possible source of iron should research the chemistry of the process carefully, because of possible toxicity.

Siderite

Siderite (FeCO_3) is an iron-rich carbonate mineral (Figure 3.9). It commonly occurs with iron-rich minerals hematite, chamosite or other limonitic Fe-rich minerals. Most siderite in sedimentary rocks is fine-grained (Petrijohn 1975). Famous sideritic nodules from Carboniferous strata in Illinois ("Mazon Creek fossils," ca. 300 million years old) sometimes feature rare preservation of the soft tissues of fossil plants and animals. Small amounts of Mn, Mg and Ca may substitute for iron at the molecular level. In enough concentration, this yields the mineral ankerite ($(\text{Fe,Ca,Mg})(\text{CO}_3)_2$). Weathering processes may alter siderite to hematite or limonite.

In sediments and sedimentary rocks, siderite may occur as distinct beds, as nodules, as fine-grained sediments or cements, or comprising part or all of small ooid grains. In many situations the siderite forms

later, during diagenesis (the development of sedimentary rocks preceding metamorphosis). Primary sedimentary siderite forms within sediments under conditions with abundant bicarbonate and depleted levels of sulfur and oxygen, and appears to have an association with methane production (Gautier 1982).

Early diagenetic formation of siderite occurs most commonly in fine-grained sideritic mudstones (Pettijohn 1975). While it is formed in both marine and terrestrial environments, siderite precipitated in freshwaters is generally compositionally purer than that formed in marine settings, where it commonly has a greater percent of Mg and Ca in the mineral latticework, sometimes becoming ankerite (Mozley 1989). Siderite is a common component of Pre-Cambrian-age BIFs, but also occurs in younger rocks throughout Earth's history. In the past, when the iron industry was more of a local industry, siderite was sometimes an important economic source of iron.

In New York State, siderite occurs in sedimentary rocks as fine-grained matrix in conglomerate or sandstone, or in nodules in mudstones and sandstones (Figures 3.1 and 3.9). This includes the Cambrian-age Burden iron ore in Columbia County, where it commonly occurs as a siderite and limonite matrix in conglomerates with pebbles of limestone, shale and sandstone. It has alternatively been interpreted to occur stratigraphically between thin quartz-rich sandstones and shales below (Nassau Fm.) and quartz-rich sandstones above (Zion Hill Fm.) or at the base of the Germantown Formation (Fisher 1956; Zen 1964).

Newland (1936) contended that widespread, locally-occurring limonites in the Taconic region of eastern New York and western New England are the result of weathering of siderites in the rocks from the Pleistocene to recent times. According to Newland, these siderites and weathered byproducts (limonites) in the Taconic region are sedimentary deposits that are bedding parallel to adjacent carbonates (limestone, marble) and pelitic rocks (shales, slates and other low-grade metamorphic rocks of fine-grained sedimentary origin). This recurring pattern of what were limestone, iron-rich and organic rich strata, and shales in the Taconic rocks corresponds very well to successions deposited during sea level rise events throughout geologic time.

With sea level rise, shallow marine limestone deposition declines and ends. The following interval of time is characterized by deepening of sea level, and very low sedimentation rates, which allow for precipitation and concentration of authigenic sediments (sediments formed by precipitation or crystallization in the location where they are found) such as ironstones and phosphates, and concentration of organic matter under low to no oxygen conditions. As sea level rise slows, and then begins to fall, accumulation of clastic sediments (e.g.,

clays or silt) begins to increase, overwhelming the accumulation rates of ironstones, phosphate, organic matter, etc. This standard model of deposition through a sea level cycle (the "sequence stratigraphy" of sedimentary geology) seems to apply directly to deposition of the Taconic siderites and their weathered byproducts of limonite.

Alternatively, Fisher (1956) and Zen (1964) discuss the possibility that the Burden iron ore comprises an ancient, deeply weathered soil at the base of the Germantown Formation. This would have formed on land on a sub-aerial exposed unconformity between the Early and Late Cambrian Period, over 500 million years ago.

It is worth noting, however, that Marian Lupulescu (personal communication 2011) says that it is possible that these "siderite" deposits may actually be composed of the mineral ankerite. New chemical analyses are needed to confirm their composition.

In the past, siderite was mined for iron ore in eastern New York. These economic deposits included those from the previously noted Burden iron ore south of Hudson, Columbia County; apparently also from the Devonian-age Marcellus shale near Napanoch, Ulster County, and a small deposit in Dutchess County (Smock 1889, 13-4, 62-5; Merrill 1895, 541-3). The Burden siderite, with its associated residual weathered byproduct limonite, was an important source of iron for the Burden Iron Works in Troy, whose office building is currently preserved as a museum to the local iron and metal products industries of Troy.

In New York, other minor sources of sedimentary siderite, and possibly the related iron-magnesium carbonate ankerite ($(\text{Fe,Ca,Mg})(\text{CO}_3)_2$) include nodules found in shales and shaly sandstones (Figure 3.9) such as the Middle Devonian Mount Marion and Ashokan formations in eastern New York (author's field notes; Friedman, Mozley, and Wersin 1993). Because these occur as scattered nodules through the rocks, they have no economic viability. No geochemical analyses on the concentration of Fe in these nodules are known to the author.

Fe-rich Precipitated Sediments/late Diagenetic Minerals in Sediments and Sedimentary Rocks

Pyrite

Iron pyrite and marcasite (FeS_2) are the only significant sulfide minerals found in iron-rich sedimentary rocks (see Figure 3.10 and Pettijohn 1975, 411). Iron pyrite, also commonly known as "fool's gold," occurs commonly in some sedimentary rocks such as shale and limestone. Unlike the previous iron-bearing deposits, iron pyrite is not an iron oxide or carbonate, but combines iron with sulfur. It typically forms in sediments under conditions where there is no oxygen available. While people will

commonly recognize such conditions in the black, rotten egg-smelling muds of wetlands, the same conditions may also occur in sediments in other freshwater and especially marine settings, and may result in the formation of “black shale” rocks.

The pyrite in sedimentary rocks may occur as crystals visible to the naked eye, as nodules, or as abundant microscopic crystals, the latter contributing to the black color of black shales. Pyrite (FeS_2) or precursor iron monosulfide minerals (FeS), may precipitate early in the depositional environment, from before to soon after burial; in some settings where the water has no oxygen, pyrite may even form up in the water column and settle out onto the sea floor (Bridge and Demicco 2008; Schoonen 2004). Alternatively pyrite may form within the sediments or rocks much later, during diagenesis (e.g., Kesler, Friedman, and Krstic 1997). The formation of sedimentary pyrite is discussed by Berner (1970, 1984) and Schoonen (2004). Dick and Brett (1986) focus on Middle Devonian pyrite beds from New York specifically. As an iron-bearing mineral, sedimentary iron pyrite is not a viable source of iron, unless the pyrite has weathered to limonite. It is, however, sometimes mined for sulfur.

New York’s Paleozoic-age limestones and black to gray shales, including the Utica, Brayman, and Marcelus/Hamilton shales (Figures 3.1, 3.10), sometimes feature common pyrite (e.g., Dick and Brett 1986; Fisher 1951; Fisher and Rickard 1953; Grabau 1906; Schieber and G. Baird 2001). In some cases, shelly or even soft tissue of fossils may be replaced or coated by pyrite, including famous occurrences like Beecher’s Trilobite Bed in the Ordovician Utica Shale (Beecher 1893; Briggs, Bottrell, and Raiswell 1991; Cisne 1973; Raiswell et al. 2008) and the Devonian Hamilton Group, for instance the Leicester, Alden and other pyrite beds (Dick and Brett 1986; Fisher 1951; Loomis 1903). These pyrites formed in the sediments under normal, early diagenetic processes of sediments and sedimentary rocks.

Some pyrites in New York sedimentary rocks, on the other hand, formed due to processes not related to normal sedimentary rock diagenesis, but formed later in diagenesis as the result of other chemical or hydrothermal processes. An example is the Shawangunk Formation in southeastern New York (Kesler, Friedman, and Krstic 1997). In addition, pyrite “lag” deposits such as the Middle Devonian Leicester pyrite of the Genesee Formation in central to western New York (G. C. Baird and Brett 1986; Formolo and Lyons 2007; Sutton 1951) may also occur within the Paleozoic rocks at ancient surfaces of erosion. These sedimentary pyrites were not and are not considered an economic resource in New York.

SUMMARY AND CONCLUSIONS

This paper has presented an overview of the different types of iron-rich sediments and sedimentary rocks and of historical and current geological perspectives on their occurrences and economic importance in New York. In many cases, little new geological research and few new analyses have been carried out on these deposits since the 1930s or earlier. This work is largely a summation of what is understood about them. Much is still unknown. It is hoped that this article may help spur new interest and research into iron-rich sediments and sedimentary rocks in New York State by geologists, historians, and archaeologists and to provide an overview of potential iron sources for traditional, artisan and experimental blacksmiths.

It should be noted that the interpretations and understanding of these mineral resources expressed in some of the older reports may not be accurate, or reflect our current understanding and definitions of iron-rich sediments and sedimentary rocks. For example, as noted above, Marian Lupulescu (personal communication 2011) questions whether the “siderite” of the Burden iron ore east of the Hudson River is actually siderite (iron carbonate), or possibly the related, iron- and magnesium carbonate mineral ankerite, and states that new analyses are needed.

Of the nine types of iron-rich sediments and sedimentary rocks discussed here, eight of them are found in New York. Five of them (limonites, iron sands, Clinton hematites, bog iron and siderite) were utilized in the past as sources of iron for local and regional iron industries from colonial times through the early 1900s. Banded iron formations are not found in New York, pyrite is not an economic source of iron for industrial use, and the one probable laterite deposit in New York has only been found in the subsurface.

Early iron manufacturing in New York utilized what was locally available, for instance bog iron in St. Lawrence County, along the Peconic River on eastern Long Island, and other local areas and Taconic limonite or Burden siderite deposits east of the Hudson River. Iron sands were also used on Long Island and possibly in the Adirondack region. Clinton hematite deposits were exploited from central to western New York. In the late 1800s to early 1900s, New York’s iron industry largely shifted to mining and use of the Clinton hematite ores of central New York. Its decline was associated with the rise of the mining of banded iron formations around the Great Lakes, particularly in Minnesota and Michigan.

Suggestions for further work on iron-rich sediments and sedimentary rocks in New York include revisiting older reported sites both in the field and in the lab and analyzing their character, composition, sedimentology and diagenetic history, exploration for new sites, and

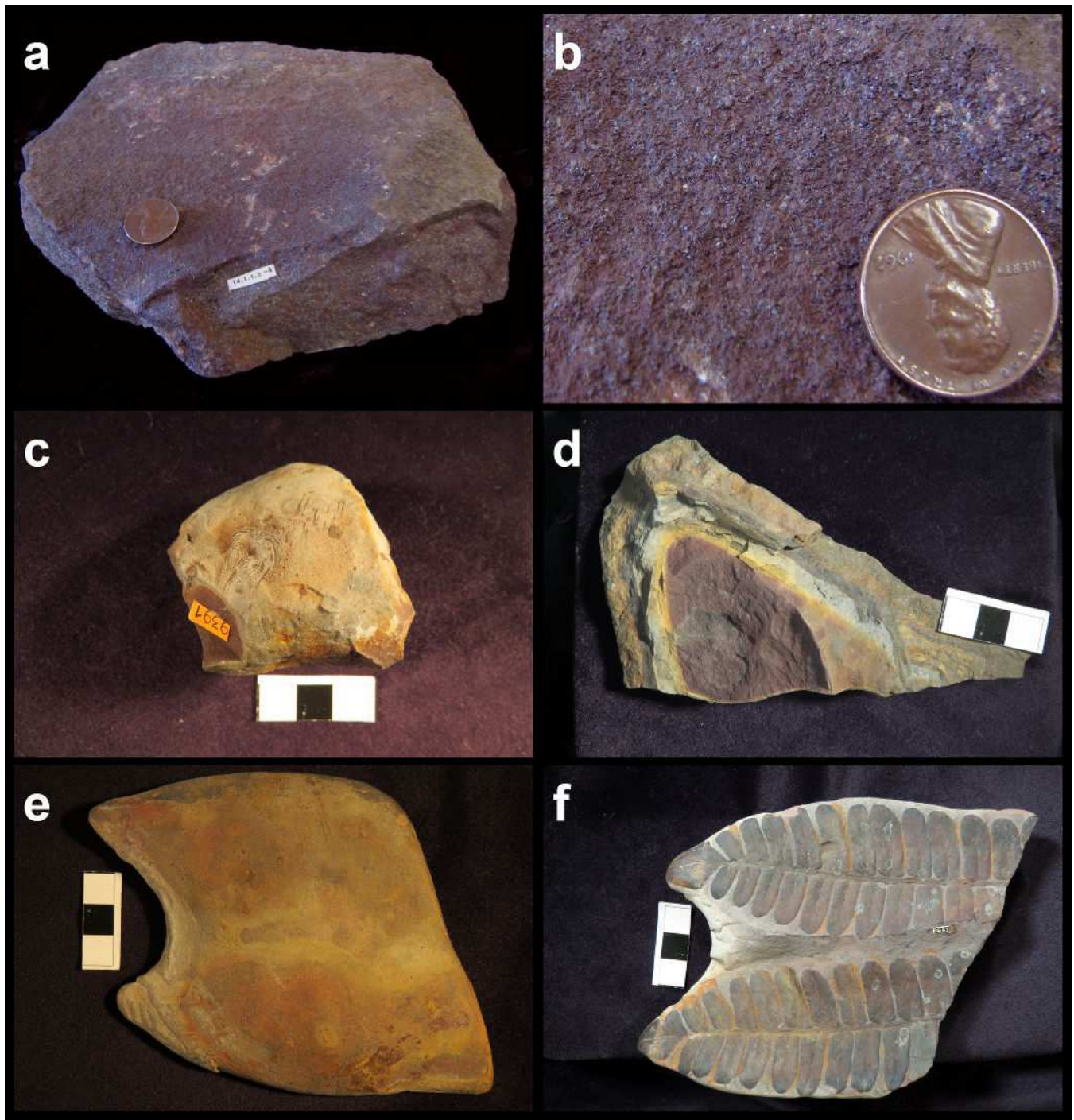


Figure 3.9. Precipitated Fe-rich sedimentary rocks: Siderite. (a) Cambrian-age Burden iron ore, Plass Hill, Greendale Township, Columbia Co., NY. NYSM Geology Collection no. 14.1.1.3-4. Siderite matrix cements together sandstone. Penny for scale; (b) Closeup of photo “a”; (c) Sideritic nodule from argillaceous marine sandstone, Middle Devonian-age Mount Marion Formation, near Kingston, Ulster County, NY. NYSM Paleontology Collection locality no. 9391; (d) Interior view of weathered sideritic nodule from argillaceous marine sandstone, Middle Devonian-age Mount Marion Formation, near East Berne, Albany County, NY; (e),(f) Exterior and interior views of sideritic nodule preserving a Carboniferous-age fern leaf (*Neuropteris*). From the famous Mazon Creek nodules, Francis Creek Shale Formation, unknown locality, Illinois. NYSM Paleobotany Collection, numbered as “X17”.

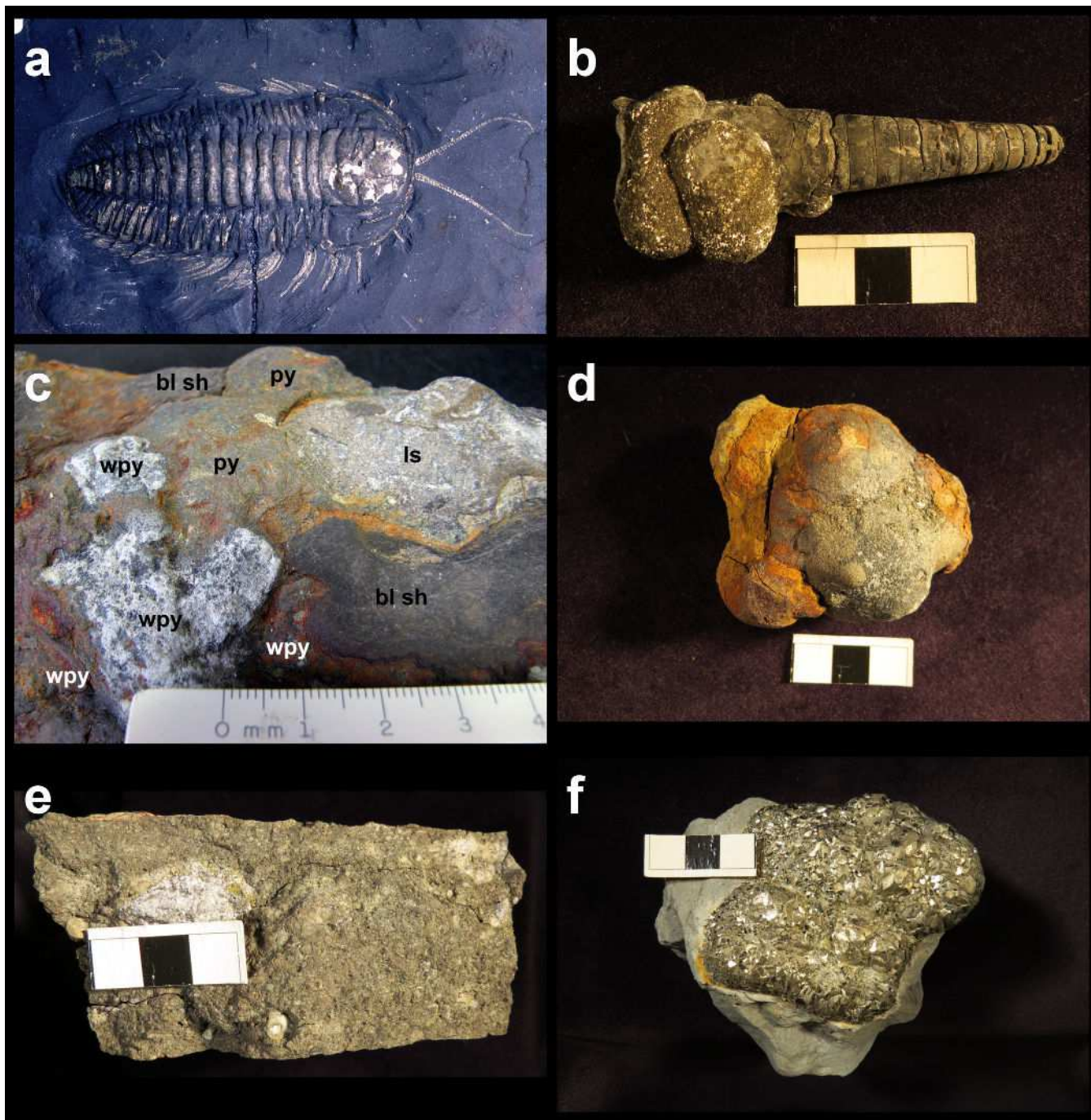


Figure 3.10. Iron pyrite: Iron-rich Precipitated Sediments/late Diagenetic Minerals. (a) Pyrite preservation of hard and soft tissue body parts on the trilobite *Triarthrus eatoni*, including legs and attached gills, frontal antennae. Ordovician-age Whetstone Gulf Formation, near Rome, Oneida County, central NY. ; Yale Peabody Museum specimen 228. Photo courtesy of Tom Whitely; (b) Pyritized straight nautiloid cephalopod fossils, Middle Devonian Alden pyrite, Ledyard Member, Ludlowville Formation, Alden Township, Erie Co., NY. NYSM Geology Collection no. 19070; (c) Pyrite and limonite on top of the Middle Devonian Cherry Valley Limestone Member, and below black shale of the East Berne Member, Oatka Creek Formation. From quarry near Honeoye Falls, Monroe Co., NY. Abbreviations: bl sh = black shale, ls = limestone, py = pyrite, wpy = areas of pyrite that have undergone weathering and decay under normal indoor conditions between 1993-2011; (d) Pyrite nodule (with limonite), weathering similarly. From same position and locality as previous specimen; (e) Leicester Pyrite, a placer deposit of pyrite nodules and pyritized burrows, reworked and concentrated into a conglomerate layer by submarine erosional processes after its precipitation. View is 9 centimeters across. Base of Middle Devonian Genesee Formation, Fall Brook, near Genesee, Livingston Co., NY; (f) Large crystals of late diagenetic pyrite. Late Silurian Brayman Shale Formation, south side of Interstate 88, near Schoharie, Schoharie Co., NY. NYSM Geology Collection no. 23134. Specimens (c), (d), and (e) from the collection of the author.

examining the geological, archaeological and historical records more deeply for further information about their occurrence and usage in New York State.

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REFERENCES

- Alling, H. L. 1947. "Diagenesis of Clinton Hematite Ores." *Bulletin of the Geological Society of America* 58:991–1018. (Cited on page 64).
- Amon, R. 2000. "Mining the Peconic for Iron." *Newsday* (Melville, NY), June 26. (Cited on page 65).
- Anderson, K. 1980. "Edison's Venture in Iron." *The North Jersey Highlander* (Newfoundland, NJ), no. 59, 3–22. (Cited on page 60).
- Baird, G. C., and C. E. Brett. 1986. "Erosion on an Anaerobic Seafloor: Significance of Reworked Pyrite Deposits from the Devonian of New York State." *Palaeogeography, Palaeoclimatology, Palaeoecology* 57:157–193. (Cited on page 71).
- Baldwin, N. 2001. *Edison: Inventing the Century*. Chicago: University of Chicago Press. (Cited on page 60).
- Beck, L. C. 1842. *Mineralogy of New York*. Albany, New York: W. & A. White / J. Visscher. (Cited on pages 60, 64, 65, 68).
- Beecher, C. E. 1893. "On the Thoracic Legs of Triarthrus." *American Journal of Science* 46:467–470. (Cited on page 71).
- Berner, R. A. 1970. "Sedimentary Pyrite Formation." *American Journal of Science* 268:1–23. (Cited on page 71).
- . 1984. "Sedimentary Pyrite Formation: An Update." *Geochimica et Cosmochimica Acta* 48:605–615. (Cited on page 71).
- Blank, H. R. 1978. "Fossil Laterite on Bedrock in Brooklyn, New York." *Geology* 6:21–24. (Cited on page 60).
- Boggs, S., Jr. 1995. *Principles of Sedimentology and Stratigraphy*. 2nd ed. Upper Saddle River, NJ: Prentice-Hall Inc. (Cited on pages 58, 62).
- Brett, C. E., B. G. Baarli, T. Chowns, E. Cotter, S. Driese, W. Goodman, and M. E. Johnson. 1998. "Early Silurian Condensed Intervals, Ironstones, and Sequence Stratigraphy in the Appalachian Foreland Basin," 491:89–143. (Cited on pages 63, 64).
- Brett, C. E., W. M. Goodman, and S. T. LoDuca. 1990. "Sequences, Cycles, and Basin Dynamics in the Silurian of the Appalachian Foreland Basin." *Sedimentary Geology* 69:191–244. (Cited on page 64).
- Bridge, J. S., and R. V. Demicco. 2008. *Earth Surface Processes, Landforms and Sediment Deposits*. New York: Cambridge University Press. (Cited on pages 58, 60, 62, 63, 71).
- Briggs, D. E. G., S. H. Bottrell, and R. Raiswell. 1991. "Pyritization of Soft-bodied Fossils: Beecher's Trilobite Bed, Upper Ordovician, New York State." *Geology* 19. (Cited on page 71).
- Britton, N. L. 1882. "On the Geology of Richmond County, N. Y.." *Annals of the New York Academy of sciences* 2 (1): 161–184. (Cited on page 60).
- Cisne, J. L. 1973. "Beecher's Trilobite Bed Revisited: Ecology of an Ordovician Deepwater Fauna." *Postilla* 160:1–25. (Cited on page 71).
- Cloud, P. 1972. "A Working Model of the Primitive Earth." *American Journal of Science* 272:537–548. (Cited on page 63).
- Cook, D. O., and D. W. Felix. 1975. "Ferromanganese Deposits in the Saranac Lake System New York." *Journal of Great Lakes Research* 1:10–17. (Cited on page 68).
- Cotter, E. 1992. "Diagenetic Alternation of Chamositic Clay Minerals to Ferric Oxide in Oolitic Ironstone." *Journal of Sedimentary Petrology* 62:54–60. (Cited on page 63).
- Cotter, E., and J. E. Link. 1993. "Deposition and Diagenesis of Clinton Ironstones (Silurian) in the Appalachian Foreland Basin of Pennsylvania." *Geological Society of America Bulletin* 105:911–922. (Cited on page 63).
- Crerar, D. A., G. W. Knox, and J. L. Means. 1979. "Biogeochemistry of Bog Iron in the New Jersey Pine Barrens." *Chemical Geology* 24:111–135. (Cited on page 65).
- Cronan, D. S., and R. L. Thomas. 1970. "Ferromanganese Concretions in Lake Ontario." *Canadian Journal of Earth Sciences* 7:1346–1349. (Cited on page 68).
- . 1972. "Geochemistry of Ferromanganese Oxide Concretions and Associated Deposits in Lake Ontario." *Geological Society of America Bulletin* 83:1493–1502. (Cited on page 68).

- Dean, W. E., and S. K. Ghosh. 1980. "Geochemistry of Freshwater Ferromanganese Deposits in North America." In *Geology and Geochemistry of Manganese*, edited by I. M. Varentsov and G. Y. Grasselly, 3:225–277. Budapest: Hungarian Academy of Sciences. (Cited on pages 68, 69).
- Dean, W. E., W. S. Moore, and K. H. Nealson. 1981. "Manganese Cycles and the Origin of Manganese Nodules, Oneida Lake, New York, U.S.A." *Chemical Geology* 34:53–64. (Cited on page 68).
- Dick, V. B., and C. E. Brett. 1986. "Petrology, Taphonomy and Sedimentary Environments of Pyritic Fossil Beds from the Hamilton Group (Middle Devonian) of Western New York." In *Dynamic Stratigraphy and Depositional Environments of the Hamilton Group (Middle Devonian) in New York State, Part I*, edited by C. E. Brett, 102–127. New York State Museum Bulletin 457. Albany: New York State Museum. (Cited on page 71).
- Earle, R. B. 1914. "The Genesis of Certain Paleozoic Interbedded Iron Ore Deposits." *Annals of the New York Academy of Science* 24:115–170. (Cited on page 63).
- Faure, G. 1998. *Principles and Applications of Inorganic Geochemistry*. 2nd ed. Upper Saddle River, NJ: Prentice-Hall. (Cited on page 58).
- Fettke, C. R. 1912. "Limonite Deposits of Staten Island, New York." *School of Mines Quarterly* 33:382–391. (Cited on page 60).
- Fisher, D. W. 1951. "Marcasite Fauna in the Ludlowville Formation of Western New York." *Journal of Paleontology* 25:365–371. (Cited on page 71).
- . 1956. "The Cambrian System of New York State." In *El Sistema Cambrico, Su Paleogeografia Y El Problema De Su Base: 20th International Geological Congress Symposium, Part II, Mexico City: 20th International Geological Congress Symposium, Part II*, 321–351. Mexico City. (Cited on page 70).
- Fisher, D. W., and L. V. Rickard. 1953. *Age of the Brayman Shale*. New York State Museum Circular 36. Albany, New York: The University of the State of New York. (Cited on page 71).
- Formolo, M. J., and T. W. Lyons. 2007. "Accumulation and Preservation of Reworked Marine Pyrite Beneath an Oxygen-rich Devonian Atmosphere: Constraints From Sulfur Isotopes and Framboid Textures." *Journal of Sedimentary Research* 77:623–633. (Cited on page 71).
- French, J. H. 1860. *Gazetteer of the State of New York: Embracing a Comprehensive View of the Geography, Geology, and General History of the State, and a Complete History and Description of Every County, City, Town, Village and Locality. With Full Tables of Statistics*. 8. Syracuse: R.P. Smith. (Cited on page 65).
- Friedman, G. M., P. S. Mozley, and P. Wersin. 1993. "Isotopic Composition of Siderite as an Indicator of Depositional Environment: Comment." *Geology* 21:380. (Cited on page 70).
- Gautier, D. L. 1982. "Siderite Concretions: Indicators of Early Diagenesis in the Gammon Shale (Cretaceous)." *Journal of Sedimentary Petrology* 52:859–871. (Cited on page 70).
- Gillette, T. 1947. "The Clinton of Western and Central New York," 341:191. (Cited on page 64).
- Glasby, G. P. 2002. "Deep Seabed Mining: Past Failures and Future Prospects." *Marine Georesources and Geotechnology* 20:161–176. (Cited on page 68).
- Gordon, T. F. 1836. *Gazetteer of the State of New York*. Philadelphia: T.M. / P.G. Collins. (Cited on page 65).
- Grabau, A. W. 1906. *Guide to the Geology and Paleontology of the Schoharie Valley in Eastern New York*. New York State Museum Bulletin 92. Albany, NY: New York State Museum. (Cited on page 71).
- Gross, G. A. 1980. "A Classification of Iron Formations Based on Depositional Environments." *Canadian Mineralogist* 18:215–222. (Cited on page 63).
- . 1995. "Stratiform Iron." In *Geology of Canadian Mineral Deposit Types*, edited by O. R. Eckstrand, W. D. Sinclair, and R. I. Thorpe, 41–54. *Geology of Canada* 8. Geological Survey of Canada. (Cited on page 63).
- Hall, J. 1838. "Second Annual Report of the Fourth Geological District of New York." In *New York State Geological Survey Annual Report*, 287–374. (Cited on page 65).
- . 1843. *Geology of New York*. Vol. Part IV. Albany, NY: New York State Geological Survey. (Cited on page 65).
- Harmond, R. P. 2006. "The Peconic River." *Long Island Historical Journal* 19 (1-2): 164–166. (Cited on page 65).
- Harriss, R. C., and A. G. Troup. 1970. "Chemistry and Origin of Freshwater Ferromanganese Concretions." *Limnology and Oceanography* 15:702–712. (Cited on page 68).
- Helena Historical Society. n.d. "Of Bog Iron and Brasher Ironworks..." Accessed 2013. <http://helenahistoricalociety.org/history/ironworks>. (Cited on pages 65, 68).
- Hunt, T. S. 1886. *Mineral Physiology and Physiography*. Boston: Samuel E. Cassino. (Cited on page 60).
- Johnson, D. G. 1969. "Ferromanganese Concretions in Lake Champlain." Unpublished M. S. thesis, Univ. of Vermont. (Cited on page 68).
- Kesler, S. E., G. M. Friedman, and D. Krstic. 1997. "Mississippi Valley-type Mineralization in the Silurian Paleo-aquifer, Central Appalachians." *Chemical Geology* 138:127–134. (Cited on page 71).

- Komar, P. D. 2007. "The Entrainment, Transport and Sorting of Heavy Minerals by Waves and Currents." In *Heavy Minerals In Use*, edited by M. A. Mange and D. T. Wright, 3–48. Developments in Sedimentology 58. Cambridge, MA: Elsevier. (Cited on page 60).
- Komar, P. D., and C. Wang. 1984. "Processes of Selective Grain Transport and the Formation of Placers on Beaches." *Journal of Geology* 92:637–655. (Cited on page 60).
- Leeder, M. 1999. *Sedimentology and Sedimentary Basins: From Turbulence to Tectonics*. Malden, MA: Blackwell Science Ltd. (Cited on page 60).
- Lesley, J. P. 1859. *The Iron Manufacturer's guide to the Furnaces, Forges and Rolling Mills of the United States*. New York: J. Wiley. (Cited on page 68).
- Loomis, F. B. 1903. "The Dwarf Fauna of the Pyrite Layer at the Horizon of the Tully Limestone in Western New York." In *Report of the state paleontologist 1902*, edited by F. J. H. Merrill and J. M. Clarke, 892–920. New York State Museum Bulletin 69. Albany, NY: New York State Museum. (Cited on page 71).
- McLaughlin, P. I., C. E. Brett, and M. A. Wilson. 2008. "Hierarchy of Sedimentary Discontinuity Surfaces and Condensed Beds from the Middle Paleozoic of Eastern North America: Implications for Cratonic Sequence Stratigraphy." In *Dynamics of Epeiric Seas*, edited by B. R. Pratt and C. Holmden, 175–20. Special Paper 48. St. John's, Newfoundland: Geological Association of Canada. (Cited on pages 63, 64).
- Merrill, F. J. H. 1895. "Mineral resources of New York State," 3:359–595. 15. (Cited on pages 60, 70).
- Moore, W. S. 1981. "Iron-manganese Banding in Oneida Lake Ferromanganese Nodules." *Nature* 292:233–235. (Cited on page 68).
- Mozley, P. S. 1989. "Relation between Depositional Environment and the Elemental Composition of early Diagenetic Siderite." *Geology* 17:704–706. (Cited on page 70).
- New York Times* (New York, NY). 1884. "Iron Sand on Long Island." Aug. 5. (Cited on pages 62, 68).
- Newland, D. H. 1908. *Geology of the Adirondack Magnetic Iron Ores, with a Report on the Mineville-Port Henry Mine Group by James F. Kemp*. New York State Museum Bulletin 119. Albany: The University of the State of New York. (Cited on page 64).
- . 1936. "Mineralogy and Origin of the Taconic Limonites." *Economic Geology* 31:133–155. (Cited on pages 59, 60, 70).
- Pettijohn, F. J. 1975. *Sedimentary Rocks*. Third. New York: Harper / Row. (Cited on pages 69, 70).
- Prothero, D. R., and F. Schwab. 1996. *Sedimentary Geology*. New York: W.H. Freeman / Company. (Cited on pages 58, 60, 62).
- Raiswell, R., R. Newton, S. H. Bottrell, P. M. Coburn, D. E. G. Briggs, D. P. G. Bond, and S. W. Poulton. 2008. "Turbidite Depositional Influences on the Diagenesis of Beecher's Trilobite Bed and the Hunsrück Slate; Sites of Soft Tissue Pyritization." *American Journal of Science* 308:105–129. (Cited on page 71).
- Robb, L. 2005. *Introduction to Ore-forming Processes*. Malden, MA: Blackwell Science Ltd. (Cited on pages 59, 60, 62, 63, 65, 68).
- Schieber, J., and G. Baird. 2001. "On the Origin and Significance of Pyrite Spheres in Devonian Black Shales of North America." *Journal of Sedimentary Research* 71:155–166. (Cited on page 71).
- Schoettl, M., and G. M. Friedman. 1971. "Fresh Water Iron-Manganese Nodules in Lake George, New York." *Geological Society of America Bulletin* 82:101–110. (Cited on page 68).
- Schoonen, M. A. A. 2004. "Mechanisms of sedimentary pyrite formation." *Geological Society of America Special Papers* 379:117–134. (Cited on page 71).
- Shilling, D. A. 2002. The Great Iron Ore Odyssey: Clinton Iron ore history, Rochester, NY. *The Crooked Lake Review* (124). (Cited on page 64).
- Smock, J. C. 1889. *First Report on the Iron Mines and Iron-ore Districts in the State of New York*. Bulletin 7. Albany: New York State Museum of Natural History. (Cited on pages 60, 64, 65, 70).
- Smyth, C. H. 1919. "On the genetic significance of ferrous silicate associated with the Clinton iron ores." In *New York State Museum Annual Report for 1917*, 175–199. Annual Report 71.1. Albany, NY: New York State Museum. (Cited on page 64).
- Solomon Townsend/Jeremiah Petty Forge, Calverton. 1995. Comprehensive Land Use Plan. Central Pine Barrens Joint Planning and Policy Commission, June 28. (Cited on page 65).
- Sutton, R. G. 1951. "Stratigraphy and structure of the Batavia Quadrangle (New York)." *Rochester Academy of Science Proceedings* 9:348–408. (Cited on page 71).
- Taylor, K. G., and J. H. S. Macquaker. 2000. "Spatial and temporal distribution of authigenic minerals in continental shelf sediments: Implications for sequence stratigraphic analysis." In *Marine Authigenesis: from Global to Microbial*, edited by C. R. Glenn, L. Prevot-Lucas, and J. Lucas, 309–323. SEPM Special Publication 66. Tulsa, OK: Society for Sedimentary Geology (SEPM). (Cited on page 63).
- Thompson, B. F. 1839. *History of Long Island*. New York: E. French. (Cited on pages 60, 65).
- Tucker, M. 2001. *Sedimentary Petrology*. 3rd ed. Boston, MA: Blackwell Science. (Cited on page 62).

- Van Houten, F. B. 1990. "Palaeozoic oolitic ironstones on the North American Craton." *Palaeogeography, Palaeoclimatology, Palaeoecology* 80 (3): 245–254. <http://www.sciencedirect.com/science/article/pii/003101829090135T>. (Cited on page 63).
- Van Houten, F. B., and D. P. Bhattacharyya. 1982. "Phanerozoic oolitic ironstones – geologic record and facies model." *Annual Review of Earth and Planetary Sciences* 10:441–457. (Cited on page 63).
- Vanuxem, L., and J. Hall. 1842. *Geology of New York*. New York: Natural History Survey. (Cited on page 65).
- Welland, M. 2009. *Sands: The Never Ending Story*. Berkeley, CA: University of California Press. (Cited on page 60).
- Williams, R. L. 1998. "Iron ore mining and manufacturing in the Town of Kirkland." Clinton Historical Society, Clinton, New York. <http://www.clintonhistory.org/A019.html>. (Cited on page 64).
- Yeager, E. H. 1965. *Peconic River Mills and Industries*. Riverhead, NY: Suffolk County Historical Society. (Cited on pages 65, 68).
- Zen, E. 1964. *Taconic stratigraphic names; definitions and synonymies*. Bulletin 1174. U. S. Geological Survey. (Cited on page 70).

"MY WORKS WILL BE THE BEST IN AMERICA" Peter Townsend's Cannon Foundry, 1815-25

Steven A. Walton

In 1817, Peter Townsend (Jr.), a member of the large Townsend iron manufacturing family, opened a cannon foundry on the creek between New Windsor and Newburgh, NY. The foundry failed and local histories offer no explanation why; national stories of ordnance production fail to notice Townsend at all. Archival research has brought to light the rise and fall of Townsend's foundry between 1815 and 1825. The foundry was specifically developed to produce ordnance for the U.S. Army in the wake of the War of 1812 and was built using a substantial advance from the War Department.

Although Townsend did produce a number of cannon that were initially proved to acclaim by Army inspectors from Watervliet Arsenal, he seems to have encountered both technological and financial troubles by 1820. The foundry struggled on into the 1820s under the proprietorship of his brothers, but it was unable to meet Ordnance Dept. orders and was eventually sold, though that, too, proved problematic. The failure is also put into stark relief by comparison to the West Point Foundry, nearly across the river at Cold Spring, which was begun in 1817 on a Navy advance and flourished for nearly a century. The Townsend story tells a salutary tale of the difficulty of starting an iron foundry in America's early industrial age, of the role of private and public capital in developing the venture, and of the problems of relying on a single, complex product to sustain a foundry.

Numerous histories of cannon-making and of the lower Hudson valley note that in 1817, Peter Townsend, one of the large Townsend iron manufacturing family, opened a cannon foundry in Newburgh, NY. [1] Some local histories note his failure but offer no reason for it; the only sustained history of the works puts them into context but does not investigate the details; others do not mention his endeavors at all, as if to ignore an awkward failure in the area's early history (Dennison 1967; Eager, 1846-7, 225; Ruttenber 1876). All such histories miss the mark and understate the story. And further, none of them investigated the context of a private foundry doing federal work at the end of the Early Republic.

Peter Townsend, Jr. (1770-1857), came from a noted Quaker iron-making family with furnaces and forges

on the west side of the Hudson in Orange and Rockland Counties of southern New York (Figure 4.1). The original founder of the dynasty, Peter Townsend, Sr. (d. 1783 or '87) went into partnership with Abel Noble about a decade before the Revolutionary War and provided considerable support for the American forces. The Townsends forged the famous chain across the Hudson at West Point, a portion of which can still be seen today on Trophy Point at the U.S. Military Academy at West Point (Coxe 1906; Ransom 1966, 125-200). Their Sterling Ironworks in the northern Ramapo Mountains spanned 23,000 acres in New York and New Jersey and would later be praised as one of the finest iron sources in antebellum America (Ransom 1966, 295-315; Ruttenber and Clark 1881, 805-806). The Townsend family member of the cannon foundry in Newburgh was Peter Jr., who also holds the distinction of having reputedly been the first in America to make blister steel in 1810 (*Albany Gazette*, Nov. 30, 1812, 3) and who was also later one of the pioneers in America to use anthracite coal to smelt iron.

For the cannon foundry, Townsend purchased land from Jacob Shultz on the south side of Chamber's (Quassaic) Creek, which forms the border between New Windsor and Newburgh, Orange County. Shultz, a local dry goods merchant and editor of the *New Windsor Gazette*, operated a mill near the mouth of the creek and Townsend built the cannon foundry "just west" (upstream) of Shultz's mill. Fed from the 400-acre Orange Lake southwest of Newburgh, Quassaic Creek provided reliable flow year round, even in drought conditions.

The creek was industrialized rather late as tributaries to the lower Hudson go, but when it was, it was largely for the manufacture of military materiel. In 1775, Robert Boyd, Jr. set up a forge for the manufacture of guns and bayonets for the NY militia (Dennison 1967, 5-8; Ruttenber 1859, 163). Boyd subsequently turned to making plaster, and later sold his mill on as a paper mill. There were also sawmills and a substantial gunpowder works built about 1817 further west on the creek, and the 5-mile stretch from the Orange Lake to the Hudson supported eighteen mills by 1846.

When Jacob Schultz's brother Isaac died in 1814, Jacob closed his dry-goods store in Newburgh and purchased their father's mill, only to sell it on to Townsend within two years (Eager, 1846-7, 204-207; Ruttenber 1859, 253-

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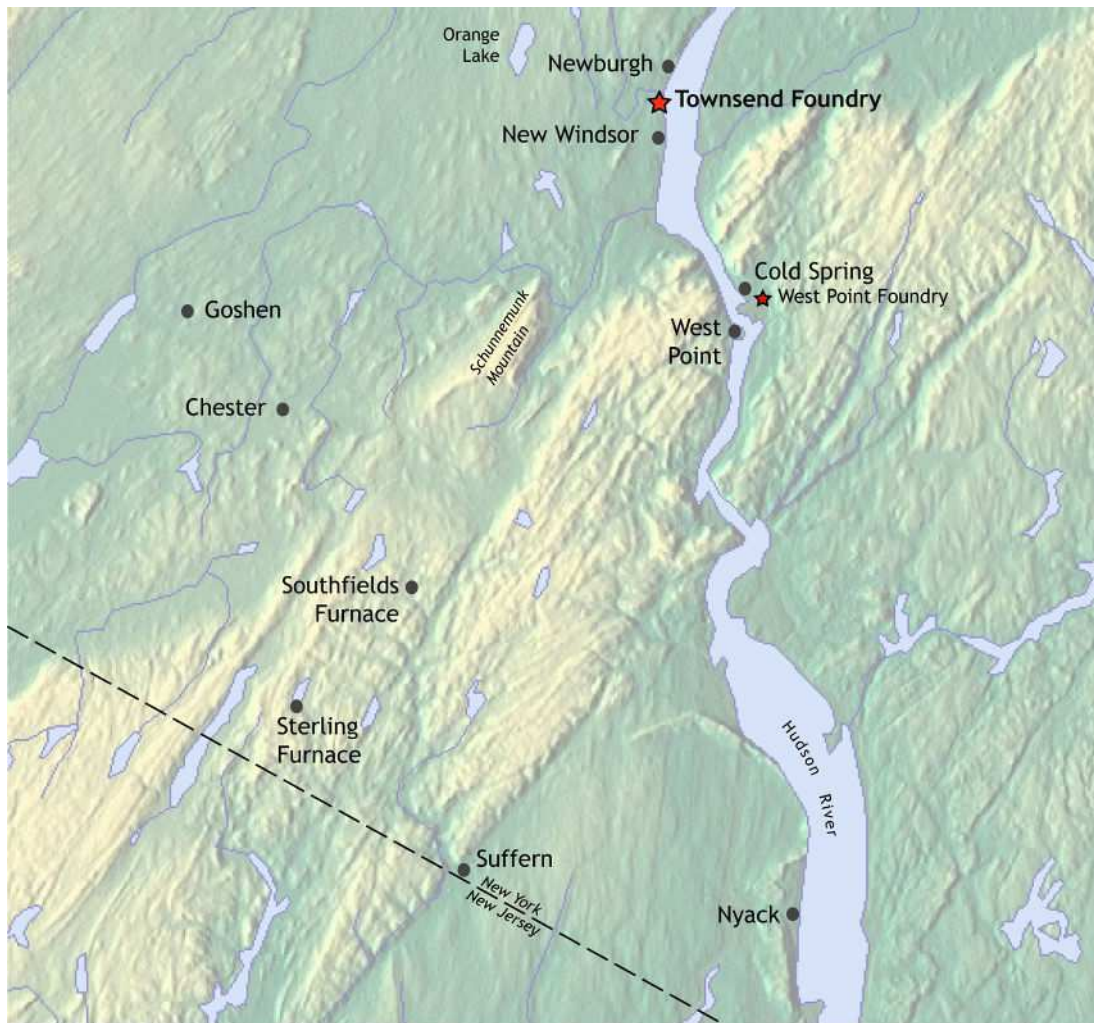


Figure 4.1. Map of the lower Hudson River, with sites mentioned in the text indicated.

254, 315-316; 1875, 193, 210, 220-221, 316; Ruttenber and Clark 1881, 220). Townsend refit the mill into a boring mill that could bore four cannon simultaneously, and erected a building with a pair of furnaces to cast cannon. When his foundry opened in the summer of 1817, a newspaper story relayed that nearly 90 tons of cannon were proved, said to be the first ever cast in New York, with 30 tons more nearly ready for proof (Dennison 1967, 5). This output represents perhaps 50-60 pieces, and in the process Townsend is said to have made “some very valuable improvements... in the mode of boring and drilling” cannon (*National Advocate*, July 30, 1817). Another article a day later rhapsodized that,

The situation of the foundry is extremely pleasant, it is placed in a deep and narrow ravine, through which the creek runs with beautiful windings, and is shaded by trees overhanging from the opposite hill, presenting a striking contrast to the objects within ... [T]he

effects of light and shade upon the countenances of the workmen, would furnish lessons to a painter, and are extremely interesting even to common spectators. The casting and boring of the canon, and the various operations in perfecting them for inspection and use, are well worth the trouble of a visit from New York to this place. (*New York Columbian*, July 31, 1817)

One modern author further hyperbolized that Townsend’s foundry, “set new standards in superiority of metal and in accuracy of firing,” but that, “despite this triumph, the cannon foundry was not a financial success and it apparently was taken over by the federal government” (Ransom 1966, 192). Such overstatement belies the sorry state of Townsend’s cannon foundry legacy. The government did indeed eventually seize the enterprise, but the claims of metallurgical superiority and ballistic excellence are more the result of local self-promotion, misty local reminiscences of the greatness denied Newburgh, and hopefulness. In what follows,

the story of Peter Townsend's cannon foundry offers an important glimpse into a fledgling industry in America right after the War of 1812.

TOWNSEND MAKES A PROPOSAL

The first we hear of Peter Townsend, Jr. in regard to the ordnance department was an order in September 1812 for 100 tons of cannon shot at \$85 per ton. He easily fulfilled this order from the Sterling ironworks by the end of the next year, and then was contracted again in March 1814 for a proposal to make more shot for a range of cannon from grapeshot to 100pdrs (Ordnance Department Contract, 27 Sept. 1812 National Archives and Record Administration [NARA], Washington DC, Record Group [RG] 156/Entry [E] 78, vol. 1, p. 5; William Simonds to Townsend, 1 March 1813, New York State Library Manuscripts and Special Collections, Albany [NYSL, MSC], Sterling Iron and Railway Company Records, 1740-1918 [SIRC], SC14069, box 1, fol.1-2, no. 5; Decius Wadsworth to Townsend, 21 March 1814 [SIRC, no. 6]).

In August of that year he was again contracted for more shot, though he had ignored a letter from the War Department for two months, having been traveling to the "Western frontiers" (Buffalo? One wonders if this had anything to do with the War of 1812 itself), and he complained that, "The number of men inlisted in this Quarter in the regular Army has drained us of moulders, founders, & colyers and it [is] with immense difficulty we get along slowly." Townsend offered to deliver his canister and ball shot to "New Burgh New Windsor or in New York" suggesting, by the mention of the first two towns, that already the outlet from the Sterling works was easier to the north through the gap east of Schunemunk Mountain (25 miles) than to the south and east where the Hudson Highlands present ten miles of difficult travel followed by another fifteen miles of overland carriage from Suffern to Nyack (Townsend to Gen. Calender Irvine, 14 Aug. 1814 [NARA RG156/E21](#), box 5).

Peter Townsend, Isaiah Townsend (from Albany), and Daniel Jackson and Henry McCoan (both of Orange Co.) joined to form the Sterling Company, which was incorporated on 1 April 1814 by the New York State Legislature. It had a capitalization of up to \$500,000 with shares at \$25 each, [2] one of only 40 manufacturing firms granted specific charters by the state assembly between 1811 and 1825 (Hilt 2006, 4). According to a finding aid in the Orange County Historical Society, "shortly thereafter, Peter Townsend completed construction of a cannon foundry on the Sterling site" (Gardner 2003, emphasis added). This claim, likely a mistake, was made earlier by Odevseff, Jan. 6, 1974 and then repeated by the Tuxedo Park town historian on the National Register of Historic Places nomination form in 1982. Ransom

(1966, 167) may be the source of the misunderstanding, though his claim for the location of the cannon foundry is oblique.

Although it is clear that Townsend's cannon foundry proper was ultimately in Newburgh, certain inconsistencies in the story which follows leave open the possibility that Townsend did cast some of his first cannon at the Sterling works in Southfields and bored those first cannon in Newburgh, at least until he got his air furnaces up and running at the latter site. For example, in the Sterling Forge Company daybook ([SIRC](#), 6/12), there are approximately 170 accounts for "Metal from the Southfields Furnace and Cannon Foundry, 1818-1819", but this may only reflect that the records of the two geographically separate endeavors in Southfields and Newburgh were kept in a common account.

Flush with his success in casting for the Army, in the fall of 1814 Townsend proposed to the Navy that he might move from making shot to making cannon for them as well. Although we do not have this proposal, the Navy wrote back, saying,

The establishment of a Cannon foundry upon a scale commensurate with the public demand from time to time in the northern section of the Union, is undoubtedly an object of great public as well as private interest, and I feel much disposed to [f]oster the undertaking. In order therefore to meet your proposal... and upon the assurance that the work will go into operation at the time, and progress in the manner stated, I am ready to contract on behalf of the Department of the Navy for five hundred tons of Cannons, or Cannon and Carronades, of such Calibers and forms, and in such quantities of each as the Department shall direct; giving due notice, and furnishing the drawings for the same. (W. Jones to Townsend, 17 October 1814 [SIRC](#), no.7)

The Navy wanted five to six pieces of ordnance, amounting to 12 tons of iron per week, once the foundry was up and running, and it expected to contract for everything from 12pdrs to 42pdrs as well as carronades. Townsend was clearly being brought into the larger supply network, for Jones informed him that, "The[se] are the established rates at which Mr. Foxhall [in Georgetown] has made for the Department, and at this time Col. Hughes at Cecilworks [in Maryland] and Mr. Dorsey on the Patapsco [for these three furnaces, see Gorr 1971-1972; Diggins 2000; Robbins 1986; and Troost 1831, 498n, respectively] are making Carronades [sic] for the Department at ten per cent less" (Crowninshield 1816, 378). Clearly the Navy was serious, because in a postscript they said in effect that all Townsend had to do was sign

and return the enclosed contract and it would be in force and forwarded to Congress for ratification.

It is at this point that the story gets confusing. Just over a month later, Townsend was in Washington and wrote to Col. George Bomford, head of the Army Ordnance Department, with details on the costs required for setting up a cannon foundry, and added a rather frantic postscript: “NB time is now every thing & every day is a week in this object.” Why Townsend was in Washington is unknown, though one imagines that it could either be because something had gone wrong in the contract process and he went down to sort it out, or he may have been visiting the Columbia Foundry run by Henry Foxall in Georgetown for information on furnaces and boring. What we do know is that Townsend claimed it would cost just over \$100,000 to build his foundry and he asked for a \$60,000 advance from the War Department:

In order to give you a correct view of the necessary expenditures which must be made before cannon can be furnished on the bank of the Hudson, I think it proper to present a statement of the disbursement necessary to be made before canon can be furnished for market.

4 air furnaces will cost	\$16,000
1200 tons of pig iron @ \$50	60,000
p[er] ton	
Boaring Mills & &	4,500
Iron flasks & & &	3,500
3000 boards of wood for the	9,000
air furnaces @ \$3	
putting in operation one	3,500
blast furnace which has not	
been used for 12 years	
teams, carriages, & & for	4,000
transporting cannon to the	
landing	
	<hr/>
	\$105,500

In this letter, Townsend was quite candid on the political economy of the whole enterprise:

[I]t may be worthy of observation that in consequence of creating so extensive a foundry the government may calculate on being furnished at all times at the shortest notice with such guns, carronades &[c] as they may require, I take the liberty of remarking that the extensive disbursements necessary for makeing cannon on a large scale could not be justified on any other grounds than the hope of a continuance of public patronage, as the contract now proposed to be entered into is not of sufficient magnitude to justify the expense. (Townsend to Col. George Bomford, 27 Dec. 1814 [NARA RG156/E21](#), box 5)

Within a month, and just as the War of 1812 was ending, Townsend had contracts in hand from *both* the Navy and the Army for making cannon. The Bureau of Naval Commissioners [BNC] issued a \$30,000 bond to Townsend and his securers in Orange County for 500 tons of cannon at 12 tons per week, and the Army for 500 tons of cannon, shot, and shells with an advance of \$20,000, with 60 tons to be delivered by 15 June 1815 and then 60 tons per month thereafter until finished (Navy contract, 14 Jan. 1815 [NARA RG45/E336](#), v. 2, pp. 285-286; Army contract, 24 Jan. 1815 [NARA RG156/E78](#), vol. 1, p. 14-15). [3] If we pause and reflect for a moment, these contracts asked Townsend to build a foundry, apparently from scratch, and be delivering over 70 tons of finished products within 6 months. One guesses that Townsend slightly oversold his capabilities.

Meanwhile, the idea of a cannon foundry somewhere up the Hudson was being promoted in the regional discourse. In January 1815 a New York newspaper, apparently unaware of Townsend’s negotiations, brought together a number of documents from 1813 and ‘14 that claimed a certain timeliness – “at a time when the State Legislature is about to assemble, and Congress is actually in session” – for such an establishment as part of a new navy yard: In February 1813, Townsend had been one of a dozen signatories to a letter to Samuel L. Mitchill [sic], Representative to Congress for the 2nd District of New York, advocating for Newburgh as a new, secure, deep-water dockyard and stores facility. These Newburgh men also noted that it was in the midst of “inexhaustible forests [and] contiguous to numerous iron works”, that the adjacent country was “capable of producing all the hemp necessary for rigging, &c.,” and noted as a bonus that the fresh water would kill the marine borers that plagued ships’ wooden hulls.

By March 1814, the Secretary of the Navy, William Jones, wrote to William Lowndes, chairman of the Congressional committee on naval affairs, to tell him that they had decided that the site would indeed be on “the right [west] bank of the Hudson, above the Highlands” (though he avoided naming Newburgh). He foresaw the “contemplated dock-yard as the nucleus, around which a great naval establishment may be formed, comprising wet and dry docks, forges, foundaries [sic], boring, rolling, saw, and block-mills, blast and smelting furnaces, an armory, hydraulic engines, rope works, manufactories of sail duck, and work shops of all kinds” ([National Advocate](#), Jan. 2, 1815). As it turned out, none of this came to fruition, except Townsend’s lone cannon foundry on the south bank of Chamber’s Creek.

BUILDING THE FOUNDRY

Townsend seems to have bridged the process of building his Newburgh foundry by continuing to cast cannon

balls at his Southfield furnace in the mountains southwest of West Point. The Army provided the advance in Treasury notes, though since the value of these fluctuated on the market (and city by city in those days, see Kagin 1984), Townsend did not immediately cash them in, relying instead on expected local revenues. Still, it is clear that his cash flow at the time was seriously constrained (Townsend to Bomford, 14 Feb. 1815 [NARA RG156/E21 /6](#)).

By mid-February 1815, Townsend had arranged to purchase Schultz's mill and contracted for 600 tons of iron from Salisbury, Connecticut, which is all the more curious since he already owned the Sterling furnaces. The ironworks in Salisbury had cast cannon and shot during the revolution, but they had declined to take up a contract for cannon in 1814, citing lack of capacity (Rome 1977), so it may be that this was 'approved iron' as far as the government was concerned. Salisbury continued to supply iron to the Springfield Armory in Massachusetts for decades. Townsend also apparently needed to rebuild the Southfields furnace and he must have understood that he needed more iron than his own furnaces could produce, at least initially. He also contracted locally for firebrick for the re-melting furnaces at the cannon foundry, though he had to wait for the river to open in the spring before it could be delivered and the construction completed (Townsend to Bomford, 21 Feb. 1815 [NARA RG156/E21 /6](#)). [4]

Although Townsend had begun his construction on the foundry using an initial \$10,000 from the Army, he ran through that money rather quickly and the Navy contract remained stuck in the ratification process. Thus, he asked for the remainder of the Army advance early:

I wish you would immediately remit the remaining \$20,000 altho by the date of the Contract it is not due, yet the Contract is dated one month after the Contract was made Verbally and as I am giving all my attention to the Subject I hope you will help me all in your power, I feel however confident you will if you are not absent from Washington at the receipt of this Letter. (Townsend to Bomford, 12 March 1815 [NARA RG156/E21 /6](#))

The Navy, at least, was beginning to realize that Townsend was not able to produce the guns very rapidly: the head of the BNC, Benjamin Crowninshield, confided that "Had the War continued the Guns would have been wanted at an earlier day than you appear to be prepared," but then noted that his advance of \$12,000-15,000 would only be forthcoming *after* the proof of the first batch (Benjamin Crowninshield to Townsend, 28 Feb 1815 [SIRC](#), no. 12). By March 24, the Army came through and forwarded the remainder of the \$30,000

promised Townsend (Capt. John Morton to Townsend, 24 Mar 1815 [SIRC](#), no. 15).

When one examines the dates of the correspondence, it becomes clear that Townsend was gaming both the Army and the Navy to a certain extent. It was only by March 30 that he had a contract for the sale of the land on which he was going to build the foundry from Jacob Schultz. Townsend paid \$7,000 for "the houses, buildings, mills, water, water-courses, rights, claims, privileges, easements, members, hereditaments, & appurtenances thereto belonging or in any wise appertaining," and got a sort of "escape clause" from Schultz that he could back out by April 29 for a fee of \$500 (Contract, 30 March 1815 [SIRC](#), 3/76/378). It is possible that he knew that the contracts with the Army and Navy might fall through since the War had already ended. [5] Indeed even the Army was concerned that the contract might ultimately be defeated in Congress. [6]

By April, Townsend reported that the works were "now erecting" in Newburgh, and he was trying to get payment for the cannonballs already delivered to the Army, though they had reduced the price from \$100 to \$95 per ton and Townsend was worried he would be retroactively short-changed for his work (Townsend to Morton, 7 Apr. 1815 [NARA RG156/E21 /6](#)). The concern seems directly related to the fact that the government had inquired into the solvency of the creditors that Townsend had lined up for his project. Samuel Jackson (presumably related to Daniel Jackson, Townsend's partner at Sterling) and Henry McCoan (one of his partners in the Sterling Co.), both of Newburg, had been guarantors on his loan, but the Ordnance Dept. had become suspicious of their financial resources to back such a large thing as a foundry (Morton to Townsend, 8 May 1815 [SIRC](#), no. 19).

The Army therefore decided to withhold any further advances until Townsend could find new guarantors. Representative Hamilton Fisk of New York was brought in to verify the new creditors, and Townsend continued on his quest to get more of his advance paid. He claimed that to date he had only been able to actually draw on \$4,000 of the government money. Townsend then got his brother Isaac in Monroe and Seth Martin in Bloomington to back a new bond, now for \$120,000(!), though as only a draft of the bond survives, it is not clear whether Townsend secured it ([SIRC](#), no. 9).

There seems to have been a disconnect between the War and Treasury Departments in actually issuing Treasury bills for Townsend's use, and they were issued in Philadelphia or Baltimore, which was decidedly inconvenient for Townsend's banking needs (Townsend to Bomford, 17 June 1815 [NARA RG156/E21](#), box 6). Not all New York banks would immediately redeem notes from other cities, and there could be as much as a 10% difference in value of the notes in various cities (Kagin

1984). [7] All throughout May, June, and July, it is clear that there was no money available in the public treasuries to pay Townsend, either for the shot he had already delivered or for the remainder of the advances he had been promised by the Army (Morton to Townsend, letters, 24 and 26 June 1815 [SIRC](#), no. 24-26).

Curiously, the Navy seems to have been oblivious to all this and had even written in June asking for an estimate of when Townsend would deliver the cannon, but of course they had not advanced him a cent at this point. The Navy started worrying in October (John Rodgers to Townsend, 21 June 1815 and Morton to Townsend, 13 Oct. 1815 [SIRC](#), no. 20 and 28; Crowninshield [1816](#), 378).

TOWNSEND'S FAILURE BEGINS

In October 1815, Townsend informed the Army that he had made considerable progress in readying the foundry, but was not yet in production:

Capt. [James] Mortons Letter of the 15th inst came duly to hand requesting to be informed what progress I have made in preparing for the Execution of my Contract. The preparations are as follows. 400 Tons pig iron is already made and fit for melting into Cannon and Two Hundred Tons more will be made this season. The Machinery is in considerably Forwardness the Site Purchased and paid for the Fire & other Brick on the sht. My attention has been more immediately directed to the making of Pig Iron supposeing you would not Require the Cannon untill spring by the 1st of May next I shall be able to call on you for the inspection of the Quantity agreed on. The advancements have come on so slow and uncertain that I have been compeled to curtail my operations to my means. If I could have been furnished with money I should have at this moment been in compleat operation I should be glad to be informed when I can receive the remaining advancement as I can forward my business much faster with than without Funds. I find the strength of my Iron much stronger than I had imagined. (Townsend to Bomford, 24 Oct. 1815 [NARA RG156/E21 /6](#))

More revealing, however, are the changes that Townsend made in a draft of this letter. Clearly worried about announcing the delay in his foundry, Townsend was unwilling to refer to "the operations of the Foundry at New Burgh", and chose not to mention that "the Furnaces are still in blast", since it was of course the boring and finishing that the Army would care about (Townsend to Bomford, draft of letter, 24 October 1815

[SIRC](#), no. 29). The Army received the letter and perfunctorily said they would try to get money freed up to help Townsend, but added, "it is desired & expected that you will make use of every Expedition that Circumstances may admit in the completion of your intended works, Castings, &c" (Morton to Townsend, 3 Nov. 1815 [SIRC](#), no. 30).

Townsend had been contracted for 500 tons of cannon of various sizes. Patterns drawn up by T. Stephenson of the Ordnance Dept. surviving in the Sterling papers indicate that in 1815 the Ordnance Dept. had requested 10-in. mortars, 24pdr and 8-in. Howitzers, and 18pdr (long and medium) and 24pdr medium cannon (Figures [4.2-4.4](#)). Townsend also received a detailed ink drawing of a cannon boring head and collar which was probably the type used by Foxall in Georgetown (Figure [4.5](#)).

It should be recognized that moving from iron founding to cannon production was not a simple lateral shift. While casting the guns was reasonably, though not perfectly, straightforward (larger castings are by their nature more difficult to do well, but founders knew this), boring them was an entirely separate matter. The largest defect in early American cannon was their rough bores. Boring technology had undergone a pair of interrelated revolutions by the latter eighteenth century and it was in the early years of the nineteenth that these European developments had been imported into this country.

First, cannon had originally been cast with a central core and then reamed to size, but casting as a solid piece increased the strength of the cannon (the chaplets that held the core in place remained embedded in the gun and could weaken it and the narrow space at the muzzle could constrict flow of the molten metal into the mold) and since there was no core to become misaligned during the pour, this also allowed the bore to be bored truly collinear with the axis of the gun, although at the expense of a much more cumbersome process of removing all the material from the chase.

Second, however, cannon were originally bored from the solid vertically, by suspending them above a rotating vertical bit often turned by a horse. While this arrangement did let the weight of the cannon bear down on the cutting head, which itself then bore directly on a solid base, the difficulty of both lifting the canon tens of feet off the ground and keeping it reliably vertical proved difficult. Thus, foundries returned the guns to horizontal and developed water- or steam-powered lathes (co-developed with the steam-engine industry itself) that rotated the barrel around a horizontal bit. (Braid [1986](#); Forward [1924-1925](#); Graham [1993](#); Jackson and de Beer [1974](#)).

Henry Foxall brought the British boring technology, pioneered by John Wilkinson, to America in the 1790s, and had become the *de facto* federal ordnance supplier when he was induced to move from Philadelphia to

Georgetown in 1800 (Gorr 1971–1972; Peterson 1988). However, by the time Townsend was getting into the business, Foxall was retiring and his expertise was shortly to be disseminated to a series of new foundries across the country, partly by his assistance in, for example, consulting on the Richmond Manufactory in 1806, but also through his contacts with the other ordnance suppliers through the Board of Ordnance. There is no specific evidence that Foxall assisted or was consulted on setting up Townsend’s foundry, though circumstantially the likelihood is high that Townsend at least found out about Foxall’s operation through the Ordnance Department.

The technical details of Townsend’s Foundry are scarce. It was built only a few rods from the banks of the Hudson at the outlet of Chamber’s Creek and certainly included Schultz’s old mill building, but Townsend apparently built an additional structure behind it. The buildings are likely the small group to the left in a painting of Newburgh, probably from the 1820s, though this painting is known to take some liberties with the positioning of structures (Figure 4.6). [8] Townsend owned one quarter of the water rights to the creek, which one early correspondent claimed “can be managed so as to meet almost any demand that a future extension of the establishment should require,” though later potential purchasers of the property feared this was insufficient (*New York Columbian*, July 31, 1817, 2).

Although he had initially planned for four, the two air furnaces Townsend eventually did construct fed a single casting pit. Skilled machinists staffed the foundry, some apparently from Ireland. From a letter of the superintendent who had erected the foundry, Patrick Kiernan (a smith by trade), we learn that the founder was Laurence King with Samuel Smylie as assistant founder and William McDowell the assistant moulder. Kiernan’s father, John, worked there as well (Kiernan to Bomford, 16 March 1818 [NARA RG156/E21 /12](#)).

There are occasional suggestions, however, that there was at times a dearth of cannon manufacturing skill in the foundry. Townsend, for one, seems to have spent most of his early time either in New York City or at Chester, some 20 miles southwest of Newburgh nearer the Southfields furnace, suggesting that he largely entrusted the foundry to Kiernan, King, and his men. In one case Townsend apparently did not know where the trunnions of the cannon were to be set, either centered on the barrel or set tangentially below the centerline, despite having drawings from the Ordnance Dept. in hand clearly indicating their position (Morton to Townsend, 3 Sep 1816 [SIRC](#), no. 37).

In another example, Townsend had to thank Col. Wadsworth of the Ordnance Dept. for suggesting a fix for boring cannon: “I found great and important advantages from your recommendation and advice in cast-

ing a square pease of Iron to the Caskable [the knob on the breech end] it is very important in this Boaring of guns for which improvement please accept my thanks” (Townsend to Decius Wadsworth, 20 July 1818 [NARA RG156/E21 /13](#)). This detail also shows that Townsend had adopted the method of rotating the cannon rather than the bit, which also indicates he had built his boring mill with horizontal boring beds (Figure 4.7).

By early 1816, it appears that the War Department had become truly worried. They reissued a new contract to Townsend with the same deliverables and \$60,000 advance, but with a deferred delivery of a full year. However, they added a failure clause that specified that failure to produce the work would result in repayment in full of the advance with 6% interest from the time of the advances (Contract, 30 Jan 1816 [NARA RG156/E78](#), vol. 1, pp. 29-31).

Townsend ratified the new contract and, as the winter slipped away, awaited the next \$10,000 installment, while on 22 February the House of Representatives resolved to hear how Townsend’s and other Ordnance suppliers’ contracts were proceeding (House Journal, 16th Congress, 1st session: 236). Morton related in February that the appropriations bill had passed the House, but still the money had not been released. Townsend had to resort to a rather pathetic plea that “I am now Very much in want of it even to embaresment” (Morton to Townsend, 26 Feb. 1816 [SIRC](#), no. 31; Townsend to Bomford, letters, 15 Feb. and 10 March 1816 [NARA RG156/E21 /8](#)).

Clearly, the War Department was having difficulty getting enough cash from Congress to pay its obligations, and after the War of 1812, Townsend was hardly the only one affected by this problem. War Department reports are replete with projects initiated during or just after the war that by 1816 or 1817 found themselves indefinitely on hold for want of appropriations (e.g., Bomford 1822, 23, 27-28). Townsend was caught up in this bind until his money was released in later March, though this hardly solved his problems.

At the end of May, Townsend received some startling news: Bomford was now intending to prosecute him for failure to deliver the cannon and for damages. One can only imagine Bomford’s frustration when he heard from Townsend that the foundry itself was still not even fully built:

This information has given me much pain and anxiety as I am making every exertions to accomplish the Contract which I shall be able to do, tho not as soon as I have ingaged. I have all my masons and workmen employed and now reside at this place. It is my determination to have a Compleat Foundry that will be usefull to myself and my Country. I know that I shall

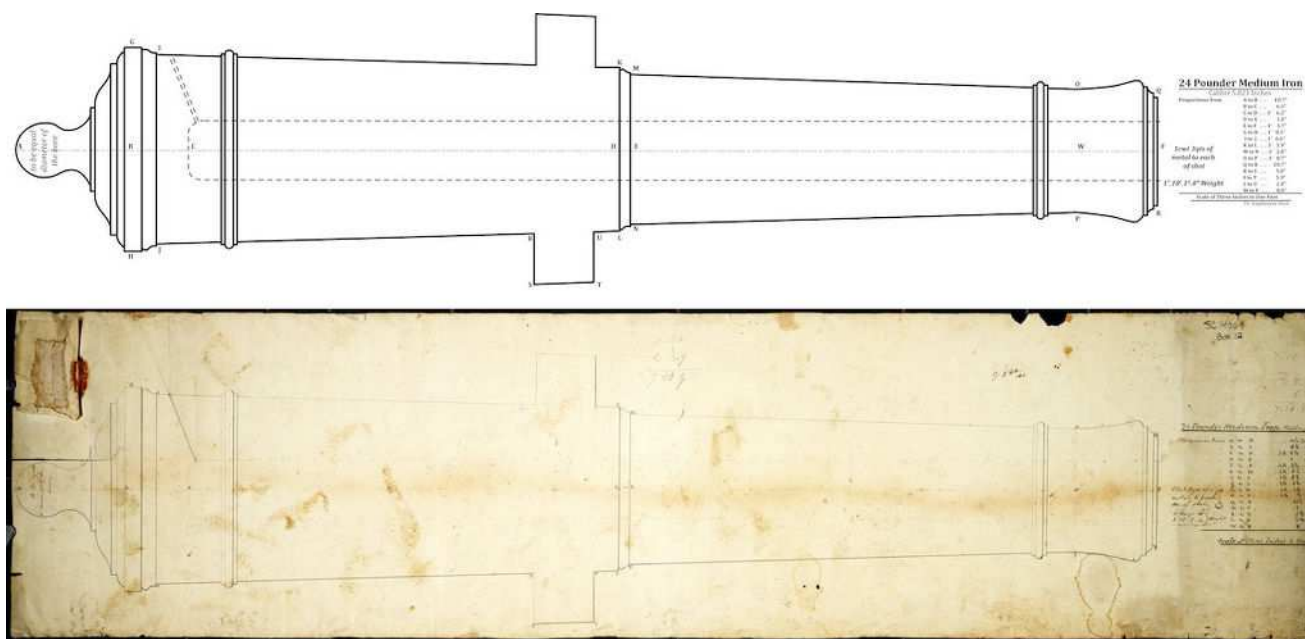


Figure 4.4. Drawing of a medium 24 pdr. cannon (5.823in. caliber) by 2nd Lieut. Thomas T. Stephenson, 1815. The cascabel is labeled, "to be equal diameter to the bore". NYSL, MSC: SIRC, box 12, no. 69e.

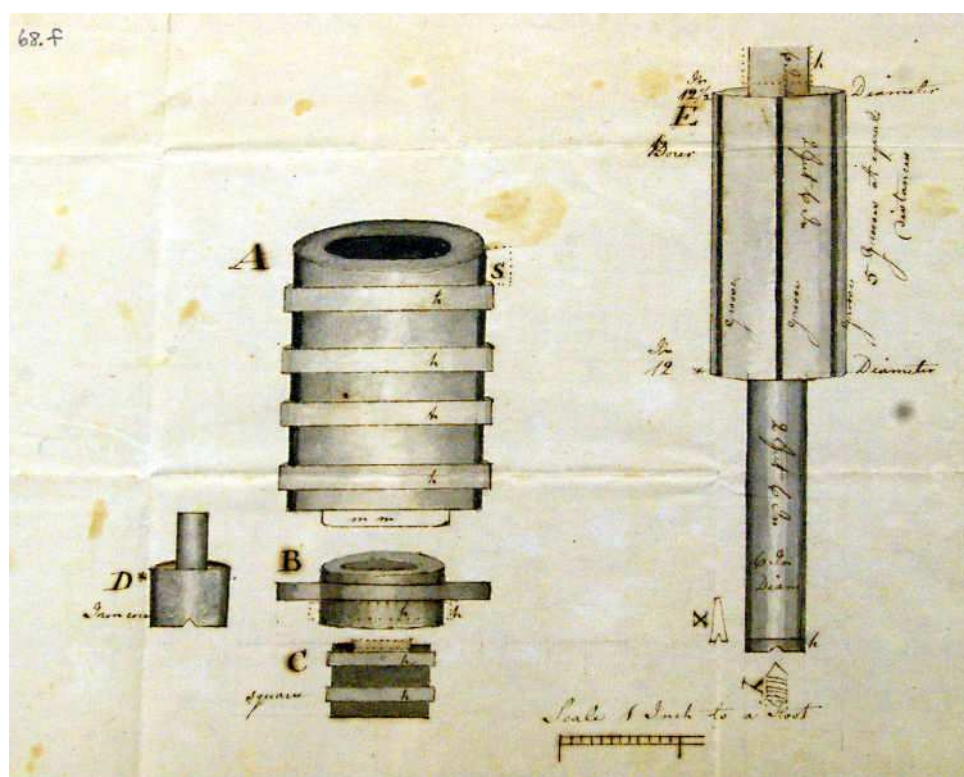


Figure 4.5. Drawing of a cannon borer, probably for a mortar. Part E is labeled "Borer" and it says that the larger cylinder is 2ft. 6in. long and tapers from 12½ to 12 inches and has "5 grooves [spaced] at Aequal distances" around its circumference. The shaft below is also 2ft. 6in. long and 6in in diameter. Cylindrical parts A and B and square part C seem, then, to be the sleeves and drive for the boring bar. NYSL, MSC: SIRC, Box 1, fol. 1-2, no. 68f.



Figure 4.6. "View of Newburgh from Beacon," (1820s?) In this undated and anonymous oil painting, the city of Newburgh lies on the far shore of the Hudson, partially occluded by the tree on the right. At the very center of the painting, in about the right position as the outlet to Chamber's Creek, is a white building which may be Schultz's Mill, though probably from after its days as Townsend's foundry. Courtesy of the Historical Society of Newburgh Bay and the Highlands.

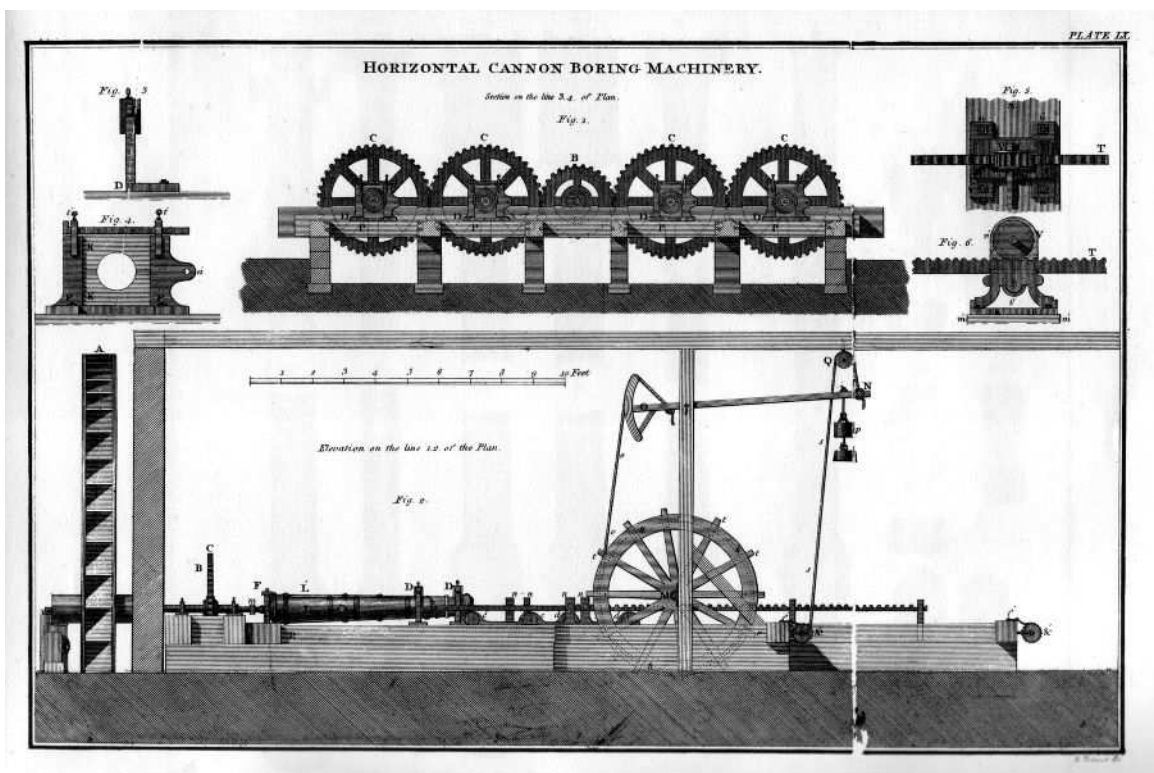


Figure 4.7. Horizontal boring machines from Louis de Tousard, *American Artillerists Companion* (Philadelphia, 1809), vol. III, pl. 60 and see vol. II: 549-51. Reproduced by permission of The Society of the Cincinnati, Washington, D.C.

fall short a Little of the time I have ingaged to Compleat the first Sixty Tons of Cannon and am intirely at your mercy eighther to be ruined or supported in the undertaking. I trust in you[r] magnanimity and forbareance and what ever dammage I create it will be left with you to determin, the Security which is given with one as well as myself are ample but It would be painfull to me and to them to be sued and I am perswaded you do not wish to do me any injury, on the Contrary I am so perfectly satisfied with your friendship that I cannot think you would cause my Bond Sued unless you had a Conviction that the Contract would not be fulfilled on my part and the Goverment was in danger of looseing the advancements made me which I am happy to say is not the case. Will you be so good as to give me some relief on this Subject as I am in a dreadfull state of anxiety. It is my intention to perform Honorably my engagements with you tho it will not be in my power to do it in the time Stipulated the means are in my power & your indulgence will confer an everlasting Favour and every dammage made good on my part to your Satisfaction. I will thank you for some consolation on this subject as early as may be convenient. (Townsend to Bomford, 24 May 1816 [NARA RG156/E21 /8](#))

In June and in July Bomford wrote; in July *and* August Captain Morton of the Ordnance wrote. Townsend did not apparently answer any of their letters.

The War Dept. grew more and more anxious. Finally on 20 August, Townsend sent a letter:

Capt Mortons Letter to me 29th July has remained unanswered in consequence of my absence in which he requires to know the exact state of my progress in makeing cannon. The following is the true state of facts. Two furnaces compleat for operations. The pit dug and now putting in a cistern to cast in. All the castings are made and buisily employed in laying them down for work. The house to boar in & the casting house compleate and a large stock of mettle on hand. We are also ingaged in casting flasks at our blast furnace and are doing every thing to advance the work. I hope verry shortly to be able to give you a specimen of our performance. I saw General [Joseph Gardner] Swift [from West Point] a few days ago. He will be up to see me. I will get him to write you also as to my state of advancement. I find the boaring mechienary more troublesome than

I expected. The works will be verry compleat and convenient from the drafts of the guns furnished we are some what at a loss to place the trunyens whither the top of the trunyen should range with the bottom line of the bore or be placed a little higher. Will you direct me on that subject. (Townsend to Bomford, 20 Aug 1816 [NARA RG156/E21 /8](#))

Townsend again dodged the specific question that both Morton and Bomford had been asking: “a more explicit statement, & engagement, is expected from you as to the fulfillment of your contract – namely, the precise time at which you will deliver any castings agreeable thereto, the amount thereof, &c” (Morton to Townsend, 3 Sep 1816 [SIRC](#), no. 37). Townsend promised them that he would be ready to start production on 15 October for 18- and 24pdrs, and would let them know as soon as he had some ready to prove. Amazingly, he still had the chutzpah to add a postscript “NB I think my works will be the best in America” (Townsend to Bomford, 23 Sep 1816 [NARA RG156/E21 /8](#)).

SUCCESS AT LAST

In 1817, the Ordnance Dept. was still optimistic that Townsend might deliver sixty of his contracted five hundred tons of ordnance, or at least they made sure the War Department knew that they would be required to pay Townsend the \$30,000 for his fulfilling that part of the contract (Decius Wadsworth to the Secretary of War, 25 Feb. 1817 “[H.R.107, 17th Cong., 2nd sess.](#)” 33). *The Political Index* newspaper of 3 Dec. reported that the first cannon were cast on Tuesday, 26 November 1816 (Ruttenber [1859](#), 136n) and by April Townsend wrote to Col. Bomford that he had “a parsel” of 18- and 24pdrs (Figure [4.8](#)) ready to be proofed (Townsend to Bomford, 28 April 1817 [NARA RG156/E21 /10](#)).

The difficulty, it seems, was not so much in the casting, but in the boring of the guns. Townsend related that,

I have been very much imbarised with Boaring my guns from the slowness with which that operation as hitherto been performed in the country. I now had it in my power to inform you that after many trials and experiments I have constructed a drill or auger which I have Boared an eighteen pounder in 24 hours without any effort. My auger Boars 4 inches an hour with a wate [weight] on the levers of 60lb each. The improvement I consider of the greatest importance in Boaring Cannon I shall forward a model of the auger to the patent office [\[9\]](#) by the first safe oportunity, when that oportunity presents I will inform you that you may examin



Figure 4.8. Undated 32pdr cannon (6¼" bore, 10ft. 7in. long, 62-1-14cwt. [6,898lbs]) of roughly the type Townsend cast in 6-, 12-, and 18pdr sizes, Union Rural Cemetery, Mayfield, New York. Unfortunately, the number of surviving early nineteenth-century guns is small and guns cast before about 1825 are rarely marked with either the foundry name or the proofing officer's initials, so there are no known surviving Townsend guns. Photo by author.

it. (Townsend to Bomford, 28 April 1817 [NARA RG156/E21](#) /10)

A mere four days later, Capt. Morton from the Ordnance Department let Townsend know that Maj. James Dalaby (variously spelled Daliba, or Dalaba) would be dispatched shortly from Gibbonsville near Troy (now Watervilet Arsenal) to proof the guns (Morton to Townsend, 2 May and 3 June 1817 [SIRC](#), no. 38 and 40). Having apparently never done this before (not surprising as there were so few foundries in the U.S. at this time) Dalaby immediately wrote to Washington asking for further details, heard from Col. Wadsworth, and then wrote to Morton asking for,

... a statement of Co. Bomford of the terms of that part of the contract which related to the inspection & proof; and also the weight & dimensions of each caliber. I wish to know the weight of the charges, and number of shot, & no. of rounds to each piece, that were agreed upon for the proof of sd cannon. Also the weight of each piece, its several dimensions & proportions, and the depth of cavities & flang[e]s which would condemn a piece, on the outside & on the inside. (Maj. James Dalaby to Morton, 27 May 1817 [NARA RG156/E21](#) /9)

On the last day of July, the *New York Columbian* reported that Maj. Dalaby and his assistants, Lieuts. Simason and Thomas, had been at the foundry, made meticulous measurements of Townsend's cannon and proofed each one. Although the participants and onlookers had "generally placed themselves in secure positions" for the first shots, as a testament to their strength, "after the first day's experience, all ideas of danger vanished, and spectators and workmen indiscriminately remained by the side of the cannon." Dalaby pronounced the bores "free from honey comb, and present to the eye a surface of the most beautiful smoothness and polish," while the newspaper correspondent proclaimed that "from the strength of the Sterling iron, from such easy access, and from the perfect polish and accuracy. . . , we may expect an extension of this establishment equal to its merits, and we confidently believe, that a large and permanent increase will reward the successful boldness and enterprize [*sic*] of the founder" (*New York Columbian*, July 31, 1817, 2; see also *National Advocate*, July 30, 1817, A1).

A month later, *Niles' Weekly Register* picked up the detailed story about the foundry and its success. They reported that ninety tons of 18- and 24pdr cannon had been cast, and that with three proof shots per gun, 150 shots had been made, suggesting that 50 cannon had been produced. They were apparently well made

and bored, as the report claims that in all those shots, not a single one missed its target at 150yds. All the guns passed their proof charges, either double- or triple-shotted and with from 6½-9 or 8-12lb. of powder for the two sizes, but Townsend was so confident that he challenged Maj. Dalaby to try to break one of the 18pdrs if he could. Dalaby then had one filled with 18lb. of powder, a "large oakum wad", two balls, and another wad, all rammed tightly home. "No other effect [was] produced than a violent report and a great recoil" (*Niles' Weekly Register*, Aug. 24, 1817, 406).

With the successful proof by the officers from Watervliet, Townsend was buoyed by his success, apparently oblivious to the problems caused by the Ordnance Dept. having slightly altered the designs of the 18- and 24pdrs that summer and some questions raised by Dalaby on a subsequent re-inspection in October (Dalaby to Townsend, 17 Sept. 1817 *SIRC*, no. 42), and this was before the larger changes in 1818 to the 'Walking Stick' pattern, which as far as we know, Townsend was never asked to produce (Birkhimer 1884, 277-281). In December, Townsend drafted a letter to the Naval Board that extolled his recent success, and even felt important enough to write President Monroe to recommend a local doctor for an appointment as an Army surgeon (Preston 2001, 695). In fact, just this previous summer he was also part of the party that discovered a famous mammoth skeleton near Chester, among whom was De Witt Clinton (soon governor of New York), Silvanus Miller (a supreme court justice in New York), and other members of the New York Lyceum of Natural History; Charles Wilson Peale would later help excavate it for his famous Museum in Philadelphia (*Independent American*, June 25, 1817; Yochelson 1992), so it is clear Townsend's star was rising.

He claimed that some further experiments on the cannon had convinced him that "the iron from which they are made possesseth a body and constitutional strength and elasticity superior to any iron now in use among any of the cannon foundries in the United States." In his examination of iron ores from Maine to the upper reaches of the James River in Virginia, Townsend claimed that he had never seen any free of arsenic or sulfur, and in fact most often the ores show the two combined, "which are considered deleterious and vastly prejudicial to the strength of cast iron if not removed or destroyed before smelting." Townsend claimed to have invented a "severe calcination and washing" process that very nearly completely "extirpate[d]" the impurities before smelting. He therefore offered to have one of his guns delivered to Commodore John Rodger's dock for trial by the Navy, and was sure that it would be as good as any gun of that caliber at one-third the weight (Townsend to Navy Board, 12 Dec. 1817 *SIRC*, no. 43).

Townsend's success in these trials, however, led him

into a "situation" which would contribute to his downfall. The *Niles' Weekly Register* 1817 article continues: "Mr. Townsend in the course of conversation observed, that he intended shortly to make some light 12 pounders of iron for field service, of which the weight will be less than the French, English, or American brass guns of the same calibre." He had written to Bomford in April, "those I have made are very light and handsom. General Swift says they are the best looking guns he ever saw" (Townsend to Bomford, 28 April 1817 *NARA RG156/E21* /10). This boast would make its way into local history as "it has generally been stated that the 6- and 12-pounders were lighter and yet stronger than the brass English pieces they modeled on" (Ransom 1966, 197).

THE CRASH

Despite the fact that he had manufactured the first cannon in New York and they had passed inspection with flying colors, storm clouds gathered over Townsend. Upon his return to New York in March 1818, Townsend brought with him a formal deed and certificate from the clerk of the New York Supreme Court for the property of a "Mr. Wills", probably Townsend's brother-in-law, Nathaniel Wills. This deed was to be transferred to the Ordnance Department as payment against the advances (Townsend to Bomford, 9 March 1818 *NARA RG156/E21* /13). Whether this was property independent of Townsend's troubles or collateral seized because of them is unclear; what is clear from a letter from the foundry foreman, Patrick Kiernan, is that Townsend had been running from his debts:

Having received information that Mr. Peter Townsend has made a further contract with the war department and actually has rec^d an advance on the new contract of \$15,000. As an officer of the public at the head of the department, I am induced to make my application to you on behalf of myself & those men who I have placed in his works. I am known to Colonels Wadworth [sic] & Bumford [sic], and it has been under my immediate inspection and superintendence the work of Mr. Townsend has been erected and the Guns cast. . . .

Four months have elapsed since he left me in charge of his works until his return from Washington. His long absence without writing me in all the time left me in doubt how to act and I was induced to advance my own cash to meet the demands of the workmen that they might not be separated until his return. To my great surprise I have seen a letter from Mr. Townsend to the Sheriff in Newburg dated from New York [where he had just arrived from Washington]

making the request that he [the sheriff] would put him on the limits in either New York or Goshen as an Insolvent, with which the Sheriff has complied & he is now claiming the benefit of the act [i.e., declared bankruptcy] and his property is to be sold on the 30th of the present month. Is it possible that the department could afford us any assistance if another person proceeds with the contract? If so, I humble hope the distressing situation to which our families are reduced will be a sufficient inducement to create an interest for us when I state that we have been the means of enabling Mr. Townsend to claim payment for what Guns he has already delivered, as they were actually completed by us. And the sums he is indebted to us is all we have to depend on at present.

Our expectations from Mr. Townsend promise us very little and as we must look out very shortly for other employers, we are anxious to ascertain how far we may depend on the interference of you, as the only person who has it in his power to assist us under the circumstances. (Kiernan to Bomford, 16 March 1818 [NARA RG156/E21 /12](#))

Kiernan, who had been hired to build and superintend the cannon foundry, had laid out \$750 of his own money, and listed the other principle skilled tradesmen who had done likewise to a total of just under \$1,500. Indeed, the Townsend Foundry was to be sold by the sheriff on the last day of March and yet the War Department was still not clear that this was happening: on that very day Capt. Morton wrote to Townsend blithely asking for clarification on when Townsend intended to finish his contract for the Army (Morton to Townsend, 30 March 1818 [SIRC](#), no. 46).

Townsend, clearly under great distress, let the Ordnance department know that his endeavors had come crashing down around his ears in his absence from Newburgh:

On my return from Washington I found that in my absence that judgments obtained for my debts had so accumulated and my Creditors so eager for money and some of them had some strong feelings of persecution that I came to the determination of Stopping payments. It was a painful alternative; but to me no other course was left. I am now on the limits where I shall not remain long. My brothers, Wm & Isaac Townsend have a large quantity of Iron on hand and are now making more and will complete the contract which I made with your department. The Cannon Foundry at New Burgh

will be put in operation the first of May and business will go on for the government as usual you may rely on the fact of their prosecuting the work to the best advantage and that you are intirely secure. The Deeds I received from New Burgh yesterday they shall be made comfortable to the directions you have given and returned in a few days to you when ever you wish any further information It shall be furnished with pleasure. (Townsend to Bomford, 4 April 1818 [NARA RG156/E21 /13](#))

In a surviving draft of this letter, one can see Townsend struggling with how to assure Bomford that the Army contract will be fulfilled. Ultimately, he cut out his comment that,

As my debts were considerable and I might by good luck worked through but that would take time It was doubtful in my mind whether from them [sic] and some uncertainty connected with it. Upon the whole I found it would be impossible for me to get along without being troublesom to you and calling on your department oftener than I wished to do for acct. in prosecuting the contract.

At the end he had at first added, rather melodramatically,

NB I wish you to be correctly informed as to every thing regarding me & the contract and if any information is required by the government that they should have it. You will do me a particular a favour to let my communications go no further. The government shall be safe if I starve indeed they are safe. P.T. (Townsend to Bomford, draft of letter, 4 April 1818 [SIRC](#), no. 48)

Townsend was facing a string of lawsuits against him in both Orange County and New York City. His incomplete financial records show at least two dozen judgments against him in Newburgh amounting to over \$25,500, and another three dozen in the supreme court of New York for nearly \$16,000. They range from \$4,600 owed to his brother Isaac for a loan from the Bank of America to small debts of under a hundred dollars to merchants for beef or goods. Clearly most were merchants trying to get their money back for goods sold to Townsend, and at the end of May the recorder of the City of New York put advertisements in papers calling for all creditors of Townsend to register his debts to them (*New York Columbian*, July 31, 1817, 3). [\[10\]](#)

Many of these suits had been filed before Townsend had entered into the contract with the government, and

the majority were initiated in 1817 and 1818, so it is hard to escape the conclusion that Townsend decided to go into the cannon founding business to pay off the impending debts, perhaps knowing that such a venture would entail a large advance. It may also explain why he had intended to offer the entire Sterling and Southfield iron complex for sale at public auction some five years before (SIRC). In the end, though, the lawsuits came fast and furious and his ploy caught up with him.

The sheriff's sale was delayed a few days, but the cannon foundry, stock, and completed but un-proofed cannon were sold on April 9, 1818. Townsend apparently arranged for his brothers William and Isaac (both of whom had been among the Sterling Co.'s original board of 13 directors) to buy the cannon so that they could still be delivered to the Army upon Bomford's order, and it seems that somehow he engineered it so that his brothers moved up from Goshen and took over the foundry to endeavor to complete the contract for the government. Peter Townsend declared bankruptcy and hoped to be free of his debts in a few months. He did admit, though, that his creditors in Orange County were not pleased that Townsend was protecting the government investment in the foundry to the exclusion of their claims against him. Townsend actually asked Bomford not to speak to his creditors and that he "be so guarded as not to give you or myself any Trouble, as every act I do will be scrutinised with extream severity" (Townsend to Bomford, 15 April 1818 [NARA RG156/E21](#) /13; draft of same misdated as "1820?" in SIRC, no. 65).

By comparison, we also have an external opinion about Townsend and his business dealings from a rival cannon foundry just downriver from Newburgh. Gouverneur Kemble, the proprietor of the West Point Foundry in Cold Spring (Walton 2009), contacted the Ordnance Department as soon as he had heard that Townsend was having difficulty meeting his contracts, offering to pick up the remainder of Townsend's contracts. It may have been this letter that first let the Ordnance Dept. know that Townsend was actually bankrupt (Kemble to Bomford, 20 March 1818 [NARA RG156/E21](#) /12). It appears that Morton then asked what Kemble knew about Townsend, and Kemble pulled no punches:

The character of this man had long been so notorious that I thought you must have been acquainted with it. He is now playing the same game towards his creditors that his father in law [11] did before him, and will cheat them in the same manner. The contract with the Ordnance Dept has no doubt been made over to the Brothers, who will go on with it as long as they may find the Interest to do so, but not one job further. The works are made over to the

Brother in Law Nath^l Wills, the rest of the property I understand is mostly in the hands of the Brothers, who have all conjoined to cheat the creditors and will no doubt effect it. I do not disguise to you that I would make a large sacrifice to get the contract, and I can hardly suppose that Colⁿ B[omford] is disposed to abet those who have leagued to cheat the creditors, to whom, if worth anything, the contract properly belongs. (Kemble to Morton, 2 April 1818 [NARA RG156/E21](#) /12)

Ransom (1966, 192) notes laconically that "a gap appears in the records of Sterling between 1817 and 1825" and speculates that some kind of "litigation or financial difficulty... brought about at least a partial suspension of activities at the old ironworks." His further observation that the limit on capital stock was increased from \$500,000 to \$750,000 in 1825 should have suggested to Ransom that the Sterling Ironworks was in trouble. While the Sterling Company was clearly directly connected to the cannon foundry, the latter seems to have operated wholly independently (even though it was absorbing the entire output of the Sterling and part of the Southfield furnaces), and Townsend seems to have kept the Sterling Co. entirely outside the contracting property with the government.

This move, perhaps a sly one given that Townsend knew he was playing one off the other, seems to have insulated the three entities (the Sterling Co., the cannon foundry, and Townsend as an individual) from each other, as when the lawsuits came, the judgments were against Townsend as an individual and not against either of the manufacturing enterprises. Admittedly, in the early nineteenth century, shareholders (and creditors) had difficulty recouping their money from delinquent businesses (Hilt 2006, 12-13), but there is no evidence that the debts against Townsend were ever prosecuted against the Company and it is significant that the contracts with the Army and the Navy were both with Peter Townsend alone. Clearly, though, the three entities all needed more capital and, as we shall see, the correspondence with the government concerning the foundry bears this out.

REORGANIZING TO CONTINUE

As far as the Army was concerned, they believed that Peter Townsend's brothers had taken over the foundry and his bankruptcy had merely removed one person from the equation, not destroyed the whole endeavor. Capt. Morton had asked Maj. Dalaby to try to find out what was really happening, and in May Dalaby wrote to Townsend, "in a manner that induced me to believe would draw from him the real situation of his

affairs.” He added a postscript that “I am informed by Peter Townsend Family that the canon foundry will progress and the contract with the government be fulfilled. It will be carried on by his brothers, who purchased his property on public sale for that purpose” (Dalaby to Bomford, 1 May 1818 [NARA RG156/E21 /11](#)). Townsend dodged his inquiries. Dalaby resolved to visit Townsend in Newburgh, but then found out that Townsend’s brother-in-law, Nathaniel Wills, was going to be in Albany and decided to meet up with him there. Wills also told Dalaby that brothers William and Isaac had taken over the foundry and intended to continue, but Dalaby was still suspicious and at the end of the month went to Newburgh.

Perhaps surprisingly, he found the works in progress and reported that there would be eight to ten ton of cannon ready to be proofed and taken by the Army within two to three weeks. Dalaby was quite confident that, “There is to me apparently a certainty that the contract will yet be completed if it is not stopped by the government” (Dalaby to Bomford, letters, 20 and 26 May 1818 [NARA RG156/E21 /11](#)). Somehow, Townsend seems to have managed in the midst of bankruptcy proceedings to arrange additional securities for the foundry and through Representative Fisk align all the deeds ready to be signed over to the government should he fail in producing the cannon for the contract. These actions do suggest that he was earnestly trying to make a go of the cannon foundry. By the end of June those cannon were indeed ready for inspection, and Dalaby was summoned down to proof them.

And yet, Townsend was still up to his old behavior. Although he swore to Bomford that he would be free of his debts in August and would again, “be in the World of business,” he told Bomford that his brother William had moved with his family to Newburgh to run the cannon foundry. Still, Peter said that William,

is in want of some money. If you can send him Five Thousand Dollars immediately he will be very thankful or if you send it to me it will be the same as I can send it to him daily. He will not ask for one cent more than is necessary for his Business. [H]e is in want of Coal for which he requires money. (Townsend to Bomford, 27 June 1818 [NARA RG156/E21 /13](#))

This time the Ordnance Department finally wised up: by July they realized that it would no longer be prudent to make any further advances, although they continued to proof cannon coming out of the foundry to try to recoup their investment (Wadsworth to Townsend, 1 July 1818 [SIRC](#), no. 49).

At this point, though, the shoe seems to shift to the other foot. There were some delays in sending inspectors to Newburgh to proof the cannon in July, and now

it was Townsend’s turn to become impatient. He wrote to Wadsworth on the 20th, imploring him to get someone there to test the cannon and take delivery because he knew he could not get paid before that happened. The cannon that Dalaby had proofed in the autumn before and those now awaiting proof on the landing at Newburgh amounted, in Townsend’s estimation, to more than \$25,000 of ordnance. “Unless suitable advances can be given,” Townsend cautioned, “it will be impossible for the Works to go on.” But, he assured Wadsworth,

the advancements required will be small, and not a dollar more required than is necessary for to expedite the work. The works are now Idle for the Want of Coal and the workmen are Idle and on Wages at a great expense.

And just to drive the point home, Townsend continued,

Without aid from your Department the works cannot progress any further. . . . As things now stand they are ruinous, the daily wages of the workmen are twenty five dollars pr day besides the loss of time. (Townsend to Wadsworth, 20 July 1818 [NARA RG156/E21 /13](#))

It should be noted, that once again, a draft of the letter exists that shows Townsend’s angst at the situation. In that draft he struck out the reminder that he had already received \$45,000 from the Army and upped the value of the outstanding payments from \$23,000 to \$25,000. He also played with the rhetoric of his wording, rewording sentences repeatedly to focus on his, rather than the Department’s, hardships and shifted “for the advancement of the Contract” to “expedite the work” (Townsend to Wadsworth, draft of letter, 20 July 1818 [SIRC](#), no. 50).

By early August, Lieut. Pomeroy had proofed all the guns, and had those that passed shipped to Albany. Townsend therefore wrote to the Ordnance Dept. that he felt he had delivered \$20,500 of guns and cannon, and that the Dept. now held the title to the foundry free and clear. “There is a good stock of Pig Iron on hand and nothing wanting but some advancements from time to time, to compleat the contract,” he said ([NARA RG156/E21 13](#); draft of same [SIRC](#), no. 52). His brother also tried to get certificates of delivery from Watervliet in order to get paid, though Dalaby – not wanting to risk double-payment by issuing two receipts – claimed that he should already have had them (Dalaby to Wm. Townsend, 17 Aug. 1818 [WAL Letterbook 119-20](#); [SIRC](#), no. 54). The Ordnance Dept. was not so sure, and summoned Townsend to Washington to discuss any further advances (Wadsworth to Townsend, 12 Aug. 1818 [SIRC](#), no. 53).

What Townsend had not addressed in his letter to Wadsworth was that a number of the guns in this second batch failed the proof. It appears that some burst and

some others were not made to specifications (one 18pdr was too variable, for example). But rather than accept blame for this, Townsend decided to challenge the proofing standards. Specifically, he was “dissatisfied with the proof charges established by you [Col. Wadsworth] of late for light pieces.” Under Col. Bomford, the proof charge was smaller than under Wadsworth, and even though some of Townsend’s 12pdrs had withstood the stronger charges, he did not allow all his light pieces to be tried with the heavier charges. Even more frustrating to Townsend was that Lieut. Pomeroy had proofed and passed eleven 12pdrs using Bomford’s lighter proof charge, but then did not stamp or receive them and left them at the foundry. Dalaby believed that if Wadsworth’s new proof charge were to be maintained, then the 12pdr guns would need to be made more substantial, but in either case deferred to Wadsworth on whether or not to receive all the cannon (Dalaby to Wadsworth, 17 Aug. 1818 [NARA RG156/E21 /11](#)).

Wadsworth, who is credited for revising the American standards for ordnance at this time (Birkhimer [1884](#), 277-278, 386-387), was unmoved and would not receive the cannon. He claimed that even if Bomford had agreed with Townsend on a lighter charge, he had still specified that the 12pdrs should weigh 12cwt. Townsend balked and claimed that it was Dalaby who had told him to turn down the 12pdr pattern on the lathe so that they would weigh less than 12cwt (in a letter to the Navy Board, Townsend had mentioned that his 12pdrs weighed 10.2.14cwt [1064lb.], or about 11% lighter). Writing to William, Dalaby clarified what he believed happened:

I have understood that it has been said at the Foundry that I directed the 12 Pdr. pattern to be turned down. If it has been said, it is not true. I never have any direction on that point. I recommended to your brother [Peter] to cast one or two 12 Pdrs. as light as they would bear to prove the strength and raise the credit of his Iron... meaning upon his own responsibility & to take one of them to Washington with him – but I never gave him even any advice relative to casting the 12 Pdrs which he meant to deliver upon the contract.

And while Dalaby was willing to carefully compare the rejected cannon to the blueprints supplied by the Ordnance Dept. the next time he was at the foundry, he was fairly sure that the wooden molding pattern had been turned down too far in an attempt to save metal, Townsend believing that the smaller cannon would still stand proof. If so, said Dalaby, Townsend “did it upon his own risk” (Dalaby to William Townsend, 31 Aug. 1818 [WAL Letterbook](#) 131).

Amazingly, the Ordnance Department *still* did not give up on Townsend – probably more a comment on the scarcity of cannon founders in the country than a vote of confidence in Townsend. In fact, in September they authorized an additional \$15,000 advance to Townsend to complete the full \$60,00 advance originally agreed upon. This was to be made in two payments, \$7,500 then and the same again in December, though Townsend had to repeatedly prod for the second payment (Townsend to Wadsworth, 30 Dec. 1818 [NARA RG156/E21 /13](#)). [\[12\]](#) They did agree to a more realistic delivery rate of 120 tons per year, starting then (Memo on Peter Townsend, 1 Sept. 1818 [NARA RG156/E78](#), vol. 1, 86-7; Calhoun [1820](#), 26-27).

This time Townsend cautiously asked for clarification of what the proof charge should be for a 6pdr and the exact dimensions of 6- and 12lb. shot so “that new Molds may be provided that are perfectly correct.” He also made sure that his 24pdrs were cast with a ‘ring’ (a lifting loop, either on the cascabel or on the second reinforce behind the trunnions) as Wadsworth had directed, and asked for clarification on whether Wadsworth wanted future 24pdrs to be of the long pattern, the short pattern, or some of each (Townsend to Wadsworth, 3 Nov. and 23 Dec. 1818 [NARA RG156/E21 /13](#)). It is interesting to note that Townsend seems to have moved into making the much smaller 6pdrs at this point (“a fine parcel of handsom guns and the six pounders have stood the proof,” he says in the latter letter) possibly as each required less metal and given his continuing financial straits this may have been all he could manage.

In light of these delays, miscommunications, and difficulties, Wadsworth seems to have had no choice but to start shifting contracts to other foundries due to Townsend’s “dilatoriness.” John Clark’s foundry near Richmond had been reliably casting 300 tons of ordnance for various Chesapeake Bay fortifications, as well as shot and shell for infantry units, and the Ordnance Dept. began to give up on Townsend (Frye [1818](#), 70-72).

In the spring of 1819, the West Point Foundry approached Townsend to purchase the remainder of his contracts, but Townsend wanted far too much for them. Soon, however, Townsend came back, asking them to buy the remaining 300 tons of his contracts. Still, as Townsend wanted twice what Kemble was willing to pay, nothing came of this (Kemble to Wadsworth, 3 and 20 Mar 1819 [NARA RG156/E21 /14](#)). To his credit, Townsend kept trying to produce 6- and 12pdrs, but (again) begged forgiveness in their slow delivery, this time blaming “the extream drouth last summer & dureing the last winter I have been unable to advance the Boaring of the Cannon made at the New Burgh Foundry with that dispatch I could wish.” He claimed these small calibers were “a slow gun to boar & finish” and quite amazingly asked for yet *more* money (\$4,000-5,000

this time), "Owing to the unexampled scarcity of money none can be procured here and credit is entirely out of the Question" (Townsend to Wadsworth, 7 May 1819 [NARA RG156/E21 /15](#); draft of same [SIRC](#), no. 66). Wadsworth was diplomatic in his refusal: "Pressures of the Times operat[ing] on the national Treasury with as much effect, as elsewhere" and therefore that it was very unlikely that any advances would be forthcoming, *finally* saying that "There is a large Balance standing against you on the Treasury Books and I wish to see it diminished rather than increased" (Wadsworth to Townsend, 10 May 1819 [SIRC](#), no. 56).

To make matters worse, when Dalaby was dispatched to proof what Townsend had recently produced, there were major problems. Although he had tried very hard at Wadsworth's direction to proof the cannon and had been given full discretion for their acceptance, he had "*at first adjudged [them] to be not serviceable*" (emphasis in original). And indeed, he had to refuse to receive the "greater part of them, viz, the 24pdr, all the 6pdrs, and a part of the 18pdrs" (Dalaby to Townsend, 25 Nov. 1819 [SIRC](#), no. 58). It looks like the rejection rate was at least 50%, judging from instructions Dalaby gave to Lieut. B. Vining later in the fall, though he again bent over backwards for Townsend, reminding him "It being now Solely left to my judgment to decide the fate of those Cannon – and my own reputation, as an Officer, being subject to be effected by that decision, I am under the necessity of refusing to receive the greater part of them." He instructed Vining, "If, however, when you come to review them externally you should believe that we have misjudged of the defects of any of the remaining 18pdrs. and believe them equally good with those above numbered, you will receive them" (Dalaby to William Townsend and Lieut. B. Vining, both 25 Nov. 1819 [WAL Letterbook](#) 224-5).

Quite unbelievably, when those that were accepted were to be retrieved to Albany the following March, Dalaby sent a sloop down only to find that Townsend had not moved them from the foundry to the dock for loading. Since moving cannon was Townsend's job and the Ordnance Dept. had not agreed to pay for that, the cannon sat there until May, when Townsend finally moved the fourteen accepted 18pdrs to the dock (falsely claiming that he had he had never been told to do so) and they were finally sent upriver to Watervliet (Dalaby to William Townsend, 8 May 1820 [SIRC](#), no. 60; Dalaby to Wadsworth, 25 May and 15 June 1820 [NARA RG156/E21 /16](#)).

By the end of the summer 1820, Townsend had finally thrown in the towel. He wrote to Wadsworth and to John Calhoun, the Secretary of War, that although he did have some cannon ready for proof at Newburgh, calamity continued to plague his family. This time William had "become unhealthy and unable to prose-

cute the Contract with that ability which such an establishment requires." Thus, "Messers Kemble & Co. proprietors of the Cold Spring Foundry [*i.e.*, the West Point Foundry] have signified a disposition to purchase the New Burgh Foundry and compleat the contract which I made with Colⁿ Bomford." Townsend asked Calhoun and Wadsworth's permission to sell the foundry and transfer the contract to the West Point Foundry (Townsend to John C. Calhoun and copy to Wadsworth, 27 Aug. 1819 [NARA RG156/E21 /15](#)).

Gouverneur Kemble was not quite as willing as Townsend seems to imply. Separately, but six months later, he wrote to Wadsworth to find out what exactly he was buying into. Kemble was concerned by the fact that the House of Representatives had just ordered an inquiry into the Townsend affair, and wanted to make sure the WPF "shall not at any rate run a risk of losing money." Kemble wanted an "exceptly [*sic*] simple purchase of the contract for a specific sum," because "the reputation of P.T. with whom in a complex negotiation I should consider myself and unequal match," he feared could cause trouble. Kemble asked who the sureties on the bond were so that he could get a full picture of the deal (Kemble to Wadsworth, 11 March 1820 [NARA RG156/E21 /16](#)).

And indeed, by the end of 1820 Col. Wadsworth, who seems to always have been lenient with Townsend, wrote to him that the recent report from Dalaby was "not very creditable to the character of your foundry. The guns are described as being badly cast, badly finished, and incorrect in their dimensions." To make matters worse, Wadsworth had told Townsend that he did not need any more 18pdrs, but Townsend had made more anyway, and the majority of those entirely failed inspection. Wadsworth kindly then suggested that perhaps Townsend would prefer to make 100 tons of the simpler 10-in. shells and 24lb. round shot by the time navigation opened again in the spring (Wadsworth to Townsend, 8 Dec. 1819 [SIRC](#), no. 59). Between January 1815 and January 1819 Townsend had received \$60,000 in advances from the Ordnance Dept., and had only produced \$12,885.46 worth of product. Wadsworth informed the Secretary of War that, "No certain reliance can longer be placed on the full performance of that contract" (Calhoun 1820, 5, Table A).

And thus it came to pass in July 1820 that the U.S. government filed suit in the District Court of New York against Peter Townsend to recover \$47,114.54. By May 1821, they had received a judgment against Townsend for \$54,601.92. [13] In the process, Townsend had been arrested and released on bail, though not before countering the government for improperly charging him \$800 in marshal fees for his own arrest, plus interest. Those fees were subsequently upheld as Townsend lost his suit (*Townsend v. United States*, 24 F.Cas.103). The question

now became what to do with the Newburgh Foundry.

DISPOSING OF A CANNON FOUNDRY

By all accounts, it appears that Peter Townsend had raised a fully working cannon foundry on Chamber's Creek, and had he had enough capital and been able to follow instructions, he might well have made a go of it. Now that he was bankrupt and over \$50,000 in debt to the government, the property had to be sold.

General J. G. Swift, who had been an initial and important investor in the West Point Foundry, asked Gouverneur Kemble his thoughts on Townsend's foundry in June 1821. Although the district attorney for southern New York, Robert F. Tillotson, was anxious that something should be done with this property, nothing seems to have happened that year, either by the hand of Kemble or by that of the Ordnance Dept. (Swift to Kemble, 16 Jun. 1821 [KFP Kemble Family Papers](#), box 4, fol. 2; Tillotson to Bomford, 27 July 1821 [NARA RG156/E21 /19](#)). In the summer of 1822, Louis Dubois from Salisbury, Connecticut made an offer of \$5,000 for the Townsend foundry, far below its actual value.

The district attorney suggested to Bomford that at the very least the property could bring more at auction (Tillotson to Bomford, 24 May 1822 [NARA RG156/E21 /22](#)). The West Point Foundry continued to express interest, but the problem was now that Townsend's foundry began to be vandalized in its idle state, apparently looted by creditors seizing anything of value (Kemble to Bomford, 11 July and 24 Sept. 1822 [NARA RG156/E21 /21](#); William Kemble to Gouverneur Kemble, 26 Aug. 1822 [KFP Kemble Family Papers](#) 4/17). The firm of Borland & Ludlow was hired to make a formal valuation of the property, but they were slow in beginning, and in the meantime, "the persons having charge of the Newburgh foundry and property accompanying it, [were] destroying the same in every possible manner."

Over the winter, they had destroyed the gun patterns stored there, and within a week of the Ordnance Department authorizing Kemble to take possession of the foundry in May, he reported that, "they have begun to take the iron clamps from the furnace chimney, having already stolen every thing else" (Kemble to Bomford, 5 and 12 May 1823 [NARA RG156/E21 /23](#)). Not surprisingly, Kemble was not enthusiastic to take possession of a depredated property, and informed Bomford that he would have to reexamine the property before receiving it under whatever terms they had agreed.

By July, Kemble does seem to have taken possession of the property, though presumably under reduced terms (Kemble to Bomford, 22 June and 14 July 1823 [NARA RG156/E21 /23](#)). To make matters worse, when the property was transferred to Kemble, the district attorney discovered that there had never been a deed for

the property in Townsend's name on record in Orange County because the law requiring that all land transfers be recorded in the county clerk's office was not passed until after Townsend bought the property from Schultz.

Townsend had had his title fully vetted and had given it over to Bomford in 1818, but without a deed in the recorder's office, the transfer to Kemble became problematic. Bomford had to have his copy of the deed sent back to New York and Tillotson had to re-check its unencumbered status. Bomford wanted Kemble to accept full quitclaim rather than a warrantee deed (Tillotson to Bomford, 11 Aug., 24 Nov. and 24 Dec. 1823 [NARA RG156/E21 /24](#); Kemble to Bomford, 19 Jan. 1824 [NARA RG156/E21 /26](#)). Kemble had gone to Washington in December to finalize the deal but had discovered that the original deed for the property was questionable, and that

the only title is a quit claim from an associate of Peter Townsend, a man devoid of character in the community, that the deeds have none of them been accorded, and that it will still require a great many years of uninterrupted possession to render them valid; circumstances moreover have occurred which would lead to a suspicion that P. Townsend or some one of his family does at this moment hold a claim on the property, for their conduct can be explained in no other way. (Kemble to John C. Calhoun, 19 May 1824 [NARA RG156/E21 /26](#))

Kemble refused to accept the property, and the matter dragged on with only one other lowball offer in the next two years (Kemble to Bomford, 3 Jul. 1824; Bomford to Kemble, 27 Aug. 1824 [NARA RG156/E21 /26](#)).

Meanwhile, Peter Townsend seems to have retreated to the iron furnaces near Goshen in Orange County, specifically Southfields Furnace, and continued to produce pig iron for market. In 1825, stockholders asked three notable New York businessmen of the iron industry to examine the Sterling Company in connection with their attempt to raise more capital stock. One may infer that Townsend's debts made them nervous about the whole concern. However, the committee reported that Sterling iron was second to none, and the mines seemed inexhaustible.

The Southfield furnace was in good condition and producing 300 tons of pig iron per year. The Sterling furnace was able to be finished to produce the same for a mere \$8,000, and had copious waterpower for whatever secondary operations could be wanted such as rolling, forgings, or plateworks. They found the books "candidly and fairly made," and that the property was worth its valuation (McQueen, Allaire, and White 1825). In 1826 the Sterling Co. employed over 350 people and

seems to have been, or claimed to be, doing very well (Hilt 2006, 8n25).

Townsend, then, hardly seems to have been financially ruined by all of this; in fact, he also built a rather stately mansion at Southfields at about this time (Crofut 1980) and it appears political wrangling by De Witt Clinton arranged his 1819 appointment as clerk of the Post Office in New York, an appointment that probably saved him financially and began his political career (*National Advocate*, July 21, 1819).

By 1826, it had been nearly eight years since Townsend had begun to default on his contract and had passed the foundry in trust to the War Department. He was (apparently) entirely unable to close his \$54,000 debt to the government and the depredations on the Newburgh property reduced its value to a mere \$5,000. Only two offers had come forth in all that time, one offering only \$3,000 cash (Kemble to Bomford, 21 April 1826 *NARA RG156/E21* /30), and now no one was willing to pay even that much for a dilapidated parcel of 16 acres that included a forge and three frame tenement buildings. Kemble advised Bomford that the market for such properties, even in good condition, was soft in the mid-1820s.

Bomford then asked the new Secretary of War, James Barbour, to publicly advertise it for private sale in the New York and Newburgh papers and then put it up for public auction. Barbour agreed, and the public auction was set to go forward with Kemble acting as the government's agent in the affair (Kemble to Bomford, endorsed by Bomford with instructions for the Secretary of War, 2 May 1826, 15 July 1826, and 20 July 1826 *NARA RG156/E21* /30). Of course, nothing went smoothly and if the auction ever even happened, no one met the \$5,000 reserve on the property.

In 1831, the property was still owned by the government, though it had now officially depreciated to \$3,000. Kemble made an offer of that amount, and though it appears that the Army accepted this offer, getting approximately 5.5¢ on the dollar for their debt against Townsend, even now the government refused to accept it (Ingham 1831a; 1831b, 281). The next year Richard Trimble of Newburgh, who owned the adjoining land up the creek, offered \$2,000 for the 16 acres, but now the government was holding out for \$2,500. Kemble was finally able to sell the land to John A. Tompkins of Pawtucket, RI, apparently for the \$2,500, at the end of August 1832 (James A. Hamilton to Wood & Trimble, 2 June 1832 *KFP Kemble Family Papers* 7/8; Verg L. Maxey to Kemble, 7 Jun. and 19 Oct. 1832 *KFP Kemble Family Papers* 4/5).

Tompkins converted the mill and foundry to a machine shop in 1836, but he was drowned shortly thereafter, the first in a sequence of owners who tried and failed to make pins, to manufacture equipment for daguerreotypes, and to mill flour on the site. By 1881

a local historian would comment, "Those who remember the activity which at one time prevailed here, can best appreciate the desolation that now sits with folded wings on its ruins." The remains burned to the ground in 1911 (Ruttenber and Clark 1881, 221; Ruttenber 1911, 53-54).

Thus ends the ignominious story of Peter Townsend's cannon foundry in Newburgh, New York. As the first maker of artillery in the state, Townsend tried to use government investment to shore up his looming debts, but ultimately his lack of capital hamstrung his every attempt to continue. When his willfulness in altering the patterns for the cannon (had it worked and been accepted, we would of course have called it visionary) and technical failures in casting and boring caught up with him, there was little to be done but to give up. Yet through all of this, Townsend surprisingly (and successfully) continued to dodge his creditors and yet still cheekily asked for further advances from the government.

To be fair, the War of 1812 also helps explain some of Townsend's story (Hickey 2001). That he undertook this audacious project during the war helps explain why the government was at first so willing to invest a large sum in an ironmaster with no cannon-making experience, since their ordnance infrastructure in the DC-Maryland area had been wiped out by the British incursion up the Chesapeake in 1814. Further, it also helps explain why the government advances were initially delayed, in that the U.S. was largely insolvent by the time the war ended (Bullock 1917, 359-360). Still, the governmental context does not completely explain his failure. At least three other cannon foundries, as well as a number of other industries supplying the military, were started at this same time and flourished.

Technological development is clearly not always smooth and in cases not at all progressive, but even the failures can tell us something. The combined pressures of the cessation of wartime demand, the costs of reconversion to peacetime products, and the "unforeseen competition which arose for the accumulation of English manufactured articles" that flooded the country, pushed many businesses out of business (Rome 1977). At the same time, however, the U.S. was consciously trying to develop domestic artillery production from 1815 onward, but the wider story of the successes and failures in all the American cannon foundries of the early republic are a larger story for another day.

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NOTES

1. (page ??) While the foundry was on the *south* side of the creek that is the boundary of Newburgh, thereby technically putting it in New Windsor, as Newburgh was the larger town at the time, and contemporary documents refer to it being at Newburgh, I shall follow that practice here.
2. (page ??) The "Sterling Company" was incorporated by ch. 76 of the 37th session of the New York state legislature 1 April 1814 (*Laws of New York 1814*, 84-86) and the amended by the ch. 252 of the 48th session (*Laws of New York 1825*, 372). Incidentally, 1814 was the peak of incorporation for manufacturing firms in the state, as companies sought to capitalize on the demand due to the restriction of imports from Britain during the War of 1812 (Hilt 2006, 6; Seavoy 1972).
3. (page ??) A table of existing contracts in the same volume (p.23) notes that Townsend was to be advanced \$65,000, and had received \$20,000 in 1815.
4. (page ??) Townsend adds a curious note at the end: "I shall I fear be disappointed in the Jerman Prisenors the New order of thing I aprehend will stop that project." In a letter three weeks later, he says, "I have recently been on to the north with a view to obtain some Jerman Prisenors in that object I shall not succeed." (Townsend to Bomford, 12 March 1815 *NARA RG156/E21*, box 6). Was Townsend using conscript German labor, possibly Hessian prisoners of war who had fought for the British or just local convicts from the Newburgh area (which was founded by Lutheran settlers), to build the foundry?
5. (page ??) The Treaty of Ghent had been signed on 24 Dec. 1814 and was ratified in Washington in February 1815.
6. (page ??) "I should regret, both on your account, and that of the public, that your contract should not be defeated, especially as you have spent so much time & money to prepare for its completion. It will not be defeated, I am persuaded of the government knew your

determination and your ability to perform it." (Hon. John Fisk to Townsend, 7 May 1815 *SIRC*, no. 17)

7. (page ??) On the difficulty of getting paid, both in money being sent, and in the negotiability of the payments: Townsend to Bomford, 19 June 1815 (*NARA RG156/E21* /6). On the Treasury notes and cities of issue: Townsend to Bomford, letters, 21 June and 20 July 1815 (*NARA RG156/E21*, box 6); Thomas T. Tucker to Townsend, 24 June 1815 (*SIRC*, no. 23).

8. (page ??) Figure 4.6 is the only known view of Newburgh that could be contemporaneous with Townsend's foundry that covers any activity on Quaissaic Creek. Other early nineteenth-century images of Newburgh that *ought* to show the foundry buildings, such as a painting done by William Guy Wall about 1821 of Newburgh seen from Fishkill Landing and then engraved in the *Hudson River Portfolio* (New York: Megarey, ca.1828) show a large structure south of Newburgh and on top of the bluff, but it is too far north and inland to be the foundry (Pers. Comm. Mary R. McTamane, City of Newburgh Historian, 12 October 2010). Views seem to knowingly crop out this area, perhaps as it was a failure or perhaps because it was an industrial blot on an otherwise bucolic landscape.

9. (page ??) If Townsend did send a model of the boring auger to the Patent Office, record of it was lost in the fire of 1836.

10. (page ??) Judgments against Townsend, 1815-1818: *SIRC*, 4/36/428, 4/39/431, 4/40/432. Judgments against Townsend on file in the supreme court of New York City, 1819: *SIRC*, 4/41/433.

11. (page ??) In the first years of the 1800s, Townsend married Alice Cornell from the Cornell iron family in Albany (Ruttenber and Clark 1881, 806-806), and Robert C. Cornell (her father?) was one of the initial directors of the Sterling Company when it was chartered in 1814.

12. (page ??) It was finally remitted on 5 Jan. 1819, and although it had been earmarked to come from the "Fund for Cannon", when the payment got to the Comptroller's office, it was discovered that the fund was exhausted. Wadsworth received the Secretary of War's permission to take the money from the "Ordnance Fund" instead, though this incurred an additional delay. (Wadsworth to Townsend, 15 Jan. 1819 *SIRC*, no. 55).

13. (page ??) Memorandum, 21 July 1820 (*NARA RG156/E78*, vol. 1, p. 386). Robert Tillotson to Bomford, 7 May 1821 (*NARA RG156/E21* /19); see also Lee (1822, 3), Anderson (1822; 1823, 5), Monroe (1823, 21), and Anderson (1828, 139; 1830, 29; 1833, 6).

REFERENCES

Albany Gazette (Albany, NY). 1812. "Sterling Eagle Steel." Nov. 30, 3. (Cited on page 77).

- Anderson, J. 1822. "Letter from the comptroller of the treasury, transmitting A Statement of Accounts, Which have remained unsettled on the books of the Second Auditor more than three years, prior to the 30th September, 1822." In *Congressional Serial Set*, 17th Cong., 2nd sess., U.S. House. Serial 82, H.Doc. 99. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- . 1823. "Letter from the Comptroller of the Treasury, transmitting a report of the Second Auditor, of Accounts upon which balances appear to have been due more than three years, prior to September 30, 1823." In *Congressional Serial Set*, 18th Cong., 1st sess., U.S. House. Serial 94, H.Doc. 26. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- . 1828. "Letter from the Comptroller of the Treasury... 1828." In *Congressional Serial Set*, 20th Cong., 2nd sess., U.S. House. Serial 184, H. Doc. 8. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- . 1830. "Balances on the books of the Treasury... 1830." In *Congressional Serial Set*, 21st Cong., 2nd sess., U.S. House. Serial 206, H.Doc. 4. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- . 1833. "Unsettled balances – Second Auditor... 1833." In *Congressional Serial Set*, 23rd Cong., 1st sess., U.S. House. Serial 254, H.Doc. 7. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- Birkhimer, W. E. 1884. *Historical Sketch of the Organization, Administration, Materiel and Tactics of the artillery, United States Army*. Washington DC: J.J. Chapman. (Cited on pages 89, 93).
- Bomford, G. 1822. "Report in Documents Accompanying the Bill Making Further Appropriations for the Military Service of the U.S.." In *Committee Reports and Papers of the Committee on Military Affairs from the 17th Congress: Committee Papers 1789-1946*, edited by U.S. Congress, House. Record Group 233: Records of the U.S. House of Representatives, 1789-2015. Washington, D.C.: Gales / Seaton, Apr. 8. (Cited on page 83).
- Braid, D. H. P. 1986. "Gun boring from the solid." *Transactions of the Newcomen Society*, no. 58: 45–58. (Cited on page 82).
- Bullock, C. J. 1917. "Financing the War." *The Quarterly Journal of Economics* 31 (3): 357–379. (Cited on page 96).
- Calhoun, J. C. 1820. "Letter from the Secretary of War, transmitting (in obedience to a resolution of the House of Representatives) copies of the respective contracts heretofore made with James Johnson, Alexander McRea, Elias Earle, and Peter Townsend, for the delivery of gun-powder, &c.&c., February 29, 1820." In *Congressional Serial Set*, 16th Congress, 1st session, U.S. House. Serial 36, H.Doc. 90. Washington, D.C.: Gales & Seaton. (Cited on pages 93, 94).
- Coxe, M. 1906. *The Sterling Furnace and the West Point Chain*. New York: De Vinne Press. (Cited on page 77).
- Crofut, D. 1980. *The Townsends, Early Developers of Tuxedo*. Tuxedo, NY: Tuxedo Town Historian's Office. (Cited on page 96).
- Crowninshield, B. W. [Secretary of the Navy]. 1816. "Contracts for the Year 1815." In *American State Papers*, 14th Cong., 1st sess., Naval Affairs. ASP23, Nav.aff. 132. Washington, D.C.: Gales & Seaton. (Cited on pages 79, 82).
- Dennison, J. W. 1967. *New York's First Workable Cannon (New Windsor, 1817)*. Goshen, NY: Orange County Community of Museums & Galleries. (Cited on pages 77, 78).
- Diggins, M. 2000. "Principio." *Cecil Historical Journal* (Elkton, MD) 1 (1): 3–13. online. <http://cecilhstory.org/virtualibrary/journal/journal01.pdf>. (Cited on page 79).
- "Documents Accompanying the Bill Making Further Appropriations for the Military Service of the U.S.." 1822. In *Congressional Serial Set*, 17th Cong., 2nd sess., U.S. House. Serial 82, H.R.107. Washington, D.C.: Gales & Seaton. (Cited on page 87).
- Eager, S. W. 1846-7. *An Outline History of Orange County*. Newburgh, NY: S. T. Callahan. (Cited on page 77).
- Forward, E. A. 1924–1925. "The Early History of the Cylinder Boring Machine." *Transactions of the Newcomen Society* 5:24–38. (Cited on page 82).
- Frye, N., Jr. 1818. "Documents presented by the Committee on Finance in relation to sundry estimates of moneys required for the expenses of the War Department and military service of the United States for the year 1819." In *Congressional Serial Set*, 15th Cong., 2nd sess., U.S. Senate. Serial 15, S.Doc. 65. Washington, D.C.: Gales & Seaton, Sept. 15. (Cited on page 93).
- Gardner, S. 2003. *Research Guide to the 'Sterling Forge and Furnace Papers' and the 'Sterling Iron and Railroad Papers' in the Collection of the NY State Archives*. Warwick, NY: Albert Wisner Public Library. (Cited on page 79).
- Gorr, L. F. 1971–1972. *Records of the Columbia Historical Society* 71/72:34–59. (Cited on pages 79, 83).
- Graham, D. A. 1993. *Cannon Maker for the Revolution: Thomas Rutter III (1732-1795) of Eastern Pennsylvania*. Ellicott City, MD. (Cited on page 82).
- Hickey, D. R. 2001. "The War of 1812: Still a Forgotten Conflict?" *The Journal of Military History* 65 (3): 741–769. (Cited on page 96).
- Hilt, E. 2006. "Corporate Ownership and Governance in the Early Nineteenth Century." Columbia University Seminar in Economic History. <http://economics.yale.edu/sites/default/files/files/Workshops-Seminars/Economic-History/hilt-060503.pdf>. (Cited on pages 79, 91, 96, 97).
- Independent American* (Ballston Spa, NY). 1817. "Mammoth Skeleton." June 25, 1. (Cited on page 89).

- Ingham, S. D. 1831a. "Statement of all lands acquired by, or secured to, the United States in satisfaction of debts, their location, the sums allowed for them, and their value, February 14, 1831." In *American State Papers*, 21st Cong., 2nd sess., Public Lands. ASP 033, Pub.land.903. Washington, D.C.: Gales & Seaton. (Cited on page 96).
- . 1831b. "Statement of all lands acquired by, or secured to, the United States in satisfaction of debts, their location, the sums allowed for them, and their value, February 14, 1831." In *American State Papers*, 21st Cong., 2nd sess., Public Lands. ASP 033, Pub.land.903. Washington, D.C.: Gales & Seaton. (Cited on page 96).
- Jackson, M. H., and C. de Beer. 1974. *Eighteenth Century Gunfounding: the Verbruggens at the Royal Brass Foundry, a Chapter in the History of Technology*. Washington DC: Smithsonian Institution Press. (Cited on page 82).
- Kagin, D. H. 1984. "Monetary Aspects of the Treasury Notes of the War of 1812." *The Journal of Economic History* 44 (1): 69–88. (Cited on page 81).
- Laws of the State of New York, passed at the forty-eighth session of the Legislature begun and held at the city of Albany, the fourth day of January, 1825*. 1825. Albany, NY: E. Crosswell for Wm. Gould & Co. (Cited on page 97).
- Laws of the State of New York, passed at the thirty-seventh session of the Legislature begun and held at the city of Albany, the twenty-fifth day of January, 1814*. 1814. Albany, NY: H. C. Southwick. (Cited on page 97).
- Lee, W. 1822. "Report by the Second Auditor of the Treasury, of accounts which have remained unsettled, or, on which balances appear to have been due more than three years prior to the 30th September, 1821." In *Congressional Serial Set*, 17th Cong., 1st sess., U.S. House. Serial 65-1, H.Doc.36. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- McQueen, R., J. P. Allaire, and R. White. 1825. *Report of the Committee, Appointed to Examine the Condition, &c., of the Sterling Works*. New York. (Cited on page 95).
- Monroe, J. 1823. "Message from the president of the United States, transmitting statements from the treasury department, shewing the Amount of moneys advanced to Agents, Contractors, &c. since 1st Jan. 1817, which have not been accounted for, And the amount of loss sustained in each case, the securities taken, and the names of the sureties." In *Congressional Serial Set*, 17th Cong., 2nd sess., U.S. House. Serial 82, H.Doc.102. Washington, D.C.: Gales & Seaton. (Cited on page 97).
- National Advocate* (New York, NY). 1815. "A Navy-Yard and Cannon Foundry on the Hudson, a little north of the Highlands." Jan. 2. (Cited on page 80).
- . 1817. "Cannon Foundry." July 30, A1. (Cited on pages 78, 88).
- . 1819. "Clerkship of the Post Office." July 21, 2. (Cited on page 96).
- NARA (National Archives and Records Administration). Contracts for Ordnance and Ordnance Supplies, 1812 - 1910, Records of the Office of the Chief of Ordnance, 1797-1988. Record Group 156, Entry 78. U.S. War Department, Washington D.C.. (Cited on pages 80, 83, 93, 97).
- . Letters Received, 1812-1894, Records of the Office of the Chief of Ordnance, 1797-1988. Record Group 156, Entry 21. U.S. War Department, Washington D.C.. (Cited on pages 79–83, 87–97).
- . Naval Records Collection of the Office of Naval Records and Library, 1691 - 1945. Record Group 45, Entry 336. U.S. War Department, Washington D.C.. (Cited on page 80).
- New York Columbian* (New York, NY). 1817. "Townsend's Cannon Foundry." July 31, 2. (Cited on pages 78, 83, 88, 90).
- Niles' Weekly Register* (Baltimore, MD). 1817. "Cannon Foundry." Aug. 24, 406. (Cited on page 89).
- Odevseff, C. 1974. "Only Ruins Remain of Bustling Southfields Ironworks." *Times Herald Record* (Middletown, NY), Jan. 6, 32. (Cited on page 79).
- KFP. Kemble Family Papers. private collection, New York. (Cited on pages 95, 96).
- Peterson, C. E. 1988. "Morris, Foxall and the Eagle Works: a Pioneer Steam Engine Boring Cannon." *Canal History and Technology Proceedings* 7:207–240. (Cited on page 83).
- Preston, D., ed. 2001. *A Comprehensive Catalogue of the Correspondence and Papers of James Monroe*. Westport, CT: Greenwood Press. (Cited on page 89).
- Ransom, J. M. 1966. *Vanishing Ironworks of the Ramapos: The Story of the Forges, Furnaces, and Mines of the New Jersey-New York Border Area*. New Brunswick, NJ: Rutgers University Press. (Cited on pages 77–79, 89, 91).
- Robbins, M. W. 1986. *The Principio Company*. Iron-making in colonial Maryland, 1720-1781. Garland, NY: Taylor & Francis. (Cited on page 79).
- Rome, A. W. 1977. *Connecticut's Cannon: the Salisbury Furnace in the American Revolution*. Hartford: American Revolution Bicentennial Commission of Connecticut. (Cited on pages 81, 96).
- Ruttenber, E. M. 1859. *History of the Town of Newburgh*. Newburgh, NY: E.M. Ruttenber & Co. (Cited on pages 77, 87).
- . 1875. *History of the County of Orange: with a History of the Town and City of Newburgh: General, Analytical, and Biographical*. Newburgh, NY: E.M. Ruttenber & Co. (Cited on page 78).
- . 1876. *Historical Sketch of Newburgh, N.Y.* Newburgh, NY: E.M. Ruttenber & Co. (Cited on page 77).

- . 1911. *History of the Town of New Windsor, Orange County, N.Y.*. Newburgh, NY: Historical Society of Newburgh Bay / the Highlands. (Cited on page 96).
- Ruttenber, E. M., and L. H. Clark. 1881. *History of Orange County, New York*. Philadelphia: Everts & Peck. (Cited on pages 77, 78, 96, 97).
- Seavoy, R. E. 1972. "Laws to Encourage Manufacturing: New York Policy and the 1811 General Incorporation Statute." *The Business History Review* 46:85–95. (Cited on page 97).
- SIRC (Sterling Iron and Railway Company). *Records, 1740-1918*. SC14069, box 1, fol.1-2. Manuscripts and Special Collections, New York State Library, Albany. (Cited on pages 79, 81–83, 87–92, 94, 97).
- Troost, G. 1831. "Address delivered before the Legislature of Tennessee, at Nashville, October 19th, 1831." *The Transylvania Journal of Medicine and the Associate Sciences* 4:491–507. (Cited on page 79).
- WAL. 1816. Letterbook, Watervliet Arsenal Museum, Aug.–Oct. Watervliet Arsenal, U. S. Army Center for Military History, Anniston, AL. (cited on pages 92–94).
- Walton, S. A. 2009. "Founding a Foundry: the Diary of the Setting-Out of the West Point Foundry, 1817." *IA. The Journal of the Society for Industrial Archeology* 35 (1/2): 25–38. (Cited on page 91).
- Yochelson, E. L. 1992. "Mr. Peale and His Mammoth Museum." *Proceedings of the American Philosophical Society* 136 (4): 487–506. (Cited on page 89).

THE FIELD IDENTIFICATION OF RURAL BLACKSMITH SHOPS

Daniel Seib

Blacksmith shops were once ubiquitous businesses vital to the growth and prosperity of every city and village across the country. Often prominently placed at cross-roads to accommodate travelers and townsfolk alike, these shops served multiple purposes, from shoeing horses to repairing farm implements to acting as the unofficial social hot spot. Despite these sites being so common, they are often underrepresented in archaeological reports due to archaeologists' lack of familiarity with this site type. Blacksmith shops contain artifacts and features specific to blacksmithing that may be incorrectly identified or misinterpreted without some familiarity with this site type. This paper is an introduction to the artifacts and features that define blacksmith shops sites. It is intended for the initial identification and assessment that a blacksmith shop site is present, with an eye toward additional investigation once the site is confirmed.

RURAL BLACKSMITH SHOPS

A rural blacksmith shop can be identified archaeologically in much the same way as any other historic or prehistoric site. The archaeological signature of a blacksmith shop is defined by artifacts and work areas found throughout the site. The distribution of these artifacts and features leads to the identification of various activity areas within and surrounding the blacksmith shop. Light (1984) has been the principle reference for the archaeology of blacksmith shops. Building on his work, this chapter looks at the artifact types used for the identification and interpretation of blacksmith shop sites using data from the results of three blacksmith shops in rural upstate New York identified and excavated by the Public Archaeology Facility at Binghamton University.

These sites were identified and excavated bearing in mind the fact that such sites are composed of unique artifacts and features, differing from those of domestic sites due to their rural industrial context. While this chapter is concerned with the results of rural blacksmith shop excavations, these results would also be applicable to urban blacksmith shops. All blacksmith shops are composed of the same essential elements described in this chapter, but in an urban setting they will most likely be

larger, with multiple blacksmithing stations present in the same facility.

Site Contexts

The work I cite in this chapter was conducted for the Public Archaeology Facility during the course of surveys, site examinations, and data recoveries on projects under the auspices of the New York State Museum for the New York State Department of Transportation. Surveys, the first phase of archaeological investigation, are typically when sites are first identified. Surveys consist of a series of regularly spaced shovel test pits (STPs) covering a given project area. Test pits that contain historic artifacts are further tested at the site examination level through a series of regularly spaced units dug in the area of positive STPs. Units are typically 1x1 m (3.3x3.3 ft.) square and are dug in 5 cm (2 in.) levels. For sites with research potential, a data recovery may be conducted. In a data recovery, additional units are dug to investigate as much of the site as possible to try to answer as many questions as possible about the site.

Three sites, the Marcer Site, the Vesper Blacksmith 2 Site, and the Chittenango Blacksmith Site, represent a range of rural blacksmith shop sites in central New York. The Marcer Site, located near the hamlet of Hyde Park, Otsego County, consists of a small blacksmith shop added to the front of a residential structure, and was probably in operation from 1872 until 1915 (Miroff et al. 2010). This business was one of many taken on by the Mercer family, and seems to have been an expediently built shop. The Vesper 2 Blacksmith Site, located in the hamlet of Vesper, Onondaga County, represents a typical small, rural blacksmith shop. One of Vesper's founders, John Strail, may have built the shop in the early 1800s, and the Moon family appears to have worked there from the 1850s until it was demolished just after the turn of the twentieth century (Rudler et al. 2006). The Chittenango Blacksmith Site, located in the village of Chittenango, Madison County, contains the remains of a large, two-story, village blacksmith shop. It was established in a stone shop built by John B. Yates and operated for over three quarters of a century. It was a place of business for many smiths throughout its existence from about 1819 until it was torn down between 1895 and 1900 (Zlotucha Kozub and Seib 2006). These three sites represent a range of blacksmith shops throughout rural New York,

with the Chittenango site representing the largest and most established and the Marcer site being smaller and constructed in the most expedient fashion.

Historic Context

A blacksmith shop was a common sight in any town across America in the eighteenth and nineteenth centuries; as can be seen on historic maps showing every early settlement with at least one shop (Gibb 1985; Strezze 1990). Some areas still held onto their smiths even into the twentieth century despite the march of industrialization and mass production. These shops were as common in their day as a gas station is today. One went to a blacksmith shop to get a horse shod, to get any metal item repaired, or sometimes just to socialize. Blacksmith shops were rural industries, and as such contained elements of both domestic sites and industrial sites, and their presence in the archaeological record of any community is to be expected.

Through the 1850s, blacksmith shops were vital to any hamlet or village (Gibb 1985). Every hamlet of every town had at least one shop; sometimes with two or three located in a busy area or at a crossroads. A typical village had more than enough work to keep a single shop busy year round. The blacksmith divided his time between making large, multi-component items like wagons, forging smaller metal items like tools, fasteners, and weapons, repairs, and shoeing horses (Gibb 1985; Richardson 1889; Watson 1968).

The 1860s and 1870s saw an increase in manufactured goods, and items once made by a blacksmith were sold more cheaply by general stores or mail order catalogs (Gibb 1985). Manufacturers employed a variety of artisans under one roof, each producing different parts of multi-component items such as wagons. Working quickly to produce goods that blacksmiths may take weeks or months to produce, these shops mass-produced large, complex items more cheaply than the local blacksmith (Gibb 1985).

As the century progressed, people started buying more items from stores or by mail order catalogs (Gibb 1985; Watson 1968). If these items broke, they would take them to their local blacksmith for repair. At first, blacksmiths probably did not mind (Strezze 1990). Instead of spending their spare time handcrafting large items, they filled their time trying to fix store bought items (Gibb 1985; Strezze 1990). It is in this way that the blacksmith evolved from the maker of all things metal to the repairer of all things metal. Mass production of cast iron products began to replace hand-forged items.

Cast iron is high carbon metal poured into molds to make a final product, but that product could not be easily reshaped or repaired by a smith because of its physical properties (Richardson 1889). Sometime the very

same storeowners who sold these items would supply local blacksmiths with the repair parts necessary to fix them, making the blacksmith shop a retail outlet for replacement parts for store-bought items (Gibb 1985). As mass production techniques improved, it eventually became cheaper for people to simply replace broken pieces of equipment rather than have a blacksmith mend them (Gibb 1985; Richardson 1889).

By the 1880s and 1890s, blacksmiths in all but the most rural places saw their business declining in the face of a consumer economy based on cheaper, store-bought goods and replacement parts (Gibb 1985). Blacksmiths adapted in a variety of ways (Strezze 1990). Some went off to work in the cities in the same urban plants that brought about their decline. Others focused more on keeping stocks of repair parts for mass produced items, becoming a combination service station and hardware store for their communities. Most focused on the blacksmithing services that could not be sold through a catalog: shoeing horses and fixing wagons (Gibb 1985; Lasansky 1980).

This period of time was particularly bleak for blacksmiths across the country (Strezze 1990). In just over 50 years, the traditional art of blacksmithing declined to near obsolescence (Watson 1968). After the turn of the century, the automobile dealt a serious blow to the trade. As cars became more popular, wagons and horses were used less. Only in extremely rural areas was the blacksmith needed enough to necessitate full time work (Strezze 1990). Blacksmithing was relegated to the level of a quaint, old-time profession or hobby practiced only by the few (Gibb 1985).

Historic resources

The identification of blacksmith shop sites starts with checking historic maps. Because blacksmith shops were becoming obsolete around 100 years ago and those buildings have most likely been demolished, the main resource for finding a blacksmith shop is historic maps. Historic maps identify blacksmith shops as "BS", "BSS", or "B.S. Sh.". On early 1800s maps this is the only designation given, but on maps from the late 1800s, an alternative label of "WS" was used to denote a wagon shop. The work necessary to make an entire wagon took a great deal of time out of a typical smith's busy day of manufacturing the essentials for a community, so wagon shops sprung up alongside blacksmith shops (Gibb 1985). Artifact deposits should be similar between the two types of shop, so techniques for finding a blacksmith shop should also apply to finding a wagon shop.

Blacksmith shops are often found at the intersection of major roadways (Miroff et al. 2010). Intersections in rural settings were significant places of increased traffic that had the potential for growing into a community,

so these were natural places for blacksmith shops to be built. A blacksmith shop from the 1700s was more likely to be built near a creek or stream, as waterpower could be harnessed by waterwheels for triphammers (Gibb 1985; Rudler et al. 2006). As a village grew and prospered, these shops remained near the heart of the village; while, as the village grew, later blacksmith shops might be built further out. Therefore, a shop found near the center of the village is more likely to be older than shops on the periphery (Zlotucha Kozub and Seib 2006). If a shop in the center of the village burned down, as they were prone to do (Light and Unglik 1984), it is possible that it would be rebuilt further out so as not to endanger the rest of the village should it catch fire again.

Historic maps may identify a shop's location but are often inaccurate, or are incompatible with the modern landscape (Miroff et al. 2010). Comparison of historic maps to current maps should be undertaken from the blacksmith's point of view. Horses and wagons needed to get off the road and into the shop easily, so a shop located at a distance from the road would probably receive less business than a shop adjacent to the road. Most blacksmith shop sites will therefore be located with easy access to roads. A creek or stream in the vicinity of the shop most likely would have been utilized for power by building the shop adjacent the stream, or by building it nearby and having some means of conveying the water to it. While historic maps may depict a shop, they will not show the direction the shop faced. It is not a given that the shop faced the road; it is possible that the main shop door could have faced an open field next to it (see Rudler et al. 2006).

Map of the blacksmith shop

The layout of a shop is dictated by the needs of blacksmithing (Figure 5.1). Because of this, the design and layout became generalized over time and across cultures. A blacksmith generally needed three things: a fire for heating the metal, a surface on which to shape the metal, and an area to do finishing work. In historic blacksmith shops, the heating area was the forge, the primary shaping surface was the anvil, and the primary finishing area was a workbench (Richardson 1889).

Shop design centered on the forge, which was used to heat the metal to a workable temperature. Forges, down through the ages, began as stone structures (mortared or dry laid) and changed through time into brick and then cast iron forms. Anvils probably began as plain stone that was hammered on, and developed first into square blocks of iron, and then into the current form of cast iron with a steel face. Finally, a workbench of some sort, where the product would be finished, was located near where the smith stood to do his work.

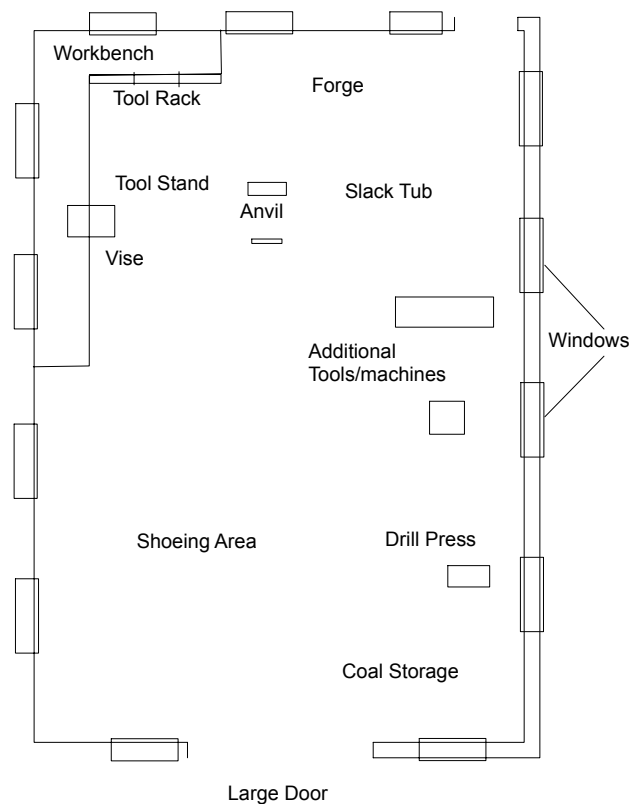


Figure 5.1. A map of a typical blacksmith shop. Drawing by Daniel Seib based on images by Richardson (1889).

This central core of forge, anvil, and workbench is present in all blacksmith shops, the only difference being elaboration and arrangement. Larger forges could be built to heat larger and larger pieces of metal. Anvils could vary in size to work larger or smaller pieces. Multiple work areas, some customized to one specific task, could line the walls of the shop. While the size and complexity of the shop was determined by the tasks required of the smith(s), the pattern of archaeological deposits will come back to this arrangement of forge, anvil, and workbench (Light 1984; Light and Unglik 1984).

The forge and the anvil needed to be close together for efficiency. The process of blacksmithing is exacting and tiring, and the smith would have wanted to maximize his efforts. The less space between the forge fire (where the metal was heated) and the anvil (where the shaping took place but heat was lost) the better. To work a piece of metal into the desired shape in one heating was the goal; this would be the most efficient use of the smith's time, strength, and resources. Because of this dynamic, the forge and anvil were located close to each other, with the forge directly in front of the smith, and the anvil located toward his dominant hand (Richardson 1889). Usually a workbench was located behind the smith where he stood at his forge, so that he could sim-

ply turn around to access his tools and have a place to finish his work (Richardson 1889).

BLACKSMITHING ARTIFACTS

Blacksmith shop sites have artifact assemblages similar to those of most other historic sites, with the addition of trade-specific categories. Three artifact categories specific to blacksmith shops are horseshoe nails, wagon or carriage hardware, and metal stock. The identification of multiple examples of one or more of these artifact categories allows an archaeologist know that a blacksmith shop is nearby.

Horseshoe Nails

The first category of diagnostic artifacts found at these shops is horseshoe nails. These were specialized nails used by blacksmiths to fasten horseshoes onto the hooves of animals. “Horseshoe nails” can be used as a general term for these nails, although they also were used for oxen. Horseshoe nails are rectangular in cross-section, and the head of the nail is thicker than a typical nail with a distinctive wedge shape. Thaddeus Fowler patented the first horseshoe nail making machine in 1867 (Government Printing Office 1868).

Prior to this, blacksmiths made hand wrought horseshoe nails. Mass production made horseshoe nails more uniform, with various sizes available depending on the size of the animal. Nails with specialized, extra large heads for traction were used in the winter. Regardless of the nail, the process whereby this artifact type ends up in the archaeological record is the same.

Shoeing a horse was an art and a science (Figure 5.2). Nails were bent slightly and driven through the shoe and into the hoof at a shallow angle. If the nail went into the hoof at the wrong angle, it was immediately pulled out and discarded, and a new nail was substituted. When the nail exited the side of the hoof, the tip was seized with a pair of nippers, snapped off, and discarded. The remaining portion of the nail exiting the hoof was twisted toward the hoof and clinched down. To remove the nail, this clinched bit was snapped off to release its hold. The shoe was then pried away from the hoof, pulling the remainder of the nail out (Watson 1968). This removal often leaves the nail with a signature ‘s’ curve which differentiates it from other types of nails (Miroff et al. 2010; Rudler et al. 2006; Zlotucha Kozub and Seib 2006).

Horseshoe nails in the archaeological record can be divided into three forms: whole nails, nail fragments, and tips. A whole nail will be found when a nail was dropped by accident or discarded due to an improper bend. Nail fragments are the most common form of horseshoe nail found (Miroff et al. 2010; Rudler et

al. 2006; Zlotucha Kozub and Seib 2006). This is a horseshoe nail without the tip, usually bent in the “s” curve from the removal process from the hoof. The third form is the tip, which is the portion of the nail snapped off in the shoeing process. These tips have been found straight, bent, or sharply curved (Figure 5.3, see also Miroff et al. 2010; Rudler et al. 2006; Zlotucha Kozub and Seib 2006).

What is missing in the archaeological record of the three sites are the snapped off clinched ends that should have resulted from shoe removal. These small bits of curved metal may have been completely unrecognizable in the archaeological record, and categorized as undiagnostic metal fragments.

Wagon Hardware

Wagons were constructed of elements common to architecture and furniture (nails, screws, wood), but they also had specialized hardware that can be identified in the archaeological record. Buggies, carriages, and wagons all have these pieces of hardware, but they are generally referred to as wagon hardware. Identifying these pieces of hardware can be difficult, requiring a wagon construction blueprint, manual, or a comparative collection. Historic sources and reference material can be used to identify individual pieces of hardware (Spivey 1979).

Common pieces recovered from the three sites studied include axle clips, felloe plates, and tire bolts (Miroff et al. 2010; Rudler et al. 2006; Zlotucha Kozub and Seib 2006) (Figure 5.4). Axle clips tie the axle to the body of the wagon, felloe plates were used to cover joints in the wooden rim (felloes) of a wagon wheel, and tire bolts were specialized countersunk bolts used to hold the metal tire to the felloes.

Collections of unbroken wagon hardware from blacksmith shops may indicate reuse piles (Watson 1968). Blacksmiths often had reuse piles with spare parts saved from previous jobs. These stockpiles were stored around the walls of the blacksmith shop for possible reuse as spare parts for other wagons (Watson 1968). It stands to reason that broken fragments of wagon hardware were pieces not intended for reuse; these would end up in scrap piles intended for recycling. Either way, pieces of wagon hardware are most likely found in piles situated near the walls or other out-of-the way locations of the blacksmith shop (Miroff et al. 2010).

Metal Stock

Blacksmiths bought much of the raw metal they used in smithing as bar stock. Bar stock came in a variety of shapes (in cross-section), including round, square, flat, oval, half round, half oval, triangular, hexagonal, and octagonal; all in various sizes and lengths (Spivey 1979).

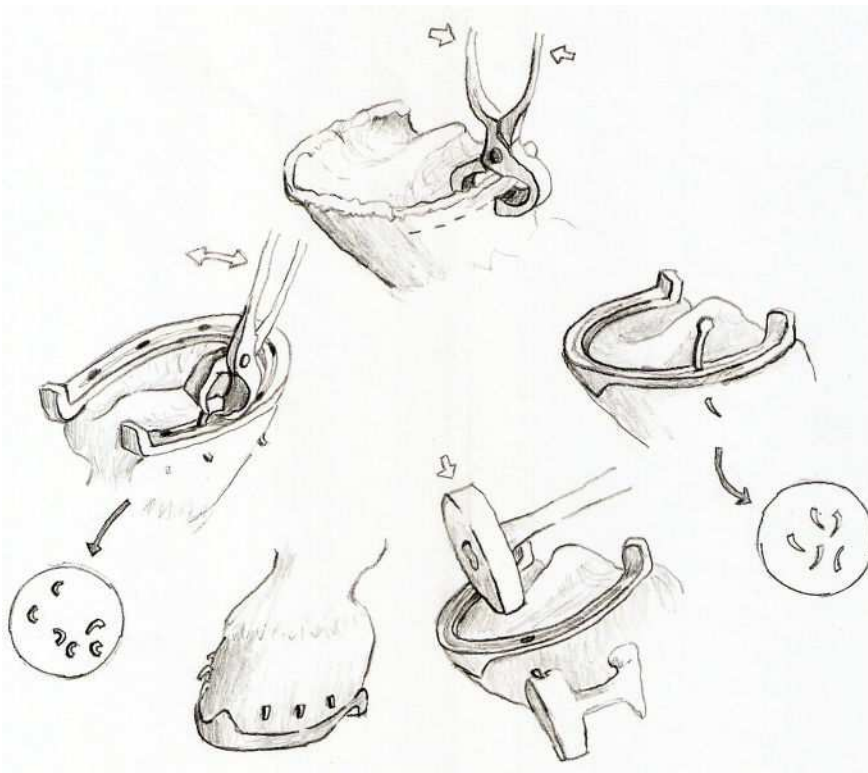


Figure 5.2. Shoeing a horse. 1. Paring the hoof. 2. Hammering in the nails (tips are clipped off between steps 2 and 3). 3. Clinching the nails. 4. Shod hoof. 5. Pulling the nails (clinched ends are clipped off before removing nails). Drawing by Laura Ort Seib based on images by Watson (1968).



Figure 5.3. Horseshoe nails. Top row: complete nails. Middle row: nail fragments. Bottom row: nail tips.



Figure 5.4. Wagon or Carriage Hardware. Top row: Tire bolts. Middle row: Bolt and half of an axle clip. Bottom row: Felloe plate and ferrule.



Figure 5.5. Metal stock. Top row: Round stock. Second row: Square stock. Third row: Flat stock, this piece was not used up fully. Bottom row: Flat stock.

Sections of the stock were cut off as needed, until all that remained was a small piece. When the bar stock was exhausted, fragments were often tossed on the floor near the forge or in the nearest scrap pile (Miroff et al. 2010; Rudler et al. 2006; Zlotucha Kozub and Seib 2006).

Most fragments in the archaeological record of these three sites were approximately 2.5 cm (1 in) long (Figure 5.5, see Miroff et al. 2010; Rudler et al. 2006; Zlotucha Kozub and Seib 2006). This is about the smallest size that can be handled in a pair of blacksmith's tongs (Gibb 1985). The shape of the stock was sometimes difficult to ascertain in laboratory analysis, given the degree of oxidation. However, metal stock is usually identifiable by a 45-degree angle or shallower cut on one end (Miroff et al. 2010; Rudler et al. 2006; Zlotucha Kozub and Seib 2006).

The cut was made by heating the metal stock, placing it on a hot cut (a triangular wedge of metal placed on an anvil), and striking it so that wedge cut the metal. The sides of this cut are usually flared. The location of the cut will indicate the working end of the stock fragment, and will aid the analyst in determining the shape for heavily oxidized pieces. On these three sites, stock pieces were found close to the area where the anvil was presumably located. This makes sense, in that the smith would have cut lengths of bar stock using the hot cut on his anvil and, when the piece was exhausted, would

have dropped the glowing red metal to the floor rather than throw it in a waste pile for fear of starting a fire.

Blacksmithing Features

The most useful feature to find on a blacksmith shop site is the foundation. Being able to ascertain if artifacts are coming from inside or outside of the shop is helpful in determining their relative worth to the blacksmith. Shop foundations varied within this sample of sites. At the Chittenango site, which was a two-story stone structure, a 50 cm (20 in) thick stone wall clearly delineated the inside of the shop from the outside (Figure 5.6). This contrasts with the Marcer site, where no foundation was found, yet a sweepings waste pile feature had a clear, flat edge identifying the wall of the shop against which the waste was piled. This suggests a post and beam construction for this shop, since no wall was present in the soil profile.

Delineating the interior versus the exterior of the shop makes identification of the main features of a blacksmith shop easier. Light (1984) identifies four areas within a blacksmith shop: work, storage, refuse, and domestic. In the research conducted for this article, the lines between these areas were often blurred. Especially in the smaller shops, these areas were not separated by a defined line; work refuse spilled over into the storage areas, domestic items were found in the work areas, refuse was found everywhere. Small shops may not have had the space for clear separations between the areas defined by Light. As a result, it appears that in these shops every inch was used and for multiple purposes.

The central feature in a blacksmith shop is the forge. Locating the forge in each shop was first attempted by identifying the largest concentration of brick or stone in the site. Interestingly, the largest concentrations were found outside the shops in Chittenango and Marcer, for differing reasons. At Chittenango, the building was sold after its use as a blacksmith shop, and the presence of the brick outside may represent the remains of the dismantled forge. Whole bricks were not found, only brick fragments and mortar. The whole bricks would have been valuable scrap that would have been carted off for reuse elsewhere. At Marcer, comparatively little brick was found; that which was found was probably from an unrelated chimney of a previous structure. Given the expedient nature of the shop, the forge at Marcer may have been a portable forge made of cast iron or a wooden box filled with earth or fireclay. The forge at the Vesper 2 Site had a clear signature. The greatest concentration of brick was inside the shop's foundation. It appeared to represent the waste parts of brick not salvaged for reuse, and the matrix contained mortar, melted metal, and slag. This forge appeared to have been in place, with fuel waste within it, when it was dismantled *in situ*.



Figure 5.6. The stone wall foundation of the Chittenango blacksmith shop.

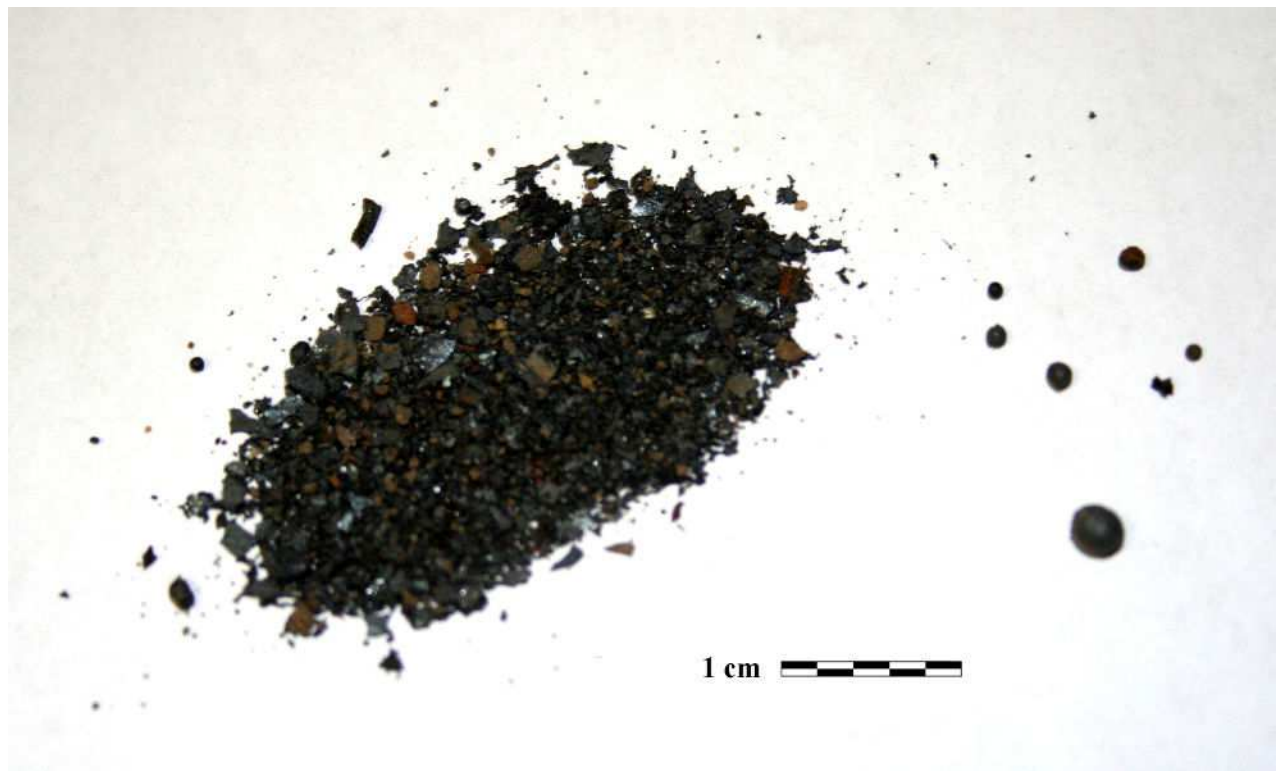


Figure 5.7. Left: blacksmithing scale. Right: “welding balls,” from tiny molten droplets splashed off an item during forge welding. Photo courtesy of Marty Pickands, New York State Museum.

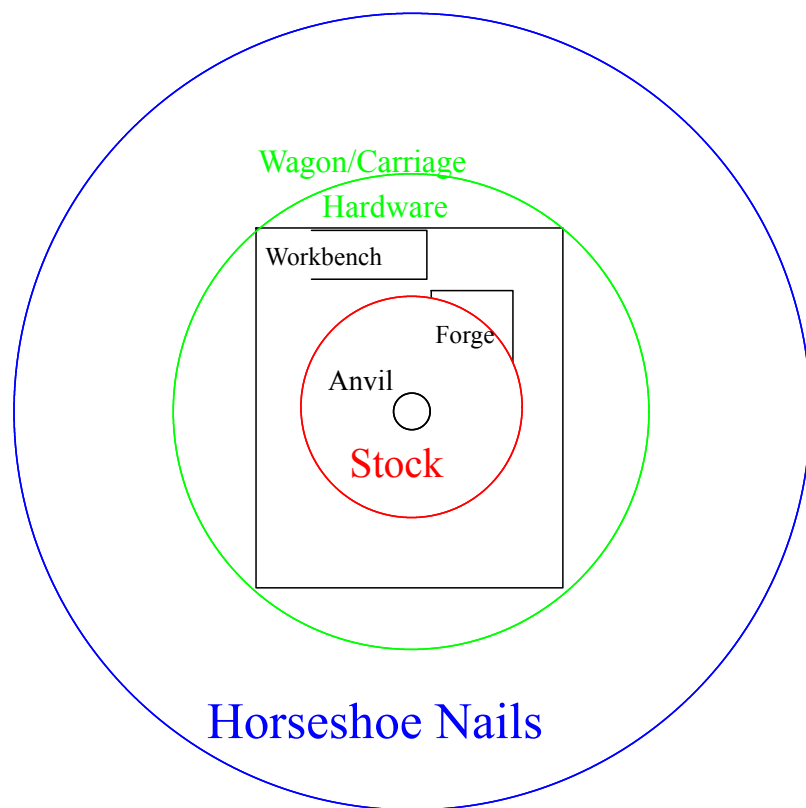


Figure 5.8. Hypothetical distribution map of the proximity of blacksmithing artifact types discussed in relation to the center of a blacksmith shop.

The anvil would have been placed within arm's reach of the forge, but it was almost never left at a blacksmith shop site due to the value of the anvil as a formal tool or in later years as scrap metal. The area where the anvil was located may be identified by finding traces of the anvil stump. An anvil stump would usually be set multiple feet into the ground, and would be surrounded by a halo of black scale after use for some time. Scale is thin layers of oxides that form on metal during heating, and come off when a smith strikes the metal. Scale looks like black grainy sand and is magnetic (Figure 5.7). If the anvil were in the same place for a length of time, the scale would have built up in a ring around the anvil stump and appear much like a post mold. Since scale is magnetic, confirming its presence in the field can be done with a magnet. The anvil stump was not identified in any of the sites studied, except for a lens of scale found at the Chittenango site.

The third component of any smithy is the workbench, which is identified by the absence of most other artifacts, the increased presence of blacksmithing tools, and the proximity of the forge and anvil. A workbench needed to be near good light, so the presence of window glass would be added evidence of its location (Light 1984). A workbench will generally be to the rear of the smith working at his forge (Richardson 1889). The workbench was identified at the Marcer Site and the Vesper 2 Site.

Interpretation

Each of the artifact categories discussed not only indicates that a blacksmith shop was present, but guides further investigation and interpretation of the site. Ideally, following the patterns of artifact distributions would lead to the discovery of blacksmithing features, with those features helping to define activity areas (Figure 5.8).

Abundant horseshoe nails will most likely be the first indicator that a blacksmith shop site is present. These nails will be found further from the heart of the blacksmith shop, probably around the shop's walls or just outside the shop, unless the shop was very large and comfortable enough to accommodate a horse within its walls. The location of complete nails and tips indicates where the horses were shod. Horseshoe nail fragments indicate where shoes were removed. Horseshoe nail fragments associated with other refuse (both blacksmithing-specific and more general midden deposits) indicate a shop waste pile.

Wagon and carriage hardware, in general, will be found surrounding the walls of a blacksmith shop. Along the outside of the walls, they usually represent reuse piles and along the inside of the walls usually represent waste piles. If these artifacts are found alone, they could indicate a wagon construction or repair area. Cut off fragments of metal stock will be found closer to

the heart of the blacksmith shop, with fragments found alone indicating that the anvil was nearby. Small bits of stock in association with other artifacts probably indicates a waste pile and not a reuse pile, as cut metal stock fragments are usually too small to be reshaped into anything.

While every shop was different, the requirements of the trade and the common experience of blacksmiths tend to make the distribution of blacksmithing artifacts somewhat predictable. Blacksmith shop sites have unique artifact types whose arrangements can guide archaeologists to properly investigate and interpret these valuable assets to the archaeological record.

ACKNOWLEDGEMENTS

I would like to thank the Public Archaeology Facility, including its director, Nina M. Versaggi, all the staff, lab personnel, project directors, and field crew for all their work that provided the data for this study. Andrea Zlotucha Kozub has offered valuable input on this work both in the field and in the lab. Thank you also to Marty Pickands of the New York State Museum for organizing the conference and for assembling these articles. Thank you also to my wife, Laura, for all her patience and understanding having to live with a man who is obsessed with rusty bits of metal in the ground.

REFERENCES

- Gibb, J. G. 1985. "Centralization and Cultural Transformation Processes: The Archaeology of Wagon Shops and other Artisan Shops." Unpublished Masters thesis, Binghamton University. (Cited on pages 102, 103, 106).
- Government Printing Office. 1868. *Annual Report of the Commissioner of Patents for the Year 1867, Volume I*. Washington, D. C.. (Cited on page 104).
- Lasansky, J. 1980. *To Draw, Upset, and Weld: The Work of the Pennsylvania Rural Blacksmith, 1742-1935*. Lewisburg Pennsylvania: Union County Historical Society. (Cited on page 102).
- Light, J. D. 1984. "The Archaeological Investigation of Blacksmith Shops." *Industrial Archaeology* 10 (1): 55-68. (Cited on pages 101, 103, 106, 108).
- Light, J. D., and H. Unglik. 1984. *A Frontier Fur Trade Blacksmith Shop 1796-1812*. Quebec, Canada: National Historic Parks and Sites, Environment Canada, Parks. (Cited on page 103).
- Miroff, L. E., M. Jacobson, C. Horn, and D. Seib. 2010. *Data Recovery Investigations, Suthrup Site (SUBi-2441, NYSM 11473), Marcer Site (SUBi-2442, NYSM 11472), Otsego III Site (SUBi-2445, NYSM 11470), Steere Site (SUBi-2448, NYSM 11468), Whitwell Site (SUBi-2447, NYSM 11469), Clark Prehistoric Site (SUBi-2449, NYSM 11467), Grasslands I Site (SUBi-2450, NYSM 11466), Grasslands II Site (SUBi-2451, NYSM 11465), PIN 9018. 41. 121, NY 28 from Goey Pond to the CR26 Intersection*. Hamlets of Hartwick Seminary, Hyde Park, and Index, Towns of Hartwick and Otsego, Otsego County, New York, MCD 07707 and 07716, 03PR05088. Cultural Resources Management Report 2010-2011 Highway Program. The Public Archaeology Facility, Binghamton University. (Cited on pages 101-104, 106).
- Richardson, M. T. 1889. *Practical Blacksmithing*. 1998th ed. Facsimile by Weathervane Books, NY. New York: M. T. Richardson Publishing Co. (Cited on pages 102-104, 108).
- Rudler, M., C. Hohman, D. Seib, and L. Carroll. 2006. *PIN 3804.36.310, Hamlet of Vesper, Town of Tully, Onondaga County, New York*. Submitted to the New York State Department of Transportation. Cultural Resource Reconnaissance and Site Examinations 2005-2006 Highway Program. Public Archaeology Facility, Binghamton University, Binghamton, NY. (cited on pages 101, 103, 104, 106).
- Spivey, T. 1979. *A Historical Guide to Wagon Hardware and Blacksmith Supplies*. 9. Lawton, Oklahoma: Museum of the Great Plains. (Cited on page 104).
- Strezze, R. A. 1990. "Rural Artisans and Social Reality in 19th Century Upstate New York." MA Thesis, State University of New York, Binghamton. (Cited on page 102).
- Watson, A. A. 1968. *The Village Blacksmith*. New York: Thomas Y. Crowell Company. (Cited on pages 102, 104, 105).
- Zlotucha Kozub, A., and D. C. Seib. 2006. *Site Examinations For: Chittenango Blacksmith Site (SUBi-2556), PIN 2057. 28. 321, Village of Chittenango, Madison County, New York. MCD# 05342*. Submitted to the New York State Department of Transportation. Cultural Resource Management Report 2005-2006 Highway Program. The Public Archaeology Facility, Binghamton University, Binghamton, New York. (Cited on pages 101, 103, 104, 106).

FINDING THE PAST, PLANNING THE FUTURE

Survey and Assessment of Remains at the Former Copake Iron Works

Fred Sutherland

The site of the nineteenth century Copake Iron Works is located within the Taconic State Park, which is adjacent to the Village of Copake Falls, New York, on the western side of the Berkshire Mountains along the border of New York and Massachusetts. In the spring of 2007, the Copake Iron Works became a National Register Historic District based on the significance the many surviving mid-to-late nineteenth century buildings. These structures include several company houses, a church, and substantial portions the furnace complex. Despite this positive development, the site had been under-studied and under-appreciated by the thousands of visitors to the park each year.

In order to address these issues of high visitation and under-interpretation, a careful and systematic survey has been conducted to precisely locate and map features above and below the ground at the park. Combined with a thorough study of historic maps and documents, the survey presents aspects of the Copake Iron Works history that were underrepresented in previous research, and has aided in subsequent efforts by the park and other heritage organizations to interpret and preserve historic features of the iron works.

HISTORICAL BACKGROUND

The Copake Iron Works began operation in 1845, shortly after the closing of one of the oldest iron works in New York, the Livingston Iron Mill, also referred to as the Ancram Iron Works (Naramore 1993, 13; Stott 1993, 56), just over 9 miles (15 kilometers) to the southwest (Figures 6.1, 6.2). The Ancram Iron Works had been operated by Lemuel Pomeroy II, the same individual who went on to sponsor the construction and operation of the Copake Iron Works (Krattinger 2007, Section 8:3). The Copake Iron Works was thus a direct successor to a regional iron industry that began with the construction of the Ancram Iron Works just over 100 years earlier in 1743 (Gobrecht 2000, 10; Naramore 1993, 13).

The sources listed below all agree that Pomeroy had selected the site at Copake because it fulfilled three basic requirements for a successful iron works. It had good quality ore, a source of running water to power

the needed equipment (Bash Bish Brook), and plenty of nearby timber to burn as charcoal for the furnace (Smith 1900, 735; Ellis 1878, 392; Krattinger 2007, Section 8:3). Stott (1993, 56–57) reveals that toward the end of operations at the Ancram Iron Works “in about 1830-1835” it began to use ore “from the Copake Mine”. This remark indicates that iron deposits near the site of the Copake Iron Works were already being mined. Therefore, Pomeroy would not have had to establish mining operations on his own.

Another reason for building the works at this location, which is not mentioned in most historical sources, is that Pomeroy probably anticipated the building of a rail line adjacent to the site that would eventually connect the iron works to New York City. Peter Stott (2007, 113) notes that Lemuel Pomeroy was “one of the leading spokesmen for the New York and Albany Railroad, which was projected to follow the course adopted by the Harlem Railroad.” This anticipated rail line is clearly depicted on county maps as early as 1839 running almost exactly where it would (as noted in Stott 2007) when completed in 1852 (Figure 6.2).

It is likely that Pomeroy selected this site in anticipation of this rail connection because it would remove his dependence on shipping goods by cart to Hudson, New York (20 miles [32 kilometers] to the west), where these items could then be transported on the Hudson River. The arrival of the rail connection made it easier for Pomeroy to develop the increased facilities at Copake “to transport and receive goods beyond the immediate region” (Ellis 1878, 392). Ellis (1878, 392) notes that a year later in 1853 Lemuel Pomeroy II passed away and the remaining business partners carried on operations of the iron works until 1862.

The reason for the sale of the iron works in 1862 is not disclosed in any known historical source. The date may suggest the sale was related to the American Civil War, perhaps involving speculation in industrial properties valuable to the war effort. The first buyer, John Beckley, sold the iron works within a year, further suggesting it was sold to capitalize on war-time demand (Ellis 1878, 392). Stott (2007, 113) notes that Beckley was a regional iron company owner who built many forges and furnaces in the region at this time. Beckley may have had plans for the Copake Iron Works, but then decided

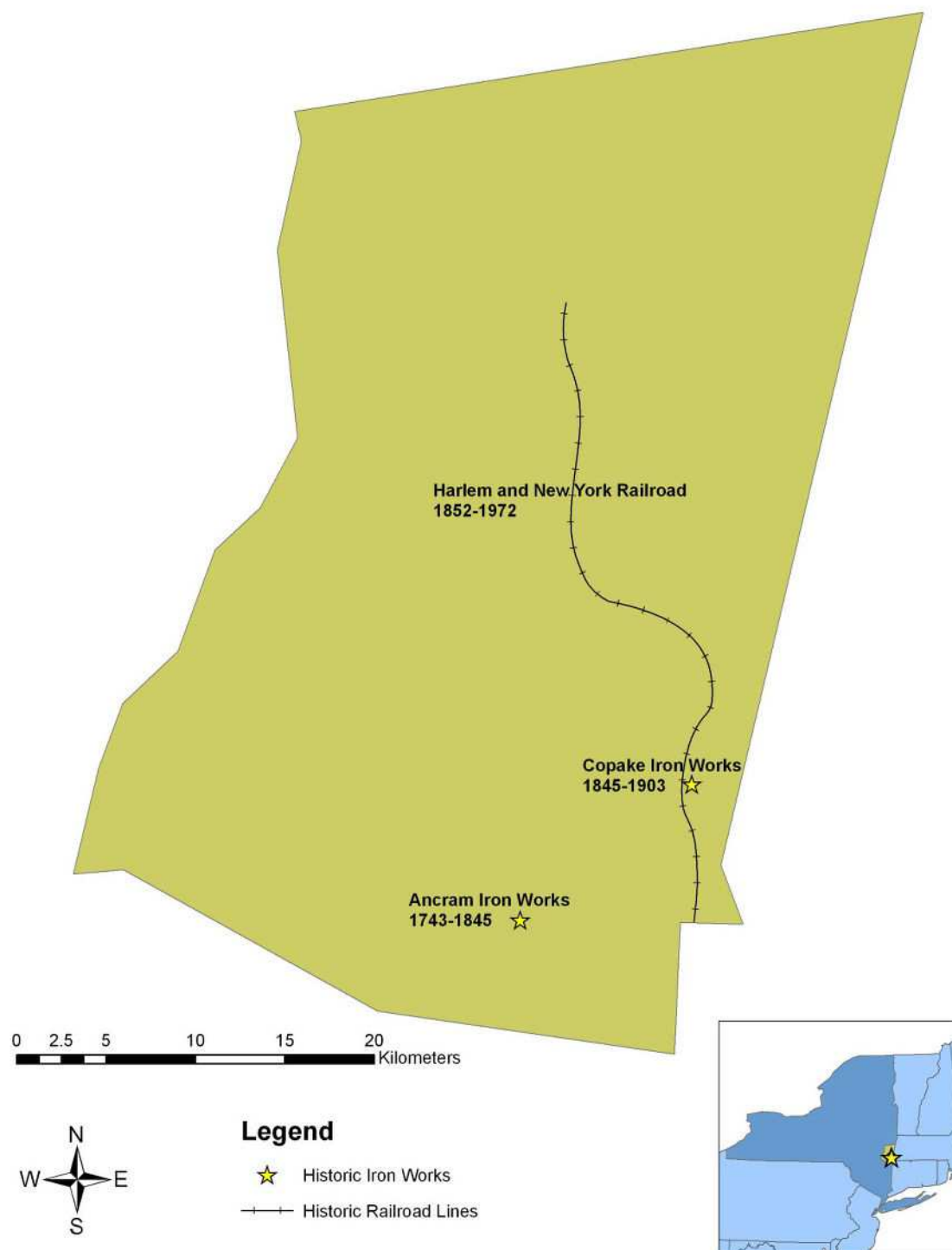


Figure 6.1. A Map of Columbia County showing the sites and years of operation of the Copake Iron Works and a nearby predecessor, the Ancram Iron Works. The approximate location of the New York and Harlem Rail Road which would directly link the Copake Iron Works with markets and resources further south is also represented in the map.

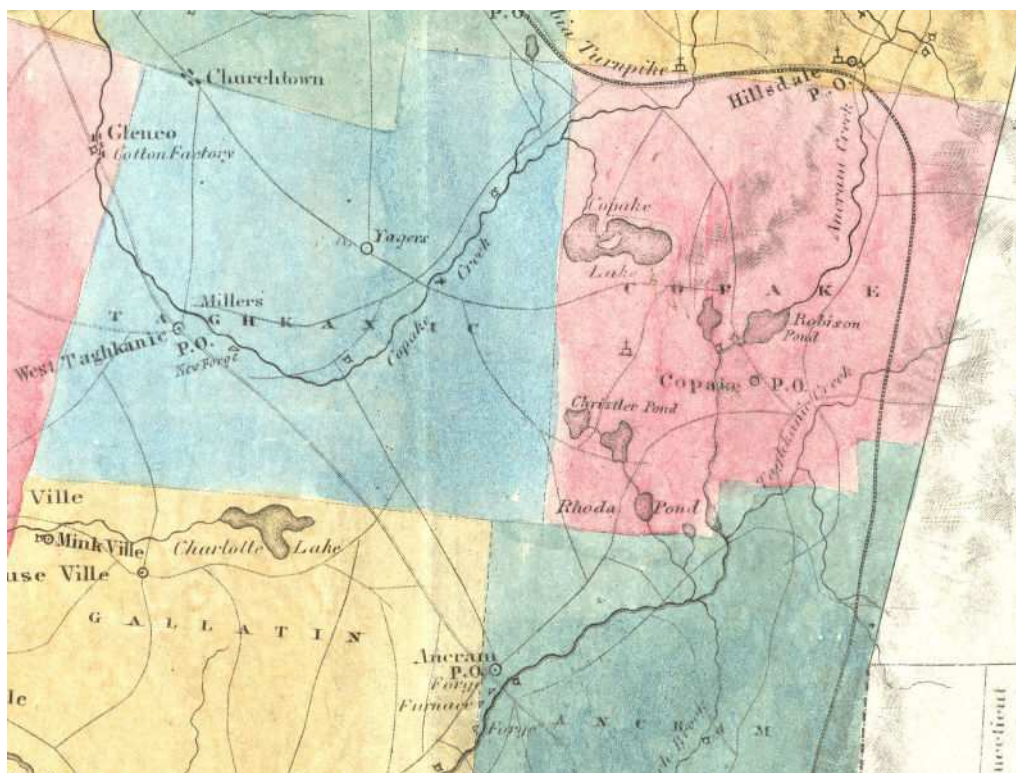


Figure 6.2. Copake and its surroundings in 1839. The railroad, not completed until fourteen years later, is already shown following its future route. The Ancram Iron Works may be seen to the south listed as “furnace”, with another iron forge just to the west (Burr 1839).

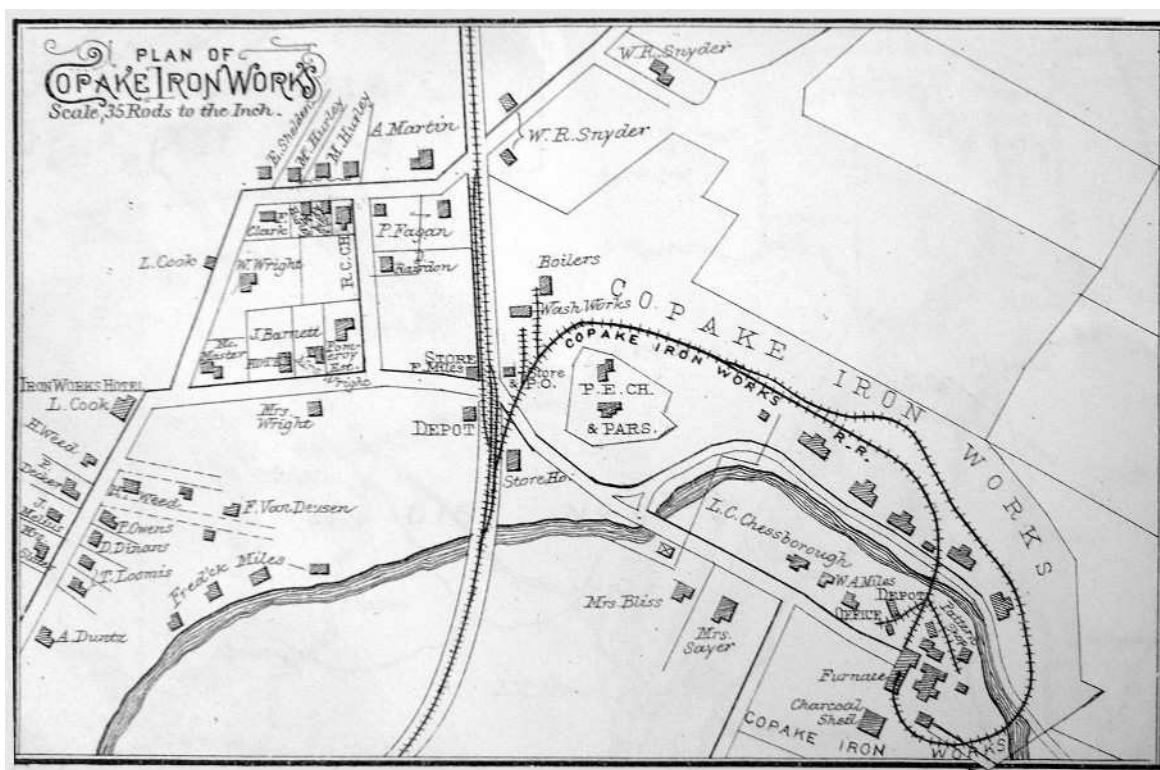


Figure 6.3. Copake Iron Works in 1888. This Columbia County atlas map shows the iron works at its height, apparently after the mine had gone out of use, as it is not shown (*Atlas of Columbia County, New York 1888*).

not to follow through with them and sold the property instead.

The final buyer of the Copake Iron Works as an operating business was Frederick K. Miles who, along with his descendants, would operate the iron works for almost 40 years (Smith 1900, 735; Ellis 1878, 392). Stott notes that Miles was a relative newcomer to the iron industry at the time he purchased the Copake Iron Works. He had previously only operated iron furnaces in the Salisbury, Connecticut region for four years. Miles probably purchased the Copake Iron Works to supply his other iron working operations in Salisbury, Connecticut with cast iron and ore (Stott 2007, 113–114).

All known historic accounts are silent for the next ten years leading up to 1872 when Frederick K. Miles began significant renovations at the Copake Iron Works. While the original 1845 furnace was never discussed in any detail, the 1872 furnace was likely built on or near the site of the original furnace. The 1872 furnace was described as built of Dover Marble from quarries 30 miles (48 kilometers) south of the iron works (Ellis 1878, 392). Dover, New York is located along the same former rail line (The New York and Harlem) as the Copake Iron Works, which would have facilitated the easy transportation of quality building materials.

The dimensions of the furnace given in 1878 match modern observations of the surviving structure: 39 feet square (11.8 x 11.8 meters) by about 32 feet (9.7 meters) high (Ellis 1878, 392). Ellis' 1878 account of the iron works made other interesting observations as well. He noted that the draft for the renovated furnace provided by an overshot water wheel about 20 feet (6.1 meters) in diameter, and "a fine steam engine, which is used in times of low water" (Ellis 1878, 392).

The operation of the nearby iron mine is also mentioned in Ellis' accounts. By 1878 the iron works was still obtaining most of its ore from the local mine adjacent to the furnace (5,000 tons), but a substantial amount (nearly 3,000 tons) was being brought in from Pawling, New York, 40 miles (64.3 kilometers) south along the rail lines and from the Weed Mines 8 miles (12.8 kilometers) south of the Copake Iron Works (Ellis 1878, 392). Ellis specifically named the types of ore processing equipment at Copake as a "Bradford washer" and a "Blake crusher" working adjacent to the mine (Ellis 1878, 392).

Frederick K. Miles and his son William A. Miles were very proud of their furnace and mining machinery. William wrote two articles in a trade journal describing the use and functioning of the machinery (see appendix for the full reproduction of the articles). In the earliest article, Miles described the Bradford Ore Washer and the special modifications he made to improve its use (Miles 1886, 6–11).

Ellis provided clear measurements of the size and scale of the works in 1878. He recorded the total num-

ber of iron works buildings (nine in all) and that "the proprietor owns about twenty buildings that are occupied by the workmen" (Ellis 1878, 392). These clues are vital to understanding the size and social organization of the Copake Iron Works. Ellis went on to mention that the iron works employed "about 50 hands" and consumed "eight thousand tons of iron ore, twelve hundred tons of limestone, and four hundred fifty thousand bushels of charcoal" to yield "three thousand seven hundred and fifty tons" of iron each year (Ellis 1878, 392). Interestingly, Ellis also mentions in the 1878 history that a plow works was being "contemplated," foreshadowing the eventual construction of the Copake Plow Works near the iron works property (Ellis 1878, 392).

In 1883 an additional mine was bought by Frederick K. Miles in Dutchess County, which borders Columbia County to the south (Smith 1900, 735). This suggests that the mine cuts nearest the Copake Iron Works were running out of easily accessible ore. Elinor Mettler's transcriptions of interviews with the Fagan sisters, Agnes and Sally, who were children in Copake Falls near the end of the iron work's operation, state that "he (Frederick K. Miles) and his son William operated the mine until 1888 when the pumps were removed" flooding the mine and turning it into a pond (Mettler 2000, 11). An 1888 Columbia County atlas map (Figure 6.3) shows the works at that time.

By 1895 the Copake Iron Works halted production "owing to a depression in the market". The following year (1896) Frederick K. Miles passed away and left control of the struggling iron company to his two sons William A. Miles and Frederick P. Miles. Frederick P. Miles passed away in 1898 leaving his share of the company to his children who are not named in the text. Lastly, the text mentions that the iron works was leased out to the Salisbury Carbonate Iron Company until 1901 (Smith 1900, 735). The Columbia County history notes that the majority of ore for the works was coming from Amenia, New York "thirty miles south on the Harlem Branch," that a small portion is arriving from Pawling and New Medford, Connecticut, and that the "home mines are not operated". Because crucial resources like ore had to come from greater and greater distances, it appears that by the end of Copake Iron Works operation most local resources were exhausted or had become too difficult to exploit efficiently.

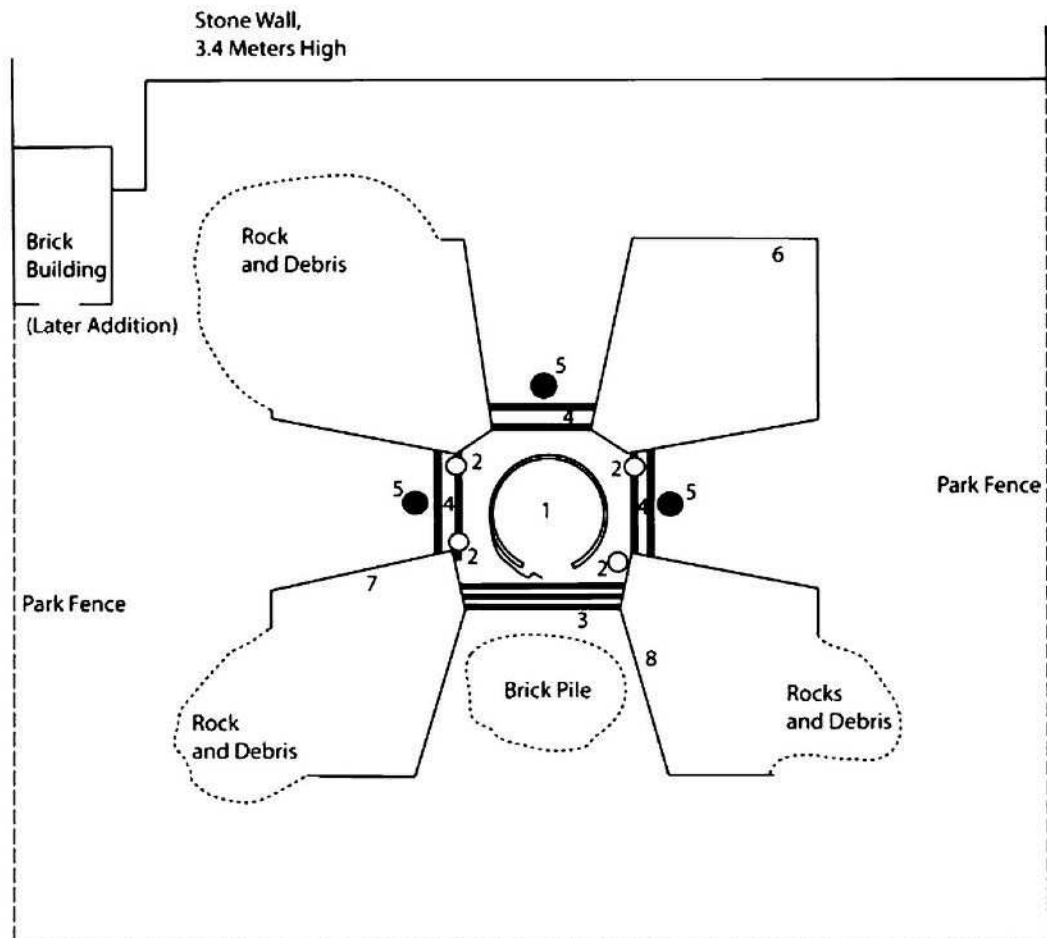
Sources such as Kirby (1998, 113), Krattinger (2007, Section 8:4), and Stott (2007, 114), as well as the Taconic Park's display materials all agree that the Copake Iron Works was last put into blast in 1903. After the iron works fell into disuse, the nearby plow works was the last remaining industry on the site to continue operation. Columbia County at the End of the Century records that in 1900 the plow works was owned by William A. Miles and the descendants of Frederick P. Miles (Smith 1900,



Figure 6.4. A recent (2013) image of the of the 1872 Copake Furnace stack with a new cover being dedicated by Friends of Taconic State Park board members. Note the lack of casing stones above the courses of marble along the bottom. This situation has led to extensive erosion of the brick and stone interior of the furnace since the late 1920s. Further stabilization should allow the stack to survive for another generation to appreciate. Image contributed by Friends of Taconic State Park.

Figure 6.5. A June 2013 image of masons stabilizing the eastern arch of the furnace stack. The masons are using a combination of new brick for stability and collected older bricks from the arches for the exterior areas visible to the public. Image contributed by Friends of Taconic State Park.





Plan view of furnace at the Copake Iron Works

- 1: Circular Cast Iron Plates (hollow)
- 2: Water Level Basins
- 3: Triple I-Beam Roof Supports
- 4: Double I-Beam Roof Supports
- 5: Downcomer Pipes (from roof)
- 6: Graffiti "ZEEAR" Location
- 7: Graffiti "C" Location
- 8: Graffiti Crosses Location

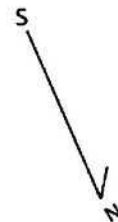
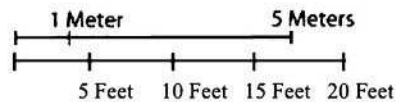


Figure 6.6. A plan drawing of the furnace stack from the survey in 2007. This and the other drawings from the project served to quickly record exterior data on each structure in the time available. This documentation has informed restoration efforts on some of the historic structures.



Figure 6.7. The author recording physical details of the furnace stack with assistant Sarah Rehrer collecting GPS point data in 2007.



Figure 6.8. A radiator pipe in the nearby Bash Bish Brook. This is one of many examples of important furnace components that may be in danger of washing away over time if they are not documented and monitored before and after seasonal flooding of the brook.



Figure 6.9. A riveted boiler section which was vulnerable to the effects of the brook's eroding shoreline. In 2013 this section of boiler was removed from the stream bank and placed near the pattern shop

735). The works produced 500 plows (in eight different styles) annually along with "a large number of extras," perhaps indicating they made other tools and farm implements as well (Smith 1900, 735). No source officially documents when the Copake Plow Works fell out of use, but Stott (2007, 114) records that the plow works site was in use as late as 1929 when a nearby Hillsdale, New York plow works company used the site temporarily while it was rebuilding its own foundry.

The remaining 80 years of the Copake Iron Works' history is dominated by New York State's acquisition of the property and its transformation into a scenic park and campground. Larry Gobrecht, an archaeologist working for the New York State Office of Parks, Recreation, and Historic Preservation (OPRHP) gives the most detailed and thorough account. Gobrecht (2000) notes that efforts to acquire the lands around the scenic Bash Bish Falls for public use had been a mission for a few conservationists as far back as the 1880s. Very little progress was made toward that goal until 1924 when Ella Masters, a woman from a prominent New York City family, purchased the lands from their various private owners. Ella Masters then donated the lands to the states of New York and Massachusetts "for no gain". This donation inspired New York State to develop a regional park system and purchase more lands in order to consolidate the various parcels donated by Ella Masters. Ella's husband Francis Masters became the first park commissioner when the

Taconic State Park was opened to the public in 1927 (Gobrecht 2000, 43-44).

In the 1930s the Taconic State Park began to modify or demolish many of the structures that were once a part of the Copake Iron Works. Stott reports that "several of the buildings surviving at that time, including the casting house and foundry, were demolished" (Stott 2007, 114). Another major structure which was dramatically affected by these renovations was the furnace stack (Figure 6.4). Sometime in this period the limestone blocks that encased the brick, stone, and mortar interior of the furnace were removed, unverified statements suggest these blocks were used to build a retaining wall to hold up the eroding hillside along Route 344, just northeast of the Copake Iron Works Property. Several authors, in particular Gobrecht (2000, 15-16), have lamented the state of the furnace stack which has suffered greatly from the effects of erosion and vegetation which made it more susceptible to collapse with each passing year until the 2012-2013 covering and stabilization projects halted most of the deterioration (Figures 6.4 and 6.5). Hopefully, the successful efforts of the Friends of Taconic State Park to build a protective shelter over the furnace stack will prevent further deterioration and allow the structure to survive for many years into the future.

These transformations must be seen in their historic context. The Taconic State Park was and is still intended to be a safe and scenic destination for tourists. The most

dilapidated structures that the park had acquired were considered a hazard to visitors. Therefore, the park decided to raze the most unstable structures soon after it acquired the Copake Iron Works property. It is quite impressive that the Taconic State Park has found uses for so many of the buildings that survive today.

SURVEYING THE COPAKE IRON WORKS

I conducted the survey of the former Copake Iron Works as a University of Massachusetts Boston graduate student, with the assistance of Professors David Landon, John Steinberg and graduate students Sarah Rehrer and Jessica Bishop. The fieldwork was done from August 13 to August 31, 2007, with a follow-up visit from October 19 to 21 in the same year. The primary goal of this survey was to thoroughly and systematically document all historical features of the Copake Iron Works that could be seen on the surface. The field survey employed a combination of photography, exterior plan drawings of buildings (Figure 6.6), and mapping with global positioning systems equipment (GPS) (Figure 6.7).

The data from this survey help to show the modifications of the landscape such as those caused by iron mining, water impoundment for waterwheels, and the dumping of furnace wastes, debris, and scrap material not reported in any historic document. In addition to the techniques listed above, one area was studied using ground penetrating radar (GPR) in order to confirm the potential locations of features shown on historic maps but no longer visible on the surface. These included a forge building, a water wheel pit, and portions of the outer furnace wall foundations (Sutherland 2008, 43-55).

The goal of thoroughly identifying and recording historic features on and below the surface of the park is threefold. First, gathering modern survey data helps further any research into the past at the Copake Iron Works by establishing a baseline for comparison. Features and buildings that survive today can be compared with those buildings that are mentioned or depicted in various historic records to learn about how the Copake Iron Works developed and changed through time. The survey was able to record certain features and remains of industry that were not depicted on any map or mentioned in any historic document, such as the distribution of slag along the bank of the nearby stream, possibly to reduce the risk of erosion and flooding near the furnace. Other types of undocumented features found during the survey include waste piles of scrap metal, remains of furnace machinery, ore tailings, and building debris.

Second, this process will help to better protect sensitive historic areas from accidental disturbance by park personnel, site visitors, and other processes. For example, in 1984 a trench for a new water line accidentally disturbed the foundation walls of several buildings that

once stood around the furnace (Workmaster 1984, 1). By presenting this research to park authorities the data provide a better chance that areas of historical significance, on the surface or below, will be protected from further disturbance. With this information, the Taconic State Park can also ask OPRHP to recover and secure materials that are at risk of being stolen, or damaged or destroyed by human and natural forces. A few locations along the stream bank have a high potential for erosion, which could destroy any material remains within those features (Figures 6.8 and 6.9). Carefully documenting the location and composition of these eroding features is the first step in properly monitoring and recovering material remains within the features.

Lastly, gathering surface data from around the park in a comprehensive way benefits the Taconic State Park's ability to present the historic significance of the iron works to the public. Current park manager Ray Doherty, and the recently formed "Friends of Taconic State Park," want to raise public awareness about the iron works and persuade state authorities, private donors, and local companies to provide additional funds to help protect and interpret the unique historic features of the park. The 2007 survey supports the new efforts at interpretation of the iron works for the public. Mr. Doherty envisions a time when a system of interpretive trails will guide the public to the many places of historic interest in the park. This survey could be invaluable to making such a vision a reality (Ray Doherty 2007, personal communication). The Friends of Taconic State Park (2012b) have stated they intend to preserve and possibly sponsor the restoration of several structures. Having a recent survey backed by thorough research helps ensure their efforts lead to more accurate restorations and minimize any impacts to historic remains above and below the surface.

The historic maps and documents used in this project are located in the Columbia County Historical Society, the Roeliff Jansen Historical Society, the Hillsdale Public Library, and the New York State Archives. These resources reveal aspects of the Copake Iron Works history that were underrepresented in previous research. Previous historical accounts of the iron works only identified the sequence of owners and basic developments on the Copake Iron Works site and the region (Gobrecht 2000, 9-16). The additional sources of information researched in this project help to either support or refute traditional historic accounts of the iron works.

A combination of historic maps and modern survey information using GIS (Geographic Information Systems) software helps explain how the Copake Iron Works developed and changed over time (Figure 6.13). GIS software allows many kinds of visual information to be layered together and compared in order to see patterns and relationships which may not have been obvi-

Historic Site Sensitivity Map

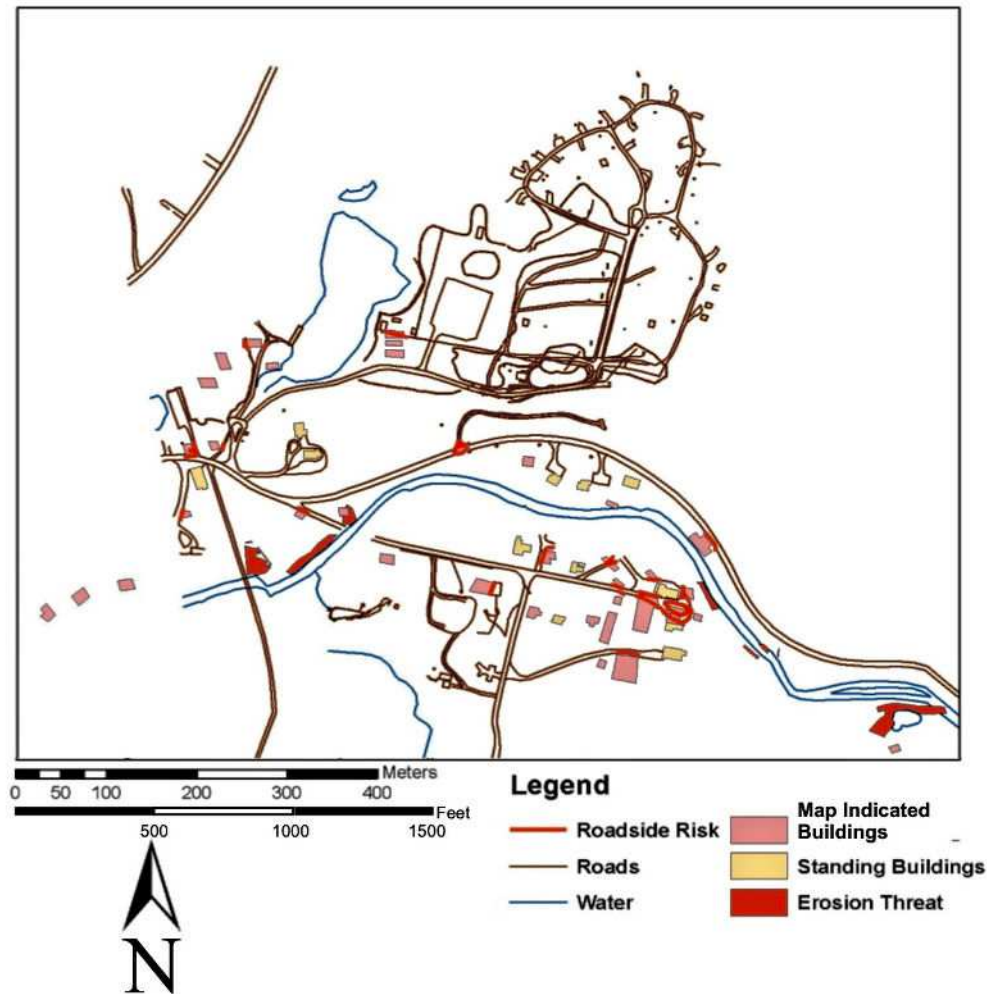


Figure 6.10. A risk map displaying which areas that are at risk to three major types of damage to historic resources including looting, accidental damage through construction projects, and natural erosion (especially near the shores of Bash Bish Brook).

ous before. The software is also a useful tool to better inform New York State archeologists and Taconic State Park managers about the historic resources around the park property. At the end of his report, OPRHP archaeologist Larry Gobrecht proposed creating a GIS database for the Copake Iron Works at the end of his report. He believes that GIS could help to prevent “accidental disturbances” and would help co-ordinate park efforts to monitor archaeological areas prone to erosion or looting (Gobrecht 2000, 57-58). A GIS database of the historic buildings and features that are or once were in the Taconic State Park was created from four historic maps, one modern park engineer’s map, and the GPS survey data collected in August 2007 (Figure 6.14).

Workmaster (1984, 1-4) describes an incident in which Taconic State Park maintenance crews disturbed at least

two historic foundations because they had no prior knowledge that buildings once existed there. This disturbance could have been easily prevented if the park and the New York State archaeologists had one map showing all the historic structures that exist and once existed on the Copake Iron Works Property. A simple test that was performed using the GIS software found sections of road that are near former historic buildings and features. These areas could be easily disturbed though routine road maintenance and traffic. A simple map generated from these data can help the park monitor sensitive areas like those depicted in the map (Figure 6.10). The area where the GIS found the most at-risk buildings along modern roadways was exactly where Workmaster states that the park work crews disturbed the historic foundations. Highlighting these areas can allow the

Ground Penetrating Radar Survey of Copake Iron Works

Overlay of historic buildings with radar image at 1.5 meter depth

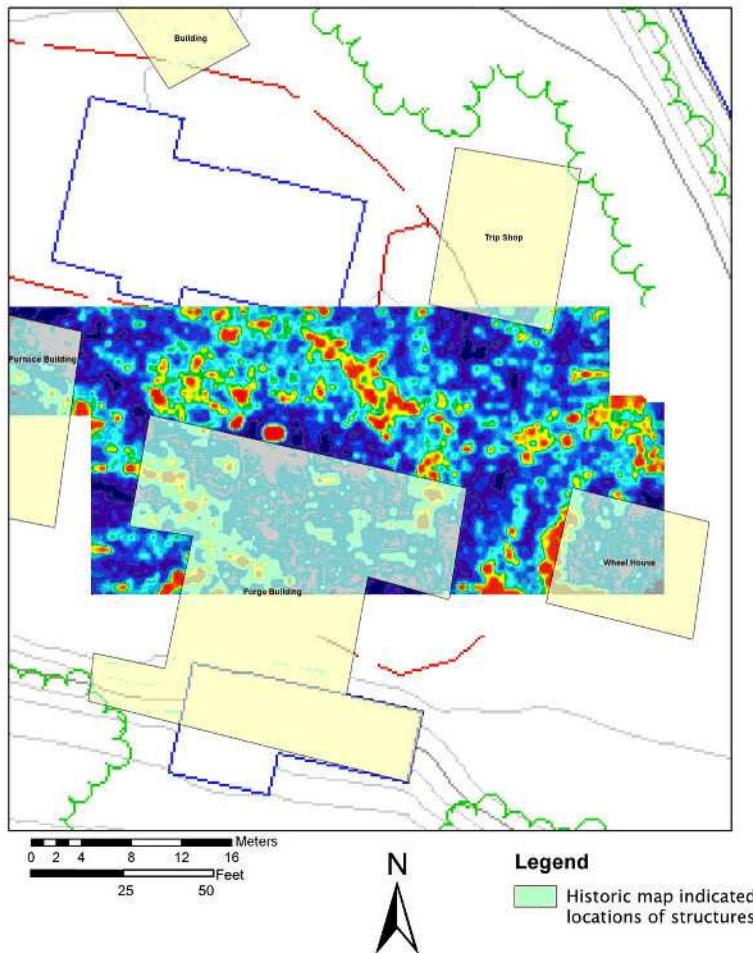


Figure 6.11. A ground penetrating radar image from about 1.5 meters or 4 feet below the ground surface. The areas in red indicate higher density objects like rocks and foundation walls. The lighter green rectangles indicate the former locations of furnace buildings as shown in historic maps. The radar and former buildings are shown over the top of a modern park map of existing structures. Note the “L” shaped high density area in the lower right corner of the area surveyed. It is possible this is an intact foundation of a 19th century structure in the approximate area that historic maps say a “wheel house” was located. The blue line from the northwest corner heading south to the bottom-middle of the area surveyed is the utility trench dug in the 1980s that damaged the foundation remains of the former forge building.

park to better monitor, protect, and potentially recover any materials at risk.

Ground penetrating radar (GPR) was used on a 100 square meter piece of land directly south of the pattern shop and east of the furnace (Figures 13 and 14). The Columbia County Atlas map of 1888 (Figure 6.4) depicts this area as the place where the forge building once stood. The 1862 Chesbrough property map (Figure 6.12) shows in addition to the forge that the water wheel house and trip hammer buildings may also have been within this area. The outlines of the buildings depicted in the 1888 and 1862 maps clearly overlap the area mapped using GPR when they are put together into the GIS map of the site. Today, this land is covered by a mixed asphalt and gravel road loop with a grassy field further east. A park shed along the southern edge of the GPR survey appears to have been built into a wall that once was a part of the forge complex.

The GPR investigation of the area to the northeast of the furnace stack was able to record buried features up to a depth of 3.87 meters (about 12 and a half feet). Im-

ages of the buried features were captured and studied at 20 centimeter intervals over the entire GPR survey. Near the southeastern corner of the area surveyed, at a depth of one meter to about two and a half meters (3 feet to 7 feet deep) there is an “L” shaped anomaly which corresponds to the southwestern corner of the water wheel house based on the 1862 Chesbrough map (Figure 6.12).

The eastern foundation walls of the forge building appear to be intact underground near the center area surveyed with GPR at about 1 meter below the surface. The depth of the forge walls appears to be similar to that of the water wheel house foundation. This analysis of the forge area using ground penetrating radar helps to validate the usefulness of combining historic map data together in a GIS. The GPR helps to demonstrate the map layering process can locate areas where former iron works structures once stood, but are no longer visible.

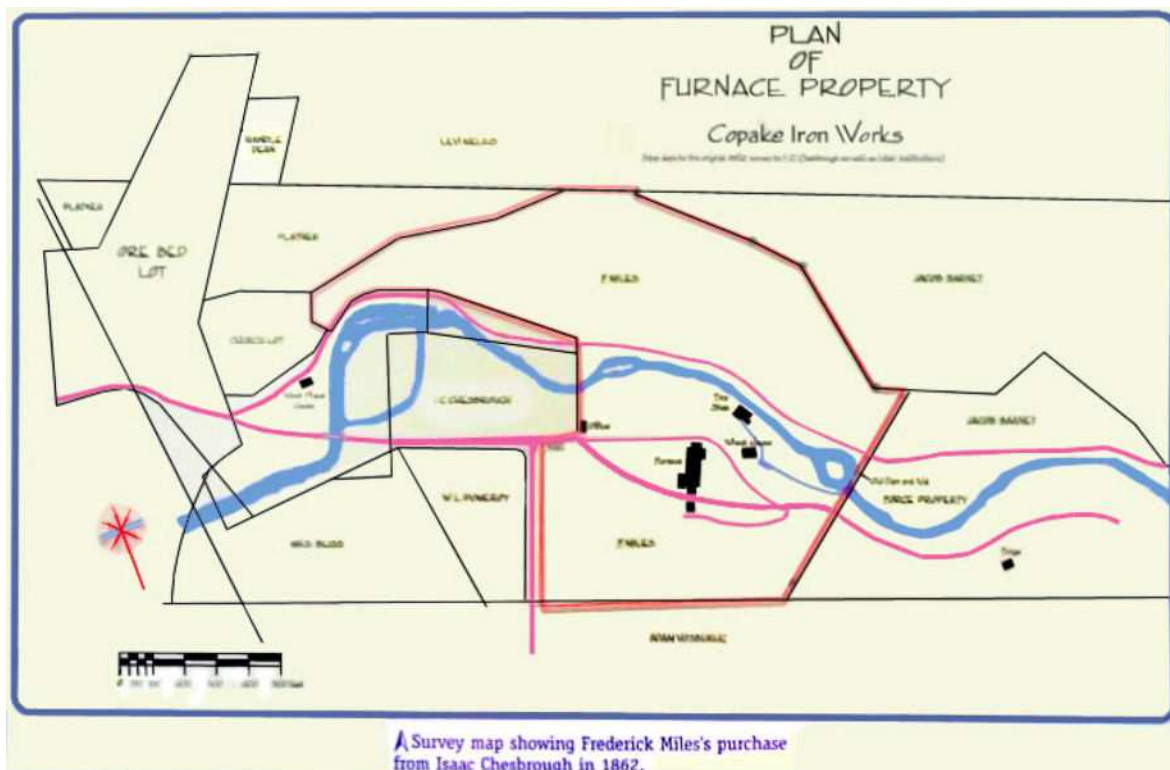


Figure 6.12. Copy of the 1862 property map on display at the ironworks showing Frederick Miles' purchase from Isaac E. Chesbrough. On display in the pattern shop exhibit space at the Taconic State Park in Copake, NY.

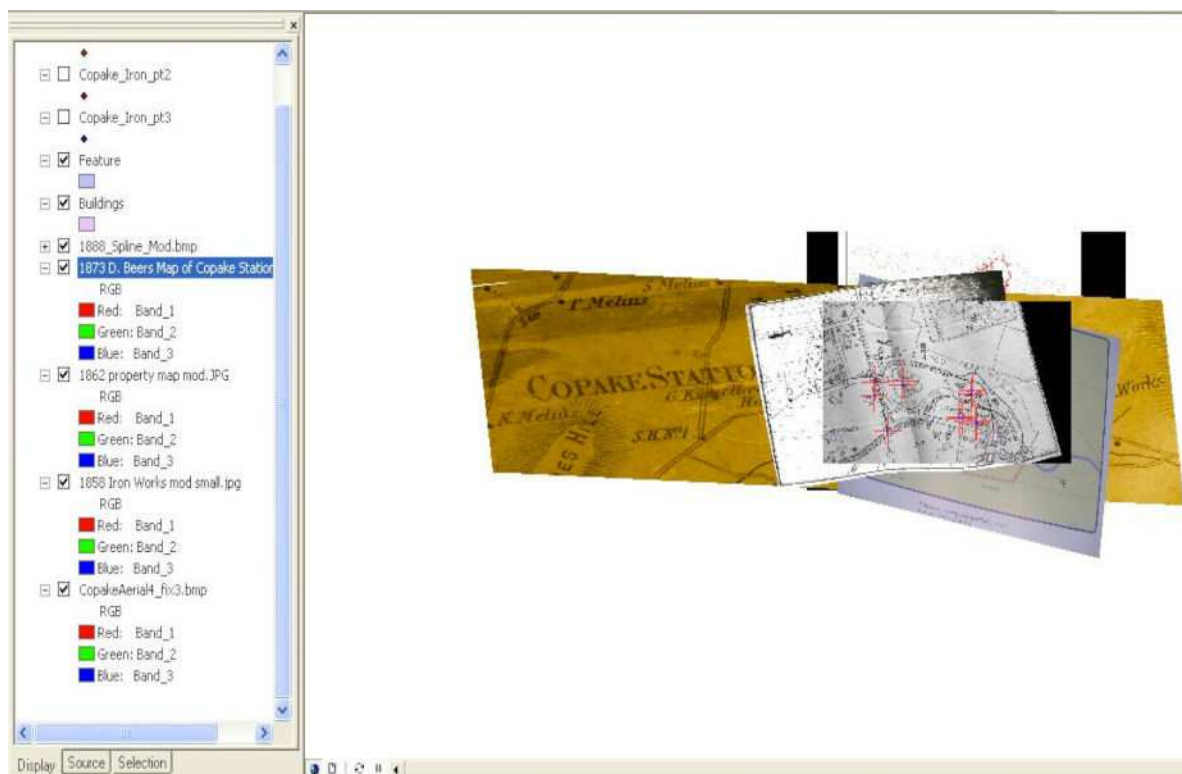


Figure 6.13. A screenshot of the GIS software (ArcView 9.6) with several historic and one contemporary park map layered together and linked by points of features appearing across several maps. Most of these intersections (see the red X marks) are the foundations of the historic buildings depicted in several maps.

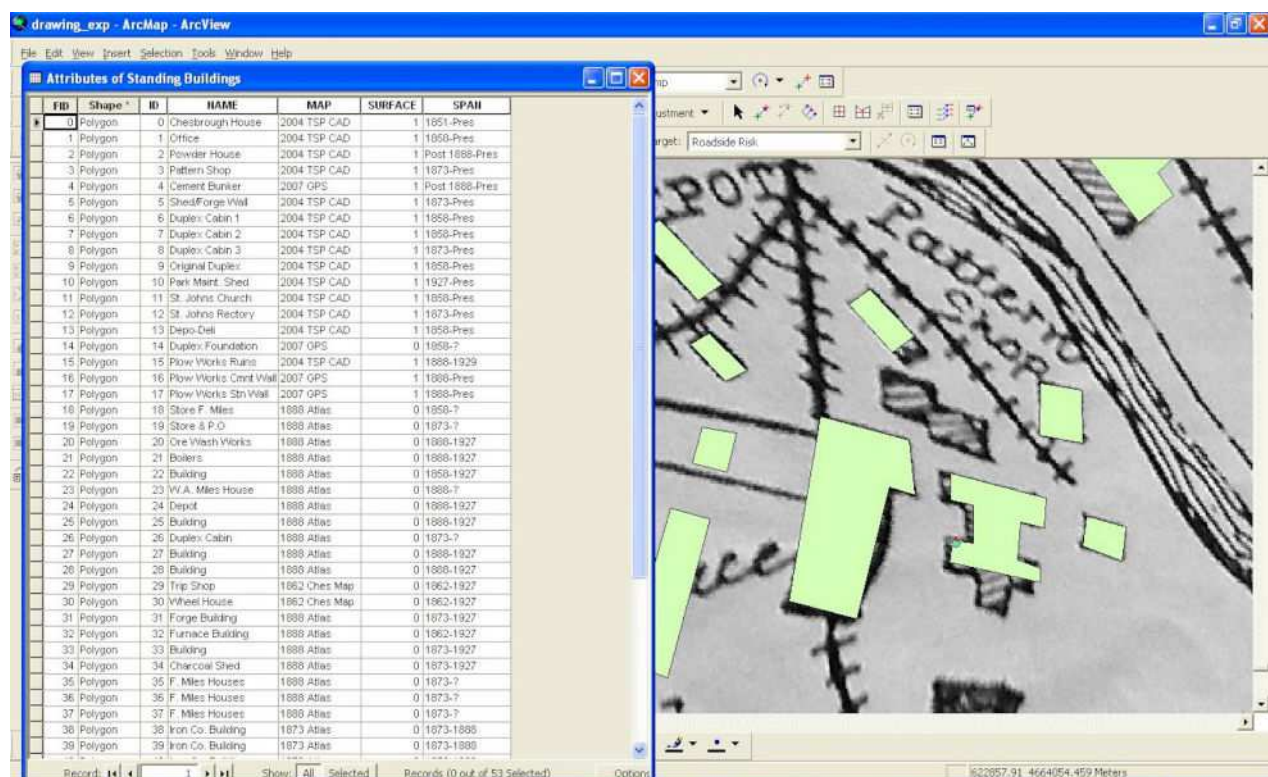


Figure 6.14. A screenshot showing the building of polygons based on map depictions of buildings. These building outlines have embedded information which is displayed on a data table to the left of the screenshot. This information was used to understand the risks to sites and their historic potential for enhanced interpretation.



Figure 6.15. Professor John Steinberg pulling his GPR device over the area between the pattern shop and furnace area.

Figure 6.16. Pieces of the Blake ore crusher discovered in the ore pond locality in 2007.



Figure 6.17. An additional piece of the Blake ore crusher discovered during the construction of the Visitors' Center to the south of the ore pond in 2011. This artifact is now next to the boiler fragment near the pattern shop.

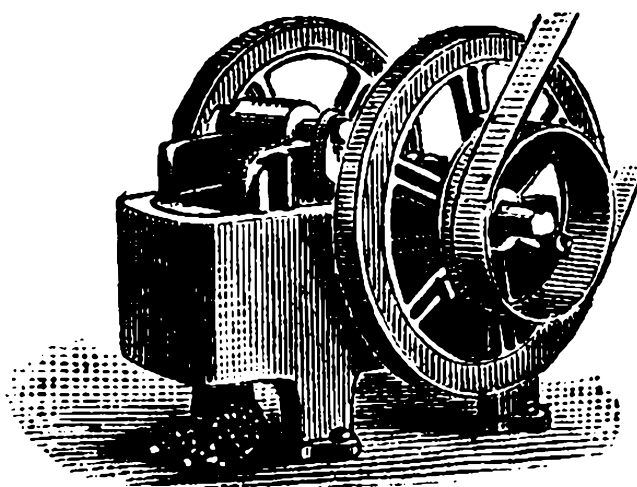


Figure 6.18. An image from Scientific American showing a complete Blake Ore Crusher. From Scientific American. Vol. XLIII.—No. 1.[New Series.], July 3, 1880. See the [Project Gutenberg Page](#) for more details.

UTILIZATION OF PROJECT DATA SINCE 2008

Since the completion of the project and thesis document in the spring of 2008 the collected data has been used by several organizations to improve the park while preserving the surviving historic remains above and below the surface. Recreational improvements to the ore pond area in late 2007 and early 2008, the construction of a new park visitor's center in 2011, the placement of footings for a covering over the furnace stack in 2012, the development of walking trails near the furnace area in 2012 to 2013, and the current 2013 efforts to stabilize the engine house, furnace arches, and one of the remaining worker's houses have been aided by the documents generated from this project.

During a follow-up visit in October 2007 I was able to partially monitor the impacts of the Taconic State Park's modifications to the southern end of the ore pond recreational area. These modifications involved excavating the earlier 20th century concrete lined wading pond and rebuilding the shoreline around this 15 square foot (approximately 10 square meter) area. Two significant pieces of iron were recovered in the ore pond area (Figure 6.16). Based on their relative location and shape, a reasonable assumption was made that they belonged to the Blake ore crusher located near this region on historic maps. Later, in early 2011, while a new visitor's center was under construction south of the ore pond, another large portion of the ore crusher was recovered and quickly identified based on the map and documentary data collected for the 2008 thesis document (Figures 6.17 and 6.18).

In fall of 2008 the non-profit group "Friends of Taconic State Park" was organized with the intent to be a "liaison with governmental bodies and with institutions" for advocacy of "maintenance and improvements of the Taconic State Park" (Friends of Taconic State Park 2012b). One of the top priorities for the group has been to provide protection for the furnace stack remains. At present (Fall 2013), the group has successfully raised the funds through New York State and private grants to build a shelter and stabilize the four arches of the furnace (Friends of Taconic State Park 2012a).

The ground surrounding the footings to support this shelter has been investigated by New York State archaeologists in order to ensure that the construction will not damage or threaten any remains beneath the ground surrounding the furnace. The 2008 thesis document assisted in providing background information and preliminary data about potential features the footings for the shelter might encounter. In late 2010, the state's reports on the test excavations around the furnace were completed and allowed for the final approval for placing the footings in a location that would minimize damage to historic features beneath the surface (Roets 2010).

The combination of recording techniques, historic research, and data analysis through GIS software has demonstrated the benefits of collecting and using information about an historic iron works site in order to better promote the site today and preserve the most important features into the future. The role of historic preservation in New York State's history of iron working will only increase as modern redevelopments, looting and natural decay take their toll on our heritage. Studying sites like the Copake Iron Works and providing the data to support preservation and interpretation can ensure our iron heritage will remain a cornerstone of New York State's historic landscape for many years to come.

APPENDIX

The following articles are from the Journal of the United States Charcoal Iron Workers (Volume 6 from October, 1885 and Volume 7, from April, 1886 – click hyperlinks to access articles from University of Michigan's online library). The first article is a short description of a meeting at the Copake Iron Works written by one of the members. The Second article is a technical description of the Blake Ore Crusher and ore washing machinery used at the Copake Iron Works, written by William A. Miles. A brief discussion between the association members (including Frederick P. Miles) is reproduced at the end where various methods of ore processing are mentioned.

REFERENCES

- Atlas of Columbia County, New York*. 1888. New York: Beers, Ellis & Co. (Cited on page 112).
- Burr, D. H. 1839. *Map of the county of Columbia*. On file at the Columbia County Historical Society, Kinderhook, New York. Ithaca, New York: Stone & Clark. (Cited on page 112).
- Ellis, F. 1878. *History of Columbia County New York: Illustrations and Biographical Sketches of Some of its Prominent Men and Pioneers*. Philadelphia: J.B. Lippincott & Co. Press. (Cited on pages 110, 113).
- Friends of Taconic State Park. 2012a. "About Us." Accessed June 8, 2012. <http://www.friendsoftsp.org/about-us.html>. (Cited on page 124).
- . 2012b. "Goals and Objectives — By-Laws, section 2, subsections 3-4." Accessed June 8, 2012. <http://www.friendsoftsp.org/goals-and-objectives.html>. (Cited on pages 118, 124).
- Gobrecht, L. 2000. *The Copake Iron Works at the Taconic State Park — A Report on its Historical Significance and Development Potential*. On file. Peebles Island, NY: New York State Office of Parks, Recreation, and Historic Preservation. (Cited on pages 110, 117–119).

- "Narrative of the Sixth Annual Meeting." 1885. *Journal of the United States Association of Charcoal Iron Workers* 6 (5): 300–215.
- Kirby, E. 1998. *Echoes of Iron — In Connecticut's Northwest Corner, Including a Field Guide to the Iron Heritage Trail*. Sharon, CT: Sharon Historical Society. (Cited on page 113).
- Krattinger, W. E. 2007. *National Register of Historic Places, Copake Iron Works Historic District, Copake Falls, Columbia County, New York, National Register #07000334*. Washington DC: United States Department of the Interior, National Park Service. (Cited on pages 110, 113).
- Mettler, E. 2000. *The Fagan Sisters — History of Life in a New York Country Village*. Charleston, SC: Acadia Publishing. (Cited on page 113).
- Miles, W. A. 1886. "Ore Washer and Separator at Copake Iron Works, New York." *Journal of the United States Association of Charcoal Iron Worker* 7 (1): 6–11. (Cited on page 113).
- Naramore, S. B. 1993. "The Livingston Iron Mill." In *The Mill on the Roeliff Jansen Kill — 250 years of American Industrial History*, edited by Roeliff Jansen Historical Society, 11–28. Black Dome Press. (Cited on page 110).
- Roets, M. 2010. *Copake Iron Works, Furnace Building, Footing Excavations*. Memorandum, December 8 & 21, to Julian Adams, Raymond Doherty, Rich Gromek, Garrett Jobson. Peebles Island, NY: New York State Office of Parks, Recreation, and Historic Preservation. (Cited on page 124).
- Smith, H. P. 1900. *Columbia County at the End of the Century — a Historical Record of its Formation and Settlement*. Hudson, NY: Record Printing / Publishing Co. (Cited on pages 110, 113, 117).
- Stott, P. 1993. "The Paper Mill: Two." In *The Mill on the Roeliff Jansen Kill — 250 years of American Industrial History*, edited by Roeliff Jansen Historical Society, 51–66. Black Dome Press. (Cited on page 110).
- . 2007. *Looking for Work — Industrial Archeology in Columbia County, New York*. Syracuse: Syracuse University Press. (Cited on pages 110, 113, 117).
- Sutherland, F. E. 2008. "From Forest to Company Town and Back again — Historical Archaeology at the Copake Iron Works." Master's thesis, University of Massachusetts, Boston. Accessed June 8, 2012. <http://www.scribd.com/doc/38355860/Sutherland-Thesis>. (Cited on page 118).
- Workmaster, W. 1984. *Copake Falls Situation*. Memorandum to Gus Thomson and John Kennedy. Peebles Island, NY: New York State Office of Parks, Recreation, and Historic Preservation. (Cited on pages 118, 119).

VISITORS AND VANDALS

The Post-Abandonment Archaeological Record at the Adirondack Iron and Steel Company's "New Furnace"

David P. Staley

Much of the archaeological record at the Adirondack Iron and Steel Company's "New Furnace" has been generated by visitors and vandals since its abandonment in 1857. The distribution of bottle glass, lamp glass, wire nails, ceramics, cans, and faunal remains indicates a preference for drinking, picnicking, and camping in the larger eastern hearth during the period between 1880 and 1940. Different forms of vandalism are linked to recent decades. Bottle smashing is focused on the roadside face of the furnace whereas more destructive digging and masonry demolition has occurred in the more secluded arches. The intensity and periodicity of visitation and vandalism appears linked to local population conditions, traffic levels and the character of stewardship through the three post-abandonment phases.

To nearly everyone, from casual traveler to aficionado of industrial history, the dark monolithic masonry structure that abruptly appears along the shoulder of the road evokes curiosity and a sense of wonderment. People have been attracted to the Adirondack Iron and Steel Company's "New Furnace" since its abandonment. Also known as the "McIntyre Furnace", the site, located on the very upper reaches of the Hudson River at the southern gateway to the Adirondack High Peak region, is arguably the best preserved example of mid-nineteenth century iron workings (Figures 7.1 and 7.2).

Archaeologists from the Cultural Resource Survey Program of the New York State Museum (CRSP) conducted excavations at the furnace prior to proposed stabilization work sponsored by the Open Space Institute (OSI) and the New York State Department of Environmental Conservation (DEC). The purpose of these excavations was to gather information about the location and character of significant archaeological deposits so that impacts to the site could be avoided. The vast majority of artifacts recovered from the excavations pertain to the period after abandonment, a span of time greater than that encompassing the construction and operations of the facility. An analysis of those artifacts, their contexts, and other on-site observations contributes to an

understanding of what happened after the furnace was extinguished.

HISTORIC CONTEXT

A detailed history of the Adirondack Iron and Steel Company and the New Furnace was compiled from primary archival sources as part of the Historic American Engineering Record (Seely 1978). In addition to this comprehensive work, earlier works written by Hochschild (1962), Masten (1935, [1923] 1968), and Haynes (reports by 1994) form the core of published knowledge about the historic context of this site. Many of these sources and others have been gathered and annotated in anthologies (Manchester 2009, 2007). The brief history that follows provides a backdrop for the site, archaeological findings, and interpretations.

In 1826, a guided prospecting party was led to a massive bed of iron ore spanning the upper reaches of the Hudson River (see Lupulescu Chapter 2, this volume). Political maneuvering, land acquisition, and investment began almost immediately and a tranquil wilderness was transformed into an industrial landscape for nearly three decades (Seely 1978).

Archibald McIntyre, David Henderson, and Duncan McMartin formed a partnership to develop this discovery. McIntyre and McMartin were wealthy and politically connected. McIntyre had been a State Assemblyman and State Comptroller. McMartin was also a former Assemblyman and was then in the State Senate. Henderson brought an engineering background to the partnership. The partnership eventually incorporated into the Adirondack Iron and Steel Company in 1839 (Hochschild 1962; Seely 1978).

Land acquisition and the development of a state road into the region occupied the partnership for the first few years. Site development was confined to the clearing of several acres near the ore beds (Haynes 1994). By 1832, development of the iron works began in earnest with construction of a forge, coalhouse, sawmill, a two-story log house, blacksmith shop, and stables (Hochschild 1962).

Due to limited transportation systems and concomitant costs, this iron work, like most other nineteenth cen-

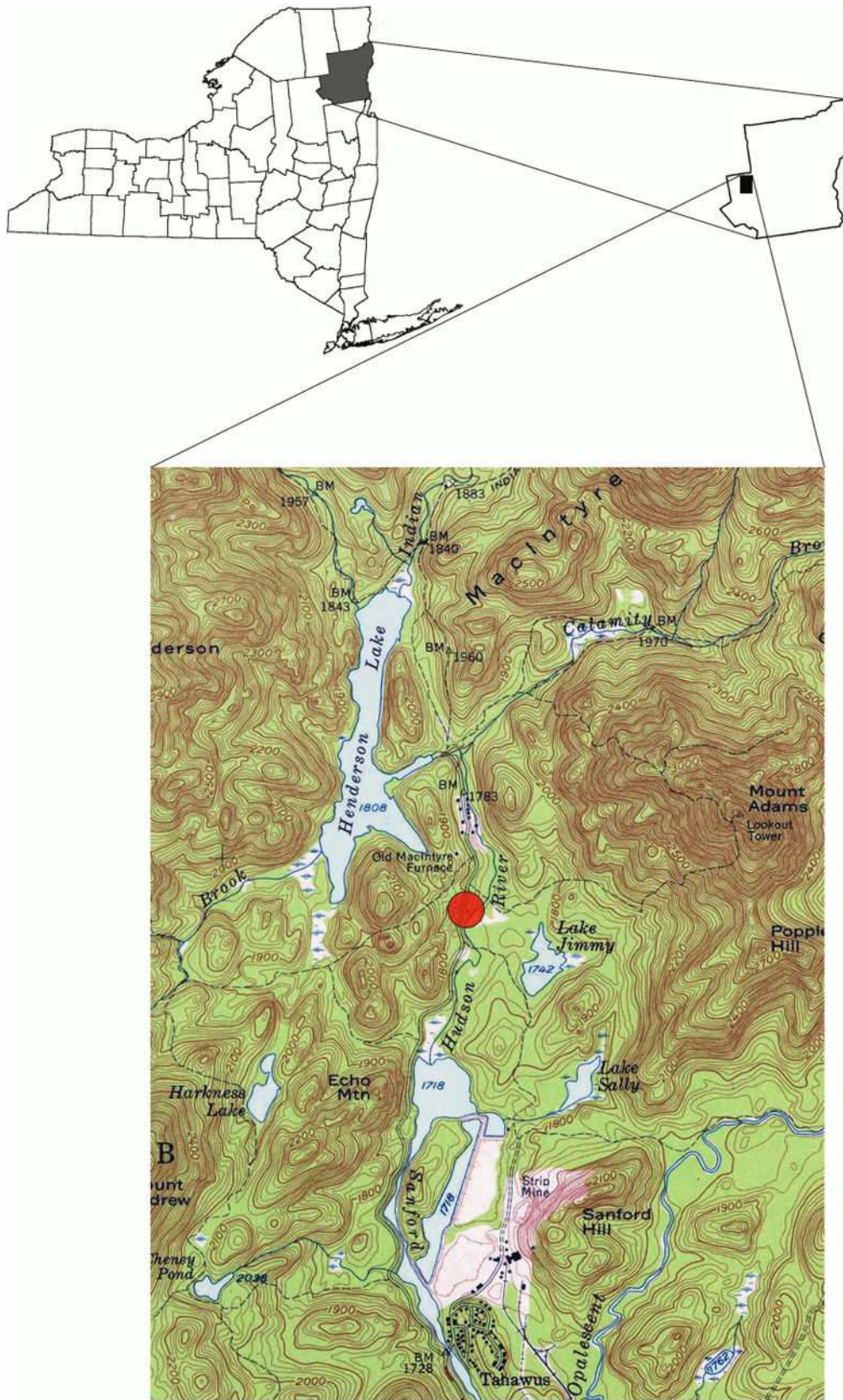
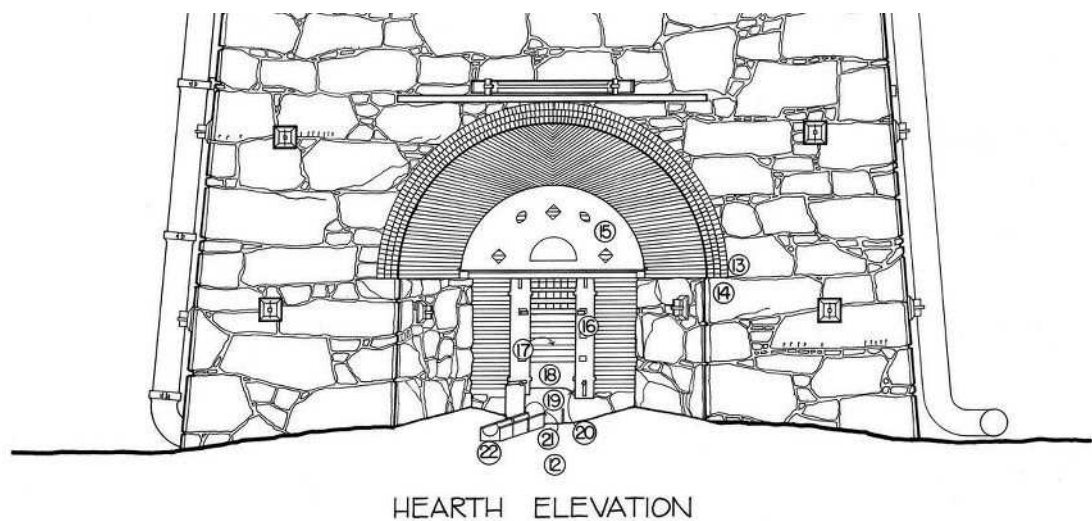


Figure 7.1. Site location.



Figure 7.2. Adirondack Iron and Steel's New Furnace (Photo J. Yuan, DEC, 2004).



THE HEARTH ARCH WAS THE SCENE OF MOST OF THE FURNACE ACTIVITY, FOR HERE THE FURNACEMASTER AND GUTTERMEN TAPPED THE HEARTH TWICE DAILY, RUNNING THE MOLTEN IRON THROUGH THE HOLE IN THE DAMSTONE AND DOWN THE IRON RUNNER TO THE CASTING HOUSE.

- ⑫ HEARTH ARCH
- ⑬ COMMON BRICK - 2 COURSES
- ⑭ FIRE BRICK - 1 COURSE
- ⑮ IRON FACE PLATE, BACKED WITH FIRE BRICK
- ⑯ IRON BUCKSTAYS
- ⑰ IRON PLATES SUPPORTING FIRE BRICK
- ⑱ TYPM STONE AND WATER-COOLED TYPM PLATE
- ⑲ DAM STONE AND WATER-COOLED DAM PLATE
- ⑳ SLAG NOTCH
- ㉑ TAP HOLE
- ㉒ IRON RUNNER

Figure 7.3. Detail of New Furnace hearth elevation (adapted from [HAER 1978](#), HAER NY,16-TAHA,1-[sheet 5 of 13]).

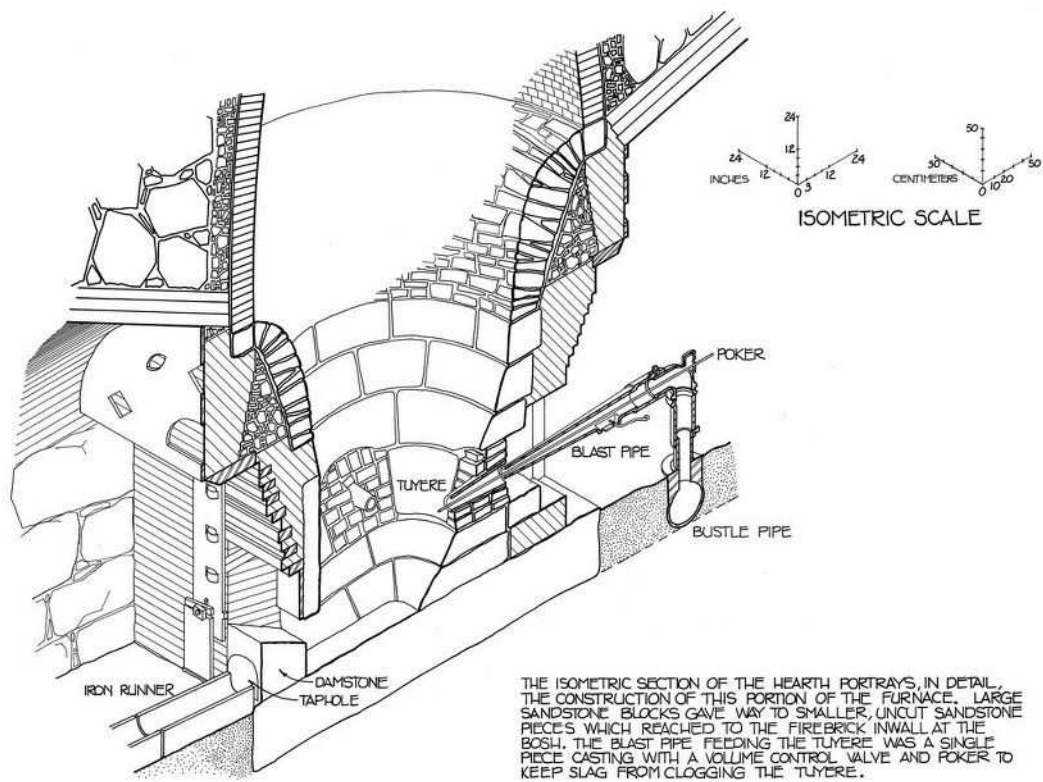


Figure 7.4. New Furnace hearth cross section (adapted from [HAER 1978](#), HAER NY,16-TAHA,1-[sheet 13 of 13]).

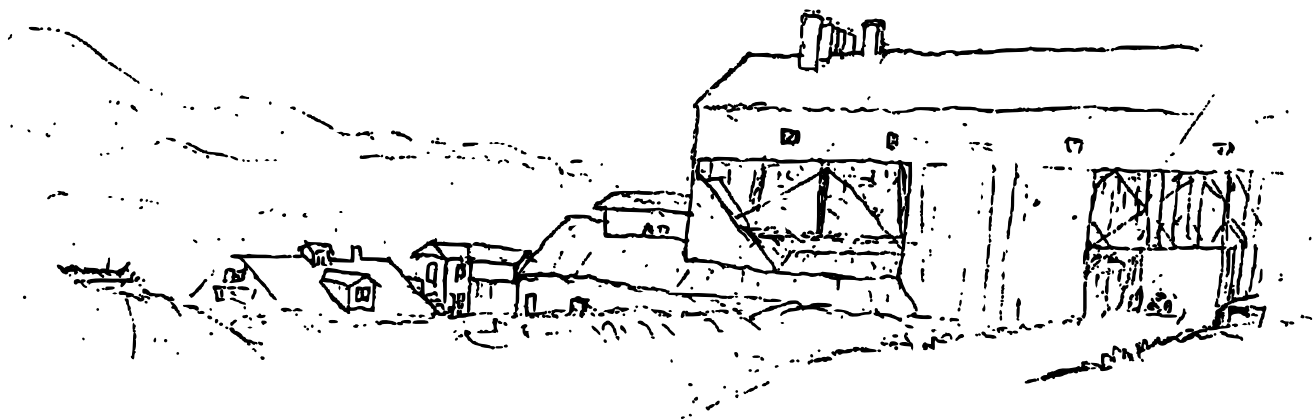


Figure 7.5. Benson Lossing's 1859 pencil sketch of "The New Furnace and Forge, Adirondack Iron Works, September 1859" (Seely [1978](#)).



Figure 7.6. Edward Bierstadt's 1886 artotype of "Old Furnace, Deserted Village, Adirondacks, N.Y." (courtesy of Ed Palin).

tury American iron works, was located near the source of iron and charcoal. The isolation and remote setting required the company to provide all necessities such as food, housing, and all other aspects of village life in what is called a plantation style development (Seely 1978, 1981). As the industrial infrastructure and the requisite labor force grew, so did the domestic, agricultural, and civic infrastructure.

Through the years, the iron works and town, first called McIntyre and later Adirondac, grew adding two farms, a school, a church, store, post office, bank, family housing, and boardinghouses. The industrial infrastructure was similarly expanded with dams and flumes, a variety of smaller forges and furnaces, charcoal kilns, stamp mills, magnetic separators, brickworks, and a larger stacked blast furnace. The company also incorporated a railroad company and built several miles of the Adirondack Railroad, a wooden track with horse-drawn carts reaching toward the southeast. The population grew from 36 in 1833 to a total of 85 in 1845. A year later the artist Thomas Cole, while visiting the village, noted 95 men in the boarding house (Haynes 1994; Seely 1978, 102).

The pace of development repeatedly waxed and waned because of inconsistent smelting results and difficulties associated with transportation. Eventually, the company shifted focus toward sale of the property. Late in the development, and as a means to attract potential

buyers, the company began construction of the larger second stack, or "New Furnace" in 1849. This state-of-the-art furnace and its ancillary facilities, located approximately a half mile south of the village, were completed and functional by 1854. Costing \$43,000, the 46 foot tall furnace was one of the largest in the country (Seely 1978, 134).

The furnace was built into the side of a hill. Workers ported ore, fuel, and flux across a wooden trestle where it was loaded into the top of the furnace. The base of the furnace had four arches. The furnacemasters, guttermen, and firemen tapped the hearth through an opening between the "dam" and "t ymp" stones in the larger eastern, front, or hearth arch (Figure 7.3). Covered by protective water-cooled iron plates, the tap hole between the dam and tym p stones was packed with fire clay to hold the molten iron. The furnacemen would unblock the tap hole and guided the molten metal down an iron trough or runner into the casting shed. The other arches provided access to the three tuyeres which delivered hot air blast to the furnace fires. These tuyeres featured mica viewing ports to monitor the hearth and an internal poker to prevent blockage (Figure 7.4). It is suspected the furnace operated in two separate long "campaigns"; from August to December of 1854 and then from January to June of 1855, although the timing is uncertain (Seely 1978, 148-9).

The furnace sat dormant for a year with the company

records showing no expenditures at the works. A flood in 1857 washed out the dam and a national economic panic that same year further dampened the company's hopes to sell the property (Hochschild 1962; Seely 1978; Manchester 2009). Robert Hunter, former brickmaker at the works, was hired as caretaker for the property (Lossing 1866; Burroughs 1899; Masten 1935; Seely 1978). He and his family continued to use the farm and preside over the former iron works as the primary business on the land changed to logging.

For a time Hunter, and later caretaker John Moore, welcomed and lodged various journalists, sportsmen, and other curious travelers to the property. T. Addison Richards visited prior to September 1859 and included village sketches in a magazine article (Richards 1859). Benson J. Lossing, illustrator and author, also visited in 1859. His drawing depicts the New Furnace and the charging bridge sheathed in a wooden structure (Figure 7.5). His characterization "deserted little village" has been used to label this phase of history (Lossing 1866; Haynes 1994).

Naturalist and writer John Burroughs visited in 1863 and noted the beginnings of structural decay around the village (Burroughs 1899). Beginning in 1873 and continuing through 1914, Seneca Ray Stoddard featured Adirondac and this furnace in his guidebook, *The Adirondacks, Illustrated* and in his photographs. He, too, emphasized the crumbling ruins and pervasive decay (Stoddard 1874; Haynes 1994). The popularity of hunting, fishing, and outdoor recreation increased during this period and one can only assume the visiting journalists represent a very small minority of the valley traffic. The journalists likely fueled visitation by highlighting the furnace and village as picturesque attractions (Figure 7.6).

Starting with the Preston Pond Club in 1876, various outdoor sporting clubs leased portions of the Adirondack Iron and Steel Company property. Renamed the following year as the Adirondack Club, the 20 member group made its headquarters the former village of Adirondac. Members converted the mining company's boardinghouse into a clubhouse, repaired and occupied existing structures, and began to build private cottages in 1891. The club policy regarding the provision of accommodations for non-member travelers vacillated. Guests were welcome in the periods 1877–1884, 1889–1892, and 1906–1914. During the summer season, the village became very much a family resort with docks, boat house facilities and even tennis courts. The club typically hired one or more year round caretakers who, at times, also managed the club house. Club occupation of the village persisted until 1947 (Haynes 1994; Masten 1935, [1923] 1968; Stoddard 1874).

New life was breathed into the Adirondack Iron and Steel Company in the early 1890s. James MacNaughton,

a grandson of McIntyre, as the shareholders trustee, employed the French metallurgist Augusta Rossi. Rossi visited the works in 1892 and conducted experiments. His work demonstrated the potential utility of these titaniferous ores. Reorganized as the MacIntyre Iron Company in 1894, the property was sold in 1906 to the Tahawus Iron Company with Wallace T. Foote as its principal owner. This company conducted extensive explorations and core drilling between 1906 and 1909 followed by temporary mining of ore between 1912 and 1914 (Seely 1978, 165-6; Haynes 1994). Mineral explorations and developments coexisted with the club occupation during this period. Exploration, mining, and lumbering occurred on lands surrounding the village with the mine operational base located south of the village at Lake Sanford (Masten 1935, 211-2).

This period of exploration and testing ended in 1941 with the sale of the property to National Lead Company (later N.L. Industries). By 1945, the mining community at Tahawus had a population of 300, 84 houses, two apartment buildings, restaurant, recreation center, store and movie hall. After 1947, the mine needed additional houses for its workers. The lease for the Tahawus Club (Upper Works Club) was not renewed at Adirondac and National Lead moved families into the housing. The village was now filled with 20 families year-round till 1964. George Cannon, former mine employee, Adirondac resident, and town supervisor, remembers the trailheads in the vicinity had been established but did not see a lot of traffic. NL Industries posted and fenced the New Furnace site with barbed wire but expended little effort keeping the curious out. The children in town had little interest in the old furnace. Mr. Cannon has no recollection of anyone camping there (George Cannon, personal communication 2011). The MacIntyre mine ceased mining in 1982 and closed operations in 1989.

During the 1970s, The Adirondack Museum and the National Park Service Historic American Engineering Record (HAER) conducted historical and architectural research at the New Furnace and in Adirondac. These investigations amassed an incredibly detailed history, conducted mapping, and generated scaled architectural drawings and high quality photographs (Youngken 1977; HAER 1978; Seely 1978). The New York State Museum conducted a larger reconnaissance survey of the Upper Works National Register District in 2003 and 2004. That survey focused on the larger plantation system and on sites and features surrounding the village and the New Furnace (Staley 2004).

ARCHAEOLOGICAL CONTEXT

Methods

Proposed stabilization efforts prompted test excavations at the New Furnace in 2006 (Staley 2006, 2007). Excavations included two quadrants of the northern arch, a series of 1 x 1 m excavation units in the east or hearth arch, units outside the furnace in the area of the casting house and another outside the western arch between the furnace and the retaining wall (Figure 7.7). Excavations were by natural levels and all sediments screened through ¼ inch mesh. Building materials such as brick, anorthosite, and sandstone were tallied and weighed by unit and level in the field. Slag was also weighed in the field.

Stratigraphy

The basic stratigraphic sequence is most clearly indicated in the northern quadrant of the north arch (Figures 7.8 and 7.9). Just above the stone floor, a thin layer of crushed brick and mortar in a matrix of silty sand represents the earliest phase of brickwork (Figure 7.9, Level 4 [4]). Clean, well-sorted gray sand covers this layer nearly everywhere at the site [3]. A plausible interpretation is that the sand was intentionally distributed to create a very smooth and clean working surface.

The surface of the sterile sand level is typically darkened by charcoal as are the mottled dark brown–grey sands immediately above [2]. These are interpreted as working levels. A thin organic lens of decaying wood was noted in the northwestern quadrant of this arch just above this level, perhaps marking the debris from the adjoining wooden structure seen intact in the 1859 drawing by Lossing (Figure 7.5) and in partial collapse in an 1886 Bierstadt photo (Figure 7.6).

The surface layer of gray loamy or silty sand includes numerous large and small fragments of brick and other construction materials [1]. Stratigraphy in the southeastern quadrant is different, in that there are multiple strongly sloped strata from the furnace core representing construction material debris flows of oxidized sands, broken brick and mortar, and very dark grey to black sands capping the lowest three levels seen in the northwestern quadrant.

In the hearth arch, the stratigraphic sequence shares some basic similarities with the northern arch (Figure 7.10). Functional operations in the hearth arch create sediments and stratigraphy unique to the arch and variable from the core to the mouth. Like the northern arch, the cobble floor of the facility has a thin cap of fine crushed brick and mortar in very dark grey brown to black sand. Clean dark grey sand overlays the crushed brick layer. The overlying strata above this are highly variable depending upon their position within the arch.

In the mid section of the arch and along the sides of the iron trough or runner in Test Units (TUs) 2 and 4 (Figure 7.10), the clean sandy level is stained black at its contact with mottled light brown sandy clays above. This level is also charcoal stained at its contact with overlying mottled dark grey brown clays. These mottled and multi-lensed clay rich strata include large volumes of slag and result from the accumulation of clay from the tap hole mixed and trampled with the slag waste tossed along the side of the iron runner. This is capped with a black charcoal rich level of loamy or silty sands that thicken toward the mouth of the arch. The surface layer is dominated by large brick and fire-brick rubble in a matrix of dark grey silty or loamy sands. Toward the mouth of the arch, TU 3 revealed stratigraphy strongly affected by operations at the mouth of the iron runner.

Above the typical brick and mortar sands, the clean dark grey sands have a subtle trough shape extending from the runner (Figure 7.11). This trough extends up through the yellow brown mottled clay soils. The trough itself is filled with the black charcoal stained and slag rich sands observed above the clay layers in the arch mid-section. This trough fill is capped by mottled dark grey and olive grey mortar rich sands, all overlain with brick rubble in a matrix of black to dark grey sands. The black charcoal and slag deposit filling the trough and capping the clays in the midsection should be interpreted as the remainder of fuel and waste that flowed from the furnace after the last blast. Found at the contact between the black trough fill and the mottled sands above, decayed wood marked the possible collapsed wood casting house superstructure.

The stratigraphic record near the core is complicated by pre-operational construction requirements and post-operational decay processes. In this area an additional red stained, brick and mortar crumb rich sand lay above the sterile grey sand suggesting a second round of masonry work prior to the initial blast. Above this lens was another level of sterile grey brown sands and then the multiple levels of charcoal stained mottled yellow brown clays. Like those in the northern arch, the levels above strongly slope down toward the arch mouth and consist of dark brown and red brown layers of sand that are the result of post-operational construction debris flows from the core (Figure 7.12).

Taken along with other sedimentological indicators, the wood lens in the north arch and a decayed board or timber in the east arch delineates the post-abandonment strata. Within the upper levels, a 1970s vintage Pepsi can found above the iron trough and the iron buckstay at the base of the brick rubble layer provide an approximate chronological mark segregating the last three decades. The beverage container very well may be a “calling card” purposely left by the HAER team after they had cleared off the trough for recording purposes.

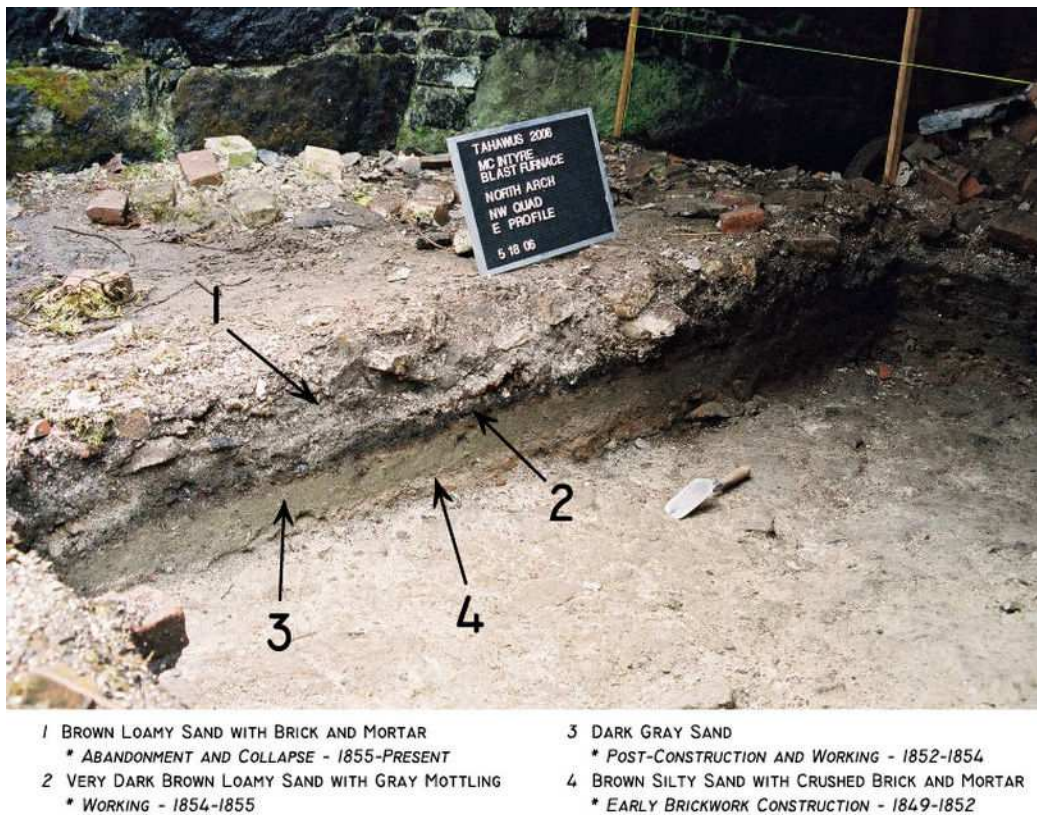


Figure 7.9. Northern arch, northwestern quad, east wall.

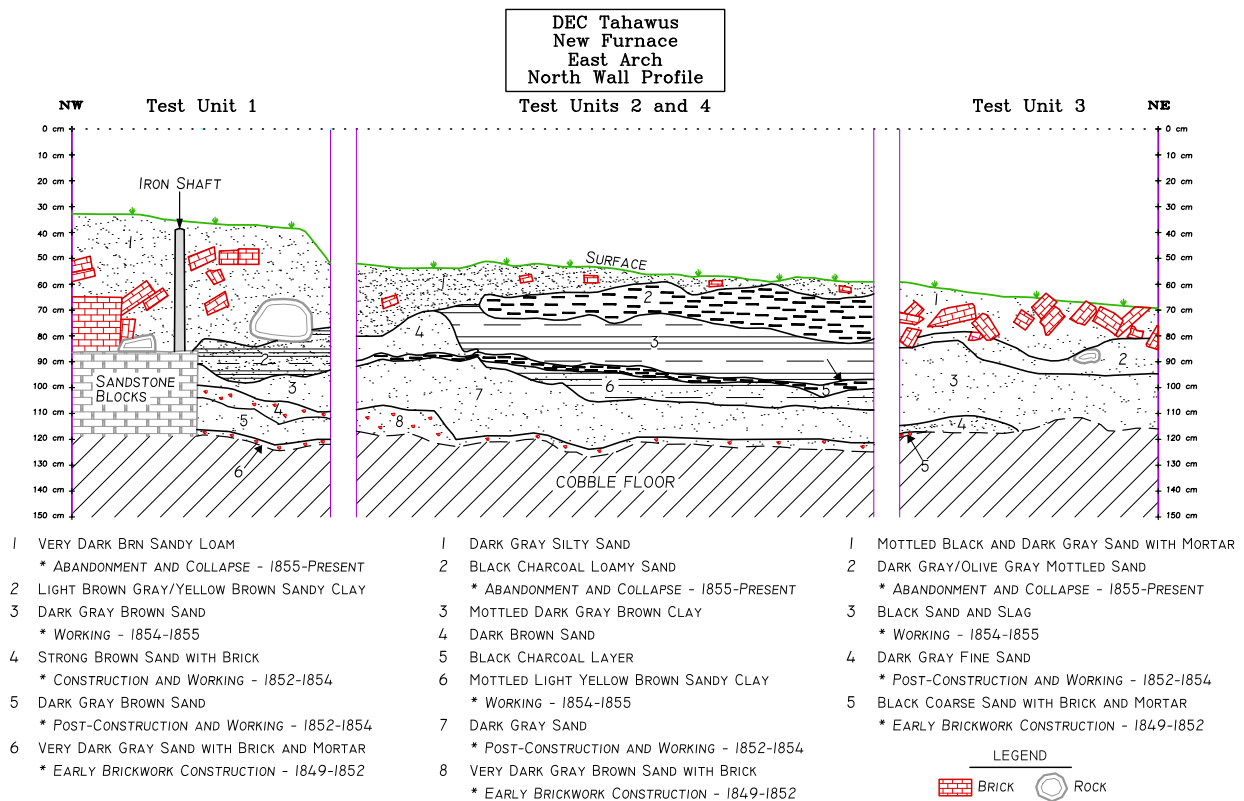


Figure 7.10. Eastern hearth arch stratigraphic profile.

The 1978 photographs clearly show both vertical buckstays in the working arch. These investigations located the northern buckstay near the base of the brick rubble level; therefore the upper brick rubble layer should date to after 1978.

ARTIFACTS

The artifact assemblage from the post-abandonment levels constitutes 81 percent of the total 2,366 items from the excavations. After excluding wood, charcoal, and soil samples, slag, scale, ore samples, unidentified iron, and brick and mortar, the upper levels contribute 1,397 items of the 1,650 recovered. Table 7.1 illustrates both the dramatic content increase and some of the artifact type variability in the post-abandonment levels. For the purposes of this paper, the focus will be primarily on this assemblage subset however; a brief discussion of the remainder is warranted.

As a preface for analysis, interpretation, and discussion it is important to recognize archaeological shortcomings inherent at this site. The ideal archaeological site would provide artifactual content and contextual control affording the researcher to tease out the functional details and patterns and clearly segregate them through time. Despite the obvious shift in content and numbers of artifacts from the construction and working levels to the post-abandonment levels, the story is neither perfect nor absolute. The bulk of the artifacts do not lend themselves to precise chronological control. Artifacts datable with some precision to the mid-nineteenth century are found in the surface levels and obviously modern items are found, thankfully rarely, in working levels.

The extent of mixing in the upper two post-abandonment levels is more thorough. For example, modern bottle glass, whether measured by count, by percentage of all glass, or standardized by excavated volume, is found evenly distributed through the hearth arch upper levels. Fortunately, most of the glass assemblage appears to date to the period between 1880 and 1940; not ideal chronological control but adequate for some interpretation.

This post-abandonment assemblage is a palimpsest, the result of repeated and overlapping behaviors, in this case visitors or tourists, day trippers or possibly campers. As an attraction, the blast furnace has drawn visitors who intentionally or inadvertently trample, churn, scavenge, collect souvenirs, gather items and then abandon them, litter, and worse... paint or scratch graffiti, pull apart masonry and dig into the furnace core. The post-abandonment archaeological deposit at the New Furnace affords a portrayal of visitors and vandals; what they did at the blast furnace and how they affected that record.

Early Souvenirs and Adaptive Reuse

Notably lacking from the assemblage are any hand tools or tools associated with smelting operations. An iron chisel was recovered from TU 6. Two ¾-inch diameter metal rods had been vertically placed near the hearth in a possible support capacity. Of course, the iron runner, more facility than tool, remains in place. Further, only several small fragments of iron pigs were recovered. Masten ([1923] 1968) suggested work at the furnace “was dropped just as it was”. His next statement was placed in unattributed quotes “The last cast from the furnace was still in the sand and the tools were left leaning against the walls of the cast house” (Manchester 2009, 125). The chisel from TU 6 was within the boundaries of the casting house but otherwise the hearth arch appears to have been stripped.

One can assume that Robert Hunter and succeeding caretakers may have made use of any tool or facility left behind but it appears the Club phase of occupation may have had a greater impact. Masten (1935, 17) notes several cottages contained pairs of tuyeres that were being used as andirons. The Museum survey of the National Register district found iron vents from the charcoal kiln being used as cellar air vents and as boat anchors. Excavations at the MacNaughton Cottage found stacked iron pigs used as joist supports under a porch. “E.L. & E.H. Farrar” fire bricks, imported for use at the New Furnace, are incorporated into various club cottages in Adirondac as well as in a fireplace in the eight bedroom Masten House built in 1905 (Staley 2004, 2006).

Drinking, Picnics and Camping

The interpretation of this assemblage as created in part by drinking, picnics and camping is strongly supported by the distribution of various artifact categories and by comparing the contents of this assemblage against assemblages at other sites. At a glance, the New Furnace assemblage of broken bottle glass, cans, ceramics, table glass, and bone might be categorized as a domestic dump or midden. A comparison with surface inventories of six domestic dumps of similar age in the immediate vicinity found all of the above items but also included greater amounts of stoneware jugs and crocks, decorated ceramics, metal pails and buckets, and a wide variety of cans. Completely absent from the blast furnace were cookware and metal hoops from kegs, casks, barrels and churns. Perhaps more significantly given their direct relationship to food storage, the assemblage lacked the assorted sauce bottles, food jars, and canning jars ubiquitous elsewhere.

Lossing’s drawing (Figure 7.5) portrays few and small windows in the superstructure and window glass is sparse and widespread in the archaeological record.



Figure 7.11. Trough feature. The iron trough carried the molten iron toward the casting house. Trough feature in foreground profile suggests the iron continued onto the casting floor in a sand channel. Note the single remaining vertical buckstay and the ironwork graffiti.

Figure 7.12. Stratigraphic complexity near hearth arch face wall. Note hardened iron in the iron trough.



Table 7.1. Artifact summary for North and East (Hearth) Arch, TU 6 and 7.

Unit	Level ¹	Total ²	Modern ³	Sherd	Frag.	Bottle Glass ⁴	Table Glass	Window Glass	Lamp Glass	Kaolin Pipe	Wire Nail	Cut Nail	Oth Nail	Bone	Kitchen Bone	Notable
East Arch ⁵	1	494	24	15	52	145 (27)	9	2	–	–	38	32	–	13	4	chisel
	2	981	8	36	59	199 (28)	9	6	11	–	193	63	1	83	12	
	3	48	–	2	–	3 (1?)	1	–	1	4	–	3	–	–	–	
	4	22	–	3	–	–	–	–	1	2	–	8	2	–	–	
	5	9	–	–	–	1	–	–	–	1	–	4	3	–	–	
North Arch ⁶	1	309	8	2	20	82 (53)	0	1	–	–	–	21	–	–	–	18 fix. Porc.
	2	139	–	–	–	11	–	–	–	3	–	20	1	–	–	
	3 and 4	57	–	–	–	–	–	–	–	2	–	16	–	–	–	ox shoe
TU 6 ⁷	1	7	–	–	–	7 (4)	–	–	–	–	–	–	–	–	–	
	2	39	–	–	–	6 (6)	–	–	–	–	–	20	–	–	4	chisel
	3	22	–	–	–	–	–	2	–	–	–	8	–	–	–	
	4	1	–	–	–	–	–	–	–	–	–	1	–	–	–	
	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	6	1	–	–	–	–	–	–	–	–	–	1	–	–	–	
TU 7 ⁸	1	193	3	–	–	124 (121)	–	8	–	–	1	38	2	–	–	tuyere
	2	9	–	–	–	11	–	4	–	–	–	–	–	–	–	

¹ The levels represent natural strata that do not have 1:1 relationship with levels as actually excavated.

² Total includes items not listed in the table such as brick, mortar, charcoal, wood, slag, scale, ore, unidentified iron, etc.

³ Modern items include foils, plastics, paper wrappers, light bulbs, twist off caps, etc. All likely associated with the last four decades.

⁴ Number in parentheses is modern or recent glass also likely from the last four decades.

⁵ Levels 1 and 2 are associated with abandonment and collapse, 1855-present; level 3 with a working period, 1854-1855; level 4 with post-construction and working, 1852-1854; and level 5 with early brickwork – construction, 1849-1852.

⁶ Level 1 is associated with abandonment and collapse, 1855-present; level 2 with a working period, 1854-1855; and levels 3 and 4 with post-construction and working, 1852-1854 and early brickwork – construction, 1849-1852, respectively.

⁷ Levels 1 and 2 are associated with abandonment and collapse, 1855-present; levels 3-5 with a working period, 1854-1855; and level 6 with construction, 1849-1854.

⁸ Level 1 is associated with abandonment and collapse, 1855-present; and level 2 with construction and working periods, 1849-1855.

Similarly, cut nails are concentrated in the upper levels yet found throughout the unit columns and found in nearly all areas. By contrast, wire nails, available and increasingly common well after abandonment, are limited to the upper levels and to the hearth arch. A small sample of fasteners evaluated for size indicated the cut nails ranged from 2.5 to 10 cm in length with the longer nails predominating, a pattern expected for structural framing. Wire nails fell in the same range but were characteristically 3.8 cm or shorter. This pattern suggests either the re-use of the collapsing building materials as “site furniture” or the use of crates and boxes in the larger arch.

The preference for the hearth arch by historic visitors is supported by the distribution of glass bottles, ceramics, cans and bone (Table 7.1). The greatest amount of broken bottle glass is found in the eastern arch. Not a single whole bottle was recovered and there were no large fragments. The bulk of the glass might generally date between 1880 and 1940. Fragments with applied lips, three-piece mold seams, and generally thicker glass with irregular thickness and air bubbles testify to the presence of earlier glass in the assemblage. Amethyst

glass suggests dates up to 1918 and an A.S. Hinds Honey-Almond Cream lotion bottle dates between 1916 and 1919. Codes embossed in bottle bases contribute dates of 1932 and a range date of 1940-1963. When standardized by excavated volume, modern glass is evenly distributed around the site (except for one location which will be addressed later in a discussion of vandalism).

The percentage of modern to total glass is reduced to less than 20 percent in the eastern arch compared to greater than 57 percent in all other levels elsewhere. An analysis of minimum number of individual (MNI) bottles produced counts of five in the north arch, four in TU 6 in the area of the casting house, seven in TU 7 west of the furnace, and 23 bottles in the hearth arch. The function of some of the bottles can be interpreted from the bottle morphology and labeling. Conservatively, a beer bottle is represented in the north arch; a beer and soda are in TU 6, liquor, soda, and three beer bottles in TU 7. The eastern arch assemblage represents two beers, two sodas, three liquor, five patent medicine bottles including one with a pharmacy lip, and a lotion bottle. To be certain, by itself, the presence of bottle glass only



Figure 7.13. Hand-painted porcelain from Test Unit 2, Level 2 in the working arch.

suggests beverage consumption and container breakage. Evidence for this behavior is found throughout the site and for all periods but greater amounts of older glass is found in the eastern arch. Other artifact classes contribute to the interpretation of picnics and possible camping.

Bits and pieces of cans are so deteriorated that size grading is futile and several fragments suggest the only shape was cylindrical. Fragmentary grey salt-glazed stoneware at the site was largely concentrated in the hearth arch. Several fragments include blue decorations. The sole functional clue is a single jug neck found in the north arch. Ceramic tableware is limited to fragments of thick, undecorated, 'hotel-style', ironstone/whiteware flatware and both undecorated and handpainted porcelain hollowware (Figure 7.13). Additionally, fragments of clear table glass such as a faceted tumbler, a fluted goblet, a possible fluted bowl, a plain bowl, and a single fragment of milk-colored table glass contributed to the overall place setting.

Other than modern wrappers and foils, the evidence for food is limited to bone. All of the unidentified and fragmentary bone and nearly all kitchen bone (cut or saw marked) were recovered from the hearth arch. A closer, yet admittedly cursory, evaluation finds interesting patterns. No significant portions of a whole ani-

mal were present except for a set of squirrel-sized rodent bones. Possible wild game represented includes portions of a turkey wing, a rabbit leg, and a very large fish. The remainder includes chicken wings, beef ribs, large mammal ribs, a sawn long bone resembling a ham steak, cut vertebrae of calf and possibly pig suggesting veal and pork chops, medium-sized mammal phalanges and a cut medium-large mammal scapula suggesting a roast. Other than the toe bones and the scapula, this assemblage represents a wide variety of portable and relatively fast cooking wings, small legs, steaks, chops, and ribs.

Much of the sedimentary matrix of the furnace includes the charcoal integral to the blast process. In the absence of a stone fire ring, therefore, a charcoal concentration and or burned and oxidized sediments are not particularly distinctive markers for a hearth. As a proxy, the distribution of all melted, burned, or crazed glass (27), ceramics (10), and bone (5) were plotted and found to be confined to the centrally-located and contiguous TUs 2, 4, and 5 suggesting camp fires were built upon the floor of the eastern arch.

Several artifacts conceivably could be associated with historic or more recent camping activities and others are merely curious finds in the setting of a nineteenth century blast furnace. Fragments of clear lamp or lantern glass (11) were found in the same central location as the burned artifacts used as a proxy for a camp hearth. The same area produced a battery carbon rod, the tips of two wooden stakes or posts, and a large grommet, like that from a tarp. Odd, yet potentially useful in camp, were two metal coat hooks. Sometime after 1904, a visitor lost a promotional lapel pin from Swift's Golden West Fatted Fowl (Figure 7.14). More recent visitors left electrical tape and duct tape fragments. A fragment of window screen remains a source of puzzlement.

The eastern or hearth arch appears preferred for picnics and camping. The brick arched space is larger and deeper than the other arches. It is exposed to the eastern skies and is open and less claustrophobic, lacking the stone retaining wall that wraps around the three uphill sides. The same openness and size could be a detriment if looking for shelter from harsh weather. However, the hearth arch is closest to water and provides greater visual privacy from the road.

Photography

Another activity documented in the archaeological record is photography. Small light bulb bases and bulb fragments were found near the core and at the mouth of the hearth arch. A Sylvania Blue Dot Magicube (post-1966) marks that activity near the tuyere opening in the northern arch.

Figure 7.14. Promotional lapel pin “Swift’s Golden West Fatted Fowl” ca. 1904 from Test Unit 2, Level 2 in the working arch.



VANDALS

Visitation becomes vandalism when the historic resource is intentionally and willfully damaged. The mixing of artifacts between levels is particularly thorough in TU 8 and less so in TUs 1 and 5. As mentioned previously in the stratigraphy section, some of this is the result of the rapid outflow of materials from the stack as seen in the hearth arch and in the northern arch. Greater churning is likely related to the attempts of vandals to reach the core which has also resulted in the disassembly of the brick facings and the removal of the sloped sands away from the openings.

The best evidence for this type of disturbance is illustrated in a sequence of photographs at the furnace. A photo taken in 1945 shows all layers of the brick arch intact all the way to the outer edge. The buckstays are in place and the brick facing solid (Seely 1981, 37). Thirty years later the outer rows of brick arch had collapsed, as had some of the hearth facing (Figure 7.15 Hay 1978). The buckstays remained upright and stack fill tailings banked against the facing. Away from the face, the floor was level from wall to wall. Another jump of twenty five years finds these tailings had been removed, exposing lower sections of the wall (Figure 7.16). The spoils had been moved to the arch sides. More brick is missing from the facing and only a single buckstay remains. A photographic series from the southern arch also shows drastically different surface contours and the impact of digging (Figures 7.17 and 7.18). In contrast, the northern and western arches feature the core fill spoils against the tuyere face but have a relatively flat grade from wall to wall and from the toe of the tailings to the mouth (Figure 7.19).

The same sequence of photography also documents the constant and ever changing graffiti. The names and

prose are typically displayed on the cast iron components in the arch faces. Rapid turnover occurred even between 2003 and 2006. By 2006, one “artist” had gone one step further by chaining and padlocking a large set of torch-cut stylized initials of iron to the remaining buckstay.

The 1978 documentation of the furnace recorded the presence of the cast iron, hydraulically-cooled tymplate in the hearth arch. By 2006, this massive, extremely heavy object had been transported across the area of the casting shed and tumbled down the embankment toward the Hudson River thereby illustrating the determination and dedication of vandals.

The environmental movement of the 1970s has shifted the collective mindset of society. Great strides have been made in changing perspectives about litter and recycling (Hays 1981; Clay 1989; Carlson 2001). New York State’s original bottle bill, creating the returnable bottle, dates to 1982 (Quade 1982). The dumping of empty bottles might be considered a wasteful, deplorable and perhaps illegal act, smashing the bottles, especially on a historic site, tends much closer to vandalism. Previous discussions of broken glass at this site mentioned that modern glass, when standardized for excavated volume tended to be equally distributed in nearly all excavation units. That standardized measure ranges between 30 and 40 fragments per cubic meter. On the western side of the furnace, adjacent to the road and down into the space created by a retaining wall, TU 7 contained a whopping 598 shards of modern glass per cubic meter. Modern glass represented 98 percent of all glass in that unit. By contrast, in the north arch also down below the retaining wall, the percentage of modern glass was 65 percent.

Acts of vandalism such as breaking bottles occur in brief instances; the greater exposure and visibility do not deter vandals probably because of the overall isolation



Figure 7.15. Eastern arch (Photo Jet Lowe [HAER 1978](#)). Photo shows the condition of the site in 1978 with both buckstays in place, vertical crossbars and bricks intact, and the general configuration of the ground surface in the arch.

Figure 7.16. Eastern arch (Photo Charles Vandrei, DEC 2003). Twenty five years later the arch face is deteriorated, buckstay missing, and the soils are banked against the side walls.



Figure 7.17. Southern arch (Photo Jet Lowe, HAER 1978). Note the brick dominated even slope.



Figure 7.18. Southern arch (Photo Charles Vandrei, DEC 2003). Now much of the brick face is gone and the irregular arch surface is covered with fine soils.



Figure 7.19. Northern arch pre-excavation.

of the location. The act can be committed even while driving by. The advantage of the overlooking wall provides a near certain target wall on the opposite side and a clear and protracted view of the spray of smashing glass. Notably, it seems other acts such as writing or drawing graffiti and especially digging and masonry destruction, occur in the more secluded southern and eastern arches.

Lastly, a curious and puzzling form of vandalism observed at the furnace again illustrates a phenomenal effort. Upper level deposits near the core of the furnace in the north arch contained 18 fragments of some form of institutional porcelain; a toilet, sink, urinal, or tub. Either the porcelain was lugged down the hill around the retaining wall and pitched into the depths of that arch or, more incredibly, climbers hauled the porcelain the top of the furnace and dropped it down the stack.

DISCUSSION AND CONCLUSIONS

Site history, variations in accessibility, and changes in the form of stewardship may have conditioned these deposits. After abandonment, the property was under the stewardship of a single family, left by the company to be caretakers of the village and the company facilities. Visitation until 1877 was likely limited and controlled. Little in the New Furnace assemblage can be attributed to this phase. The club occupation and control of the property was radically different. Control of usage was collective, especially during the summer season, when the old village was occupied by 20 affluent families. During the off seasons, the club membership placed the property back under the control of a single innkeeper/caretaker.

The bulk of the post-abandonment assemblage can be attributed to the Club phase between 1880 and 1940. During the next phase, N.L. Industries used the village for year-round housing for 20 families. Although the year-round population in the area increased, land-use control or stewardship was corporate and the village population was working class. The company posted the property and surrounded the furnace with barbed wire but did not actively enforce its policy. Children were not known to have played at the site and no camping was observed there during that time.

Although the trailheads further up the road were established, few made use of them (George Cannon, personal communication 2011). Other than a few bottles with “Duraglass” on their bases or “No Deposit No Return” embossing, there are few items suggesting visitation during the 1947 to 1964 period. Of course, this corporate stewardship continued to the 1980s and there are numerous items that could belong to this later part of N.L. Industries stewardship. Much of the vandalism such as smashing bottle glass and more significantly, the impacts to masonry walls and digging has occurred since 1978. During HAER recordation, site visitation sometimes reached 50 people per day (Hay 1978). The popularity of High Peaks trailheads doubled between 1985 and 1995. Trailhead registers provide conservative estimates of use. In 1988, 3,639 registered hikers began their hikes from the Upper Works trailhead. A decade later, 6,050 hikers logged in at the register (New York State Department of Environmental Conservation [DEC] 1999). There are no designated caretakers and no one resides anywhere near the furnace. Stewardship has

fallen to the current owners, the privately-funded collective organization, OSI, and to the DEC. The archaeological record suggests significant differences in the type and amount of visitation and vandalism depend upon the amount of traffic or people near the site and the form of stewardship.

Visitors and vandals have been attracted to the New Furnace for over 150 years, contributing artifacts and affecting all previous remains. The volume of artifacts associated with visitation vastly overwhelms those associated with the construction and operations at the furnace. Drinking, picnicking, camping, and photography have been documented. These activities are represented in an archaeological palimpsest where repeated visits have created a blended deposit. Evidence for vandalism is present at the site in the form of greater stratigraphic mixing in some locations, mounds and pits from people digging into the core, massive components moved or missing, and broken glass. Archaeological investigations at New Furnace have revealed some of the effects of visitation since the furnace fires were extinguished. Hopefully, knowing something about the visitation and vandalism will contribute to the long-term protection and management of this important cultural resource.

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REFERENCES

- Burroughs, J. 1899. *Wake-Robin*. Boston: Houghlin, Mifflin / Company. (Cited on page 131).
- Carlson, A. E. 2001. "Recycling norms." *California Law Review* 89 (5): 1231–1300. (Cited on page 139).
- Clay, J. A. 1989. "The DC Bottle Bill initiative: a casualty of the Reagan era." *Environmental History Review* 13 (2): 17–31. (Cited on page 139).
- Hay, D. 1978. "Recommendations for Stabilization and Preservation of the McIntyre Ironworks Historic Site, Tahawus, New York." In *Annals of the Deserted Village: Key 20th Century Studies of an Emblematic Adirondack Settlement*, edited by L. Manchester, 584–597. (Cited on pages 139, 142).
- Haynes, W. 1994. "Documentation Report: Upper Works, Adirondack Iron and Steel Company, Newcomb, Essex County, New York. Preservation League of New York State, Albany. Submitted to Town of Newcomb Historical Society. New York State Council on the Arts." In *Annals of the Deserted Village: Key 20th Century Studies of an Emblematic Adirondack Settlement*, edited by L. Manchester. (Cited on pages 126, 130, 131).
- Hays, S. P. 1981. "The Environmental Movement." *Journal of Forest History* 25 (4): 219–221. <http://www.jstor.org/stable/4004614>. (Cited on page 139).
- Hochschild, H. K. 1962. *The MacIntyre Mine: From Failure to Fortune*. Blue Mountain Lake, NY: The Adirondack Museum. (Cited on pages 126, 131).
- Lossing, B. J. 1866. *The Hudson, from the wilderness to the sea*. New York: Virue & Yorston. (Cited on page 131).
- Manchester, L., ed. 2007. *Tales from a Deserted Village: First-Hand Accounts of Early Explorations into the Heart of the Adirondacks*. (Cited on page 126).
- , ed. 2009. *Annals of the Deserted Village: Key 20th Century Studies of an Emblematic Adirondack Settlement*. Accessed Feb. 14, 2012. <http://www.wagner.edu/media/AnnalsOfTheDesertedVillage>. (Cited on pages 126, 131, 135).
- Masten, A. H. (1923) 1968. *The Story of Adirondac*. Reprint, Syracuse: Syracuse University Press. (Cited on pages 126, 131, 135).
- . 1935. *The Tahawus Club 1898-1933*. Burlington, Vermont: Free Press Interstate Print Co. (Cited on pages 126, 131, 135).
- Quade, V. 1982. "Bottle Bills Advance... Little by Little." *American Bar Association Journal* 68 (9): 1073–1074. (Cited on page 139).
- Richards, T. A. 1859. "The Adirondack Woods and Waters: A Forest Story." *Harper's New Monthly Magazine* XIX:454–466. (Cited on page 131).
- Seely, B. E. 1978. *Adirondack Iron and Steel Company: "New Furnace", 1849-1854*. Historic American Engineering Record NY-123. Washington, DC: Department of the Interior, Heritage Conservation and Recreation Service. Accessed July 9, 2012. <http://lcweb2.loc.gov/pnp/habshaer/ny/ny0900/ny0915/data/ny0915data.pdf>. (Cited on pages 126, 129–131).
- . 1981. "Blast Furnace Technology in the Mid-19th Century: A Case Study of the Adirondack Iron and Steel Company." *The Journal of the Society for Industrial Archeology* 7 (1): 27–54. (Cited on pages 130, 139).
- Staley, D. P. 2004. *Seeing the Furnace for the Trees: Archaeological Reconnaissance Survey of the Adirondack Iron and Steel Company's Upper Works*. Town of Newcomb, Essex County, New York. Technical report. Albany, New York: New

York State Department of Environmental Conservation and the Open Space Institute. (Cited on pages 131, 135).

———. 2006. *Excavations at the MacNaughton Cabin and MacIntyre Blast Furnace Sites, Town of Newcomb, Essex County, New York*. Letter Report. (Cited on pages 132, 135).

Staley, D. P. 2007. *The Construction, Use, and Dissolution of the Adirondack Iron and Steel Company's New Furnace*. Paper presented to the Council for Northeast Historical Archaeology Annual Conference, October 26-28. Buffalo, New York. (Cited on page 132).

Stoddard, S. R. 1874. *The Adirondacks, Illustrated*. Albany: Weed, Parsons & Co. (Cited on page 131).

HAER. *The Adirondack Iron & Steel Company, New Furnace, Hudson River, Tahawus, Essex County, NY*. 1978. Historic American Engineering Record NY-123. Washington, DC: Department of the Interior, Heritage Conservation and Recreation Service. Accessed July 9, 2012. <http://www.loc.gov/pictures/item/ny0915/>. (Cited on pages 128, 129, 131, 140).

Youngken, R. 1977. *Field Maps of the Village of Adirondac and the Upper Works of the Adirondack Iron and Steel Company: Maps on file at the Adirondack Museum Library, Blue Mountain Lake, New York*. Blue Mountain Lake, NY: Adirondack Museum. (Cited on page 131).

MODELING THE PAST

Using Working Models to Reconstruct the Logic Behind the Development of Henry Burden's Revolutionary Automatic Horseshoe Machine

Robert Rawls

Until the Bessemer Process provided a means of producing large quantities of cheap steel just after the Civil War, the material of choice for all iron products that required resilience and flexibility was wrought iron. Its layered structure gave it a toughness and ductility lacked by cast iron, and it remained the preferred material for certain applications well into the twentieth century despite the availability of relatively cheap steel. The Burden Iron Works of Troy, New York (Figure 8.1) was a major producer of wrought iron and manufactured a large variety of wrought iron products until fading demand for that material resulted in the company's closure and eventual liquidation in 1940 (Rezneck 1969).

The company's founder, Henry Burden, was a brilliant designer of machines. During his lifetime, he received a total of fifteen patents, some of which were among the most important of the 19th century iron industry. His most influential invention for the industry in general was the "rotary concentric squeezer," an astonishingly simple device that revolutionized the production of wrought iron worldwide and remained an essential part of wrought iron production until the end of the industry in the early 20th century. The Commissioner of Patents declared Burden's squeezer to be the first truly original and most important invention in the manufacture of iron known up to that time (Proudfit 1904, 66). His invention of a machine to make the "hook-headed" railroad spike was almost as important to the railroad industry, allowing mass production of the spike that became the industry standard after the introduction of modern rail and is still ubiquitous on railroads around the world.

During the 19th century, though, the invention for which he was best known to the public was undoubtedly his automatic horseshoe making machine, which had changed the production of horseshoes from one at a time hand production to mass production of enormous numbers of shoes in standard sizes. By 1859, each machine was said to be capable of turning out horseshoes at the rate of one per second, and by the opening of the American Civil War he had five of them in operation. It

is difficult to imagine the importance of this invention today, in a world where horses are no longer commonplace, but in the 19th century the impact of this machine was tremendous. While Burden was not the first inventor to obtain a patent for machine-made horseshoes, he managed his patents brilliantly, eventually becoming the major supplier of horseshoes (approximately 90%) to the Union Army during the Civil War (Gates 1981, 18).

THE HORSESHOE MACHINE MODEL PROJECT

My project began in 1998 when I attended a lecture titled "The Origin of the Modern Horseshoe" by Dr. P. Thomas Carroll at the Burden Ironworks Museum in Troy. I had shod horses in the past and wanted to know how the shoes were made. Near the end of the lecture someone else asked that very question: "How did they make the horseshoes?"

Dr. Carroll explained that he didn't know how the machines worked; that the last horseshoe machines had been dismantled and sold during the scrap drives of World War II. I felt badly that we had lost such an important piece of the history of technology and thought I would try to solve the mystery of how the horseshoes were made. I spoke with Dr. Carroll afterwards, and being a machinist by trade, I rushed home and immediately went to work. I cleaned off the table, set out my graph paper, sharpened my pencils and stared at the paper, but I didn't know where to begin. I had never seen a horseshoe being made!

For a few months, I thought I had given up the project, but I still thought about the horseshoe machines every now and then. One day I was in a used bookstore browsing through Civil War magazines, and was amazed to find an article on Henry Burden and his horseshoe machines. The best part was that there were engravings of one of the machines. My Dad always told me "things happen for a reason." When I found that magazine article, I knew he was right. I was very excited, but also apprehensive because this meant that now I really was going to have to figure out how Burden made the horseshoes, and I knew it would take a lot of time. Little did I know how much time it would really take!

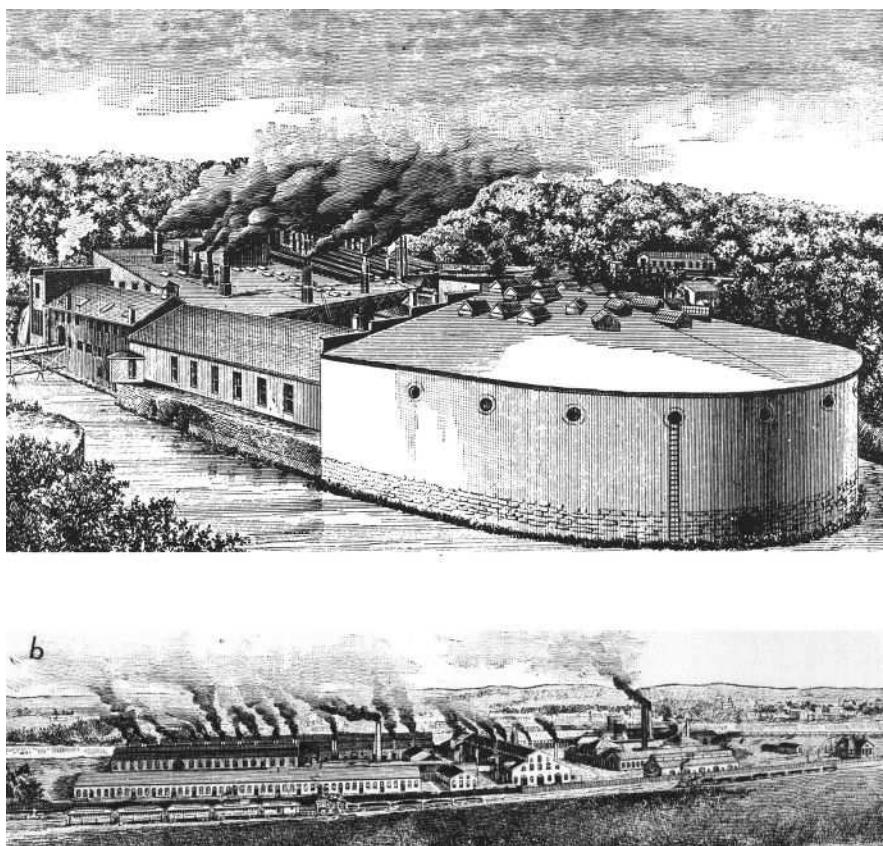


Figure 8.1. The two locations of the Burden Iron Works in Troy, as they appeared in 1886. The “lower works” (bottom image) were located along the east side of the Hudson River (in the background). They manufactured a wide range of products and included the twin blast furnaces that produced the iron used in Burden’s products. The office building, the small building furthest to the right, now houses the Burden Ironworks Museum. The “upper works” (top image) was located on the Wynantskill Creek a short distance east of the lower works and was primarily dedicated to the manufacture of horseshoes. The round building in the foreground was a storage facility for finished horseshoes (Weise 1886, 42,44; reprinted in Vogel 1973).

Again, I rushed home, cleaned off the table, took out the graph paper, and sharpened my pencils. I made cardboard gears and used aluminum foil for horseshoe stock. I remembered from the lecture that the machine had made a horseshoe “in just a second,” but no matter how I positioned the aluminum stock or moved the cardboard gears, mechanically it did not seem feasible. I kept working, eventually learning that this was because the print was not for the machine in the lecture but for Burden’s earlier 1843 machine, which only performed part of the process.

I am not sure why it was so important to me to learn how the machines worked. It just was. I have always wanted to know how things work; what makes them tick. In that, I have something in common with some great American inventors like Eli Whitney and Thomas Blanchard: we all began by taking our fathers’ watches apart. Unlike Whitney and Blanchard, though, I could not put my father’s watch back together. I still remember going to him with both hands cupped full of parts.

Later in the year, I received a telephone call from the Burden Museum informing me that the museum had obtained a copy of the patent for Burden’s horseshoe machine. I went to get a copy of it and found that it was hand-written in old-fashioned script. I took me almost one hundred hours to decipher the written text. I was having trouble reading and understanding various words and sentences in the hand-written document,

particularly the wording used to describe the parts and functions, but once I became acquainted with the terminology used in the early 1800s it became much easier to understand.

After researching the nature of patent records and documents, I learned that in order to obtain a patent the description had to be complete enough that a person could use it to construct and operate the device to be patented. Still, I was having trouble understanding from the description and drawings how the machines were constructed and the horseshoes formed. For instance, the description gave only one dimension, for a pulley 4 feet in diameter. The language of the patent, though, gave me a challenge: Henry Burden stated that it would be possible for “any person at all conversant with mechanics to construct and operate my horseshoe machine (Burden 1835).” I came to realize the only way to understand it was to build a working model. This article is the result of what I learned from doing that.

PRODUCTION OF THE WROUGHT IRON USED IN BURDEN’S HORSESHOES

Before I discuss Henry Burden’s process for making horseshoes it is important to explain how the wrought iron stock used in the machines was produced. Burden did not use steel for any of his products. Instead, he chose to work exclusively with wrought iron produced

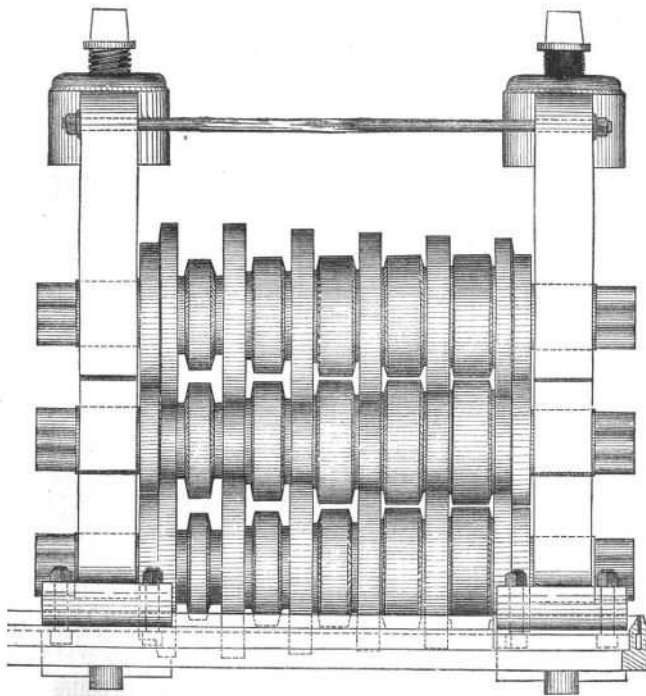


Figure 8.2. Rolls for shaping and sizing bars of wrought iron (Beach 1873, 202).

at the works. Pig iron produced in the blast furnaces at the Lower Works was melted in a reverberatory or “puddling” furnace. The resulting 150-200 lb. “puddle ball” was transferred hot by means of a small iron buggy to the rotary concentric squeezer, Burden’s innovation that took the place of the traditional tilt-hammer for forging the puddle ball into “blooms,” or squared bars of wrought iron.

The compact blooms were then rolled through a set of revolving rollers, placed one above the other (Figure 8.2), with grooves of various sizes. They were then rolled forwards and backwards until they were shaped into long bars of crude wrought iron. The iron used by Burden for his horseshoes was his best quality “Refined American Iron,” designated “number three iron.”

When the bars were cool, they were carefully tested for toughness and ductility. This was done by placing one end against an anvil and cutting a nick on one side with a cold chisel. The wrought iron bar was then bent down and struck with a sledgehammer. If the iron were bad or “cold-short,” it would break and show a bright, crystallized fracture. However, if the uncut part bent back and had the appearance of a bundle of silky looking fibers, the iron would probably stand the test of bending it double while at a cherry red heat. If the iron did not crack from these tests, it was neither “cold-short” (brittle when cold) nor “red-short” (brittle when hot) but of a good, tough quality (Hebert 1836, 778,779). After being classified, the bars were sorted into groups and moved to a large shear to be cut into pieces approximately 3 feet

long. A bundle of these pieces, called a pile, was returned to the furnace. After the proper heat was reached, the pile was returned to the rollers and rolled in to narrow bars of stock. The wrought iron was now ready to be swaged into horseshoes (Proudfit 1904, 75).

MODELING THE 1835 PATENT

In 1834, after years of study and experimentation, Henry Burden set up his first horseshoe machine, for which he received a patent in 1835. Burden’s copy of the original is in the collection of the Burden Iron Works Museum in Troy, N.Y. It is recorded as U.S. Patent No. 9,250 X, the “X” designating a patent reissued after the Patent Office fire of 1836. Under this patent, three machines were used to perform the individual steps in the process of making horseshoes. The first machine cut the wrought iron bar to length and swaged it. (*Swaging* is the process of shaping metal by pressing or rubbing.) The cut-off and swaged section was then returned to the furnace to be reheated, then was grooved and punched by the second machine. The bar was again returned to the heating furnace prior to being placed into the third machine for shaping into horseshoes.

Drawings of the machines accompany the patent description. The machines that performed the first and second parts of the three-part process (Figures 8.3 and 8.4) were constructed to the same plans and specifications, and were identical to one another except that the vertical dies (Figure 8.3 yellow, labeled “No. 2 Figure 1, 2 and 3” and “No. 1 Figure 2”) were set up differently, using different top vertical dies for each of the two processes. The top die for Machine #1 was designed to roll or flatten only the middle of the stock, leaving the ends square for the heels of the shoe, and also swaged the bottom of the shoe (the surface that went towards the ground or pavement). The top vertical die of Machine #2, however, was designed to groove the shoe-blank and punch the nail holes. The depth of the horseshoe nail holes was adjusted by four screws on the dies. The bottom vertical dies of both machines #1 and #2 were identical and swaged the top of the horseshoe (the surface that went against the horse’s hoof).

The swaging dies were made of white cast iron or other previously rolled or hammered iron, and formed by laying out the design on the rough blank and grinding and hand-filing it to shape. Burden did not use solid dies, but make them of individual sections so that they could be adjusted for the size of the horseshoe being swaged, and so that when they became worn they could be removed, reworked and placed back in service (Burden 1835). A solid die, when worn, would have to be taken out of service and discarded, or perhaps reworked for a smaller size shoe.

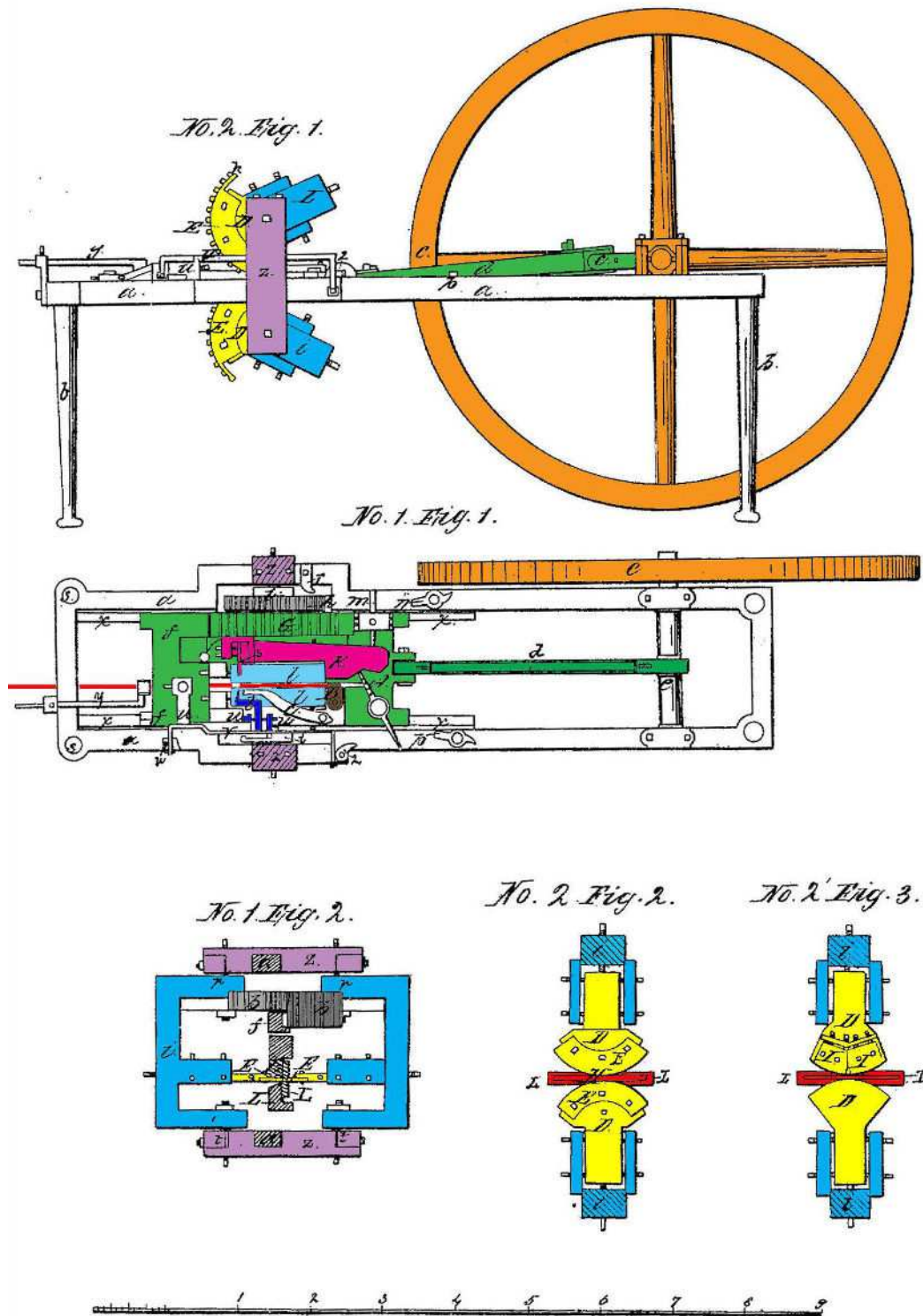


Figure 8.3. Machines No. 1 and 2 of the 1835 patent were both constructed as shown here in the patent drawings, color coded by the author for clarity. The reciprocating motion that drove the mechanism was imparted by the large flywheel (orange) through a connecting rod attached to a sliding frame (green). This frame had a rack of teeth driving two intermeshing gears (light grey and dark grey) to rock the frames (blue) to which the swages or dies (yellow) were bolted. The top vertical dies were the only part that differed between the first and second machines. The the cutter (No. 1 Fig. 1 dark blue) cut the stock (red) to length, and the side steels (light blue) on the sliding frame clamped and held the blank as it passed between the swages (where it is shown in red) and dropped it from the bottom of the machine when it was finished (after the patent drawings in Burden 1835).

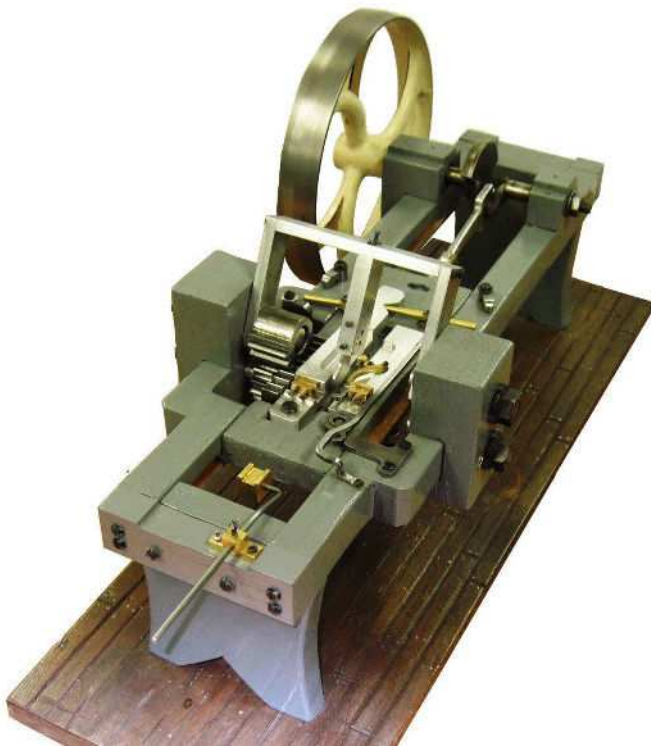


Figure 8.4. Working model of the machine for processes 1 and 2.

The model of the first machine, which could perform either the forming and cutoff of the stock or the creasing and punching of the resulting blank, depending upon how it was set up, was extremely difficult to build. It took months of study to be able to partially understand the drawings. Sometimes Burden's wording was very difficult. For instance, he used the terms "dies," "swages," and "segment-swages" in different places to describe the same object. I enlarged the drawings and, using an old toolmakers kink, I color coded the patent drawings as shown in the figures for this article. This really helped in understanding the machines, but I still had to build the model carefully step by step, one section at a time.

The bottom dies (Figure 8.3, yellow), which were the same for both machines, and the top die of the first machine (also yellow), were usually made of cast iron but could be replaced with steel. Burden described making the top creasing and punching die in this way:

I take piece of cast or other steel, previously rolled or hammered to about one fourth of an inch in thickness, about four inches wide, and as long as necessary to form the groove on one side of the shoe. I then grind or reduce the edge by a file to the proper shape to form the groove, then mark off where I want the projections or punches, filing down the spaces between the projection [sic] so as to give them

sufficient length to form the holes, which adds great strength to the punches compared to the method of inserting small pieces of steel into a roller to form punches as has been proposed, although I believe never carried into effect from its impracticability [sic] (Burden 1835)

Two pieces of cast or other steel were required to make one die. The reciprocating motion of the moving frame (Figure 8.3 green) provided the movement for the upper and lower swaging dies (yellow) through the frames (blue). The dies did not make a complete revolution, but rocked back and forth. A picture of the finished working model appears in Figure 8.4, with a link to a video showing it in operation.

The machine for the third process (Figure 8.5 and fig:Rawls06) turned the swaged wrought iron bar into a horseshoe shape. On the patent drawings I noticed what I considered to be a similarity of the horseshoe turning mechanism, at the center of its rotation, to a three-roll machine then commonly used to roll metal cylinders. This is typical of the development of such complex machine processes, in that they were often created by adapting processes from other applications. Burden had worked from 1831 to 1833 under Superintendent Roswell Lee of the Springfield Armory, to develop a process for rolling "skelps," pieces of wrought iron 14 inches long, 5½ inches wide and ⅝ inches thick, into rifle barrels (Benton 1862, 321,322; Deyrup 1948, 151-152). This experience may have inspired his design of the horseshoe swaging dies.

Although the different sections of the drawings were very difficult to comprehend, especially those of the first and second machines, I had a basic idea of how the third machine, for turning the wrought iron bar into a horseshoe shape, was built and operated. After studying the drawings and patent letters, I started to make plans to build a working model of it. For the shoe to turn correctly, Burden described turning the horseshoe on the pitch line of the gears (Figure 8.7). Because the horseshoe was not a perfect circle, for it to turn correctly the horseshoe dies had to turn eccentrically to one another so that the pitch line of the dies would describe the same curve as the horseshoe. The pitch line I calculated from the gears I had on hand in my shop dictated the size of the models.

The first problem I encountered was how to produce a reciprocating movement for the model. One day leaving my garage, I noticed an old hand grinder on the floor. This was how I could create the reciprocating movement. To create enough torque, I removed the grinding wheel and attached the grinder handle on the shaft. Where the handle had been, I attached a small wheel with a connecting link attached to the rack gear.

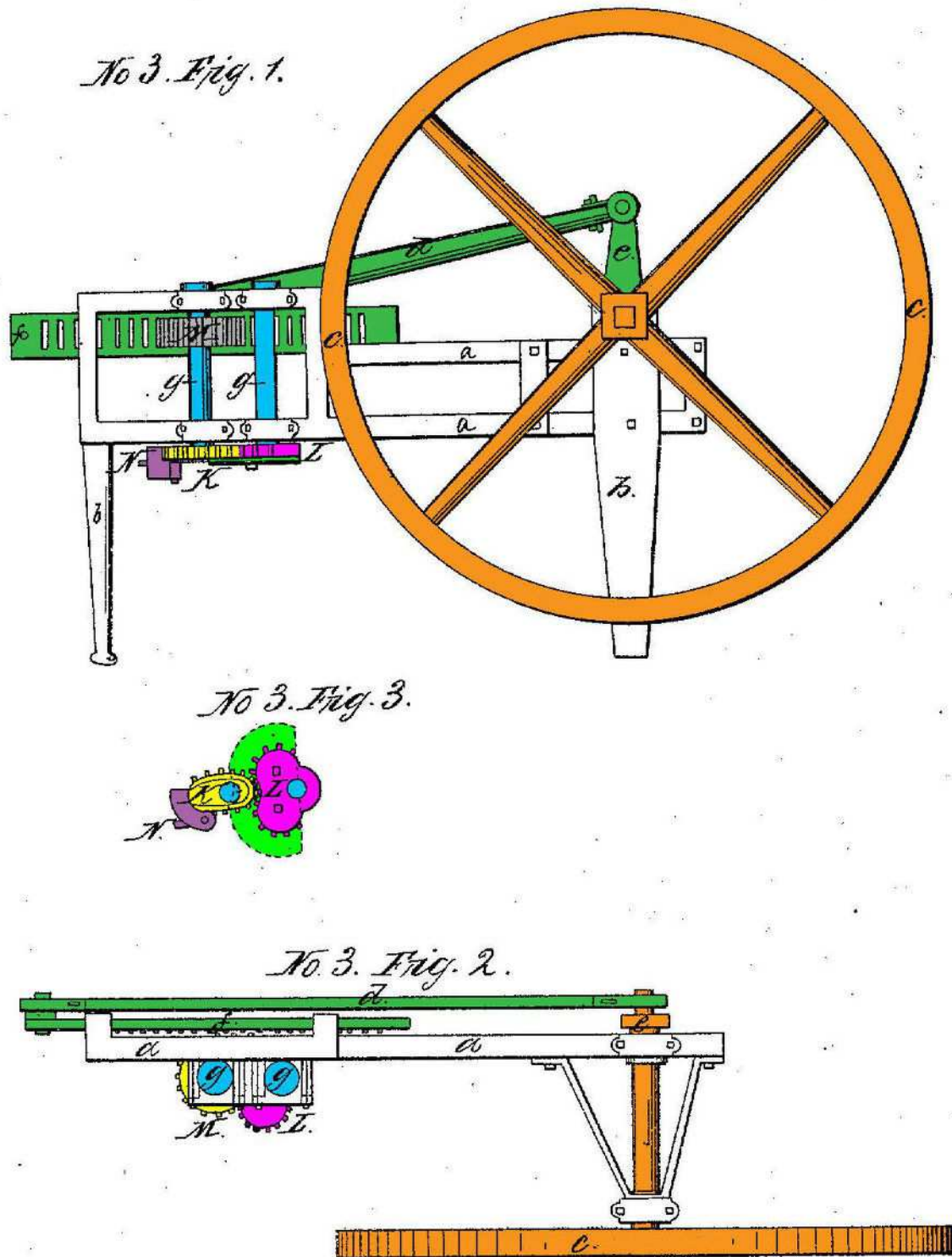


Figure 8.5. The machine for the third process, which turned the shoes into a "horseshoe" shape. No. 3 fig. 1 is a side view of the machine with the bending device underneath (magenta and yellow). The assembly labeled "No. 3. Fig.3," at center, is a bottom view of the bending device. As in Machines #1 and #2, the flywheel (orange) provides power to the crank and connecting rod, which power a sliding gear rack (green). The rack engages a gear (grey) which powers the bending assembly through two vertical shafts (blue). The eccentric gears and bending swages (magenta and yellow) bend the previously swaged and reheated blank into a horseshoe. A plate (light green) supports the shoe in the bending device until it is finished, then allows it to fall to the floor (after the patent drawings in Burden 1835).

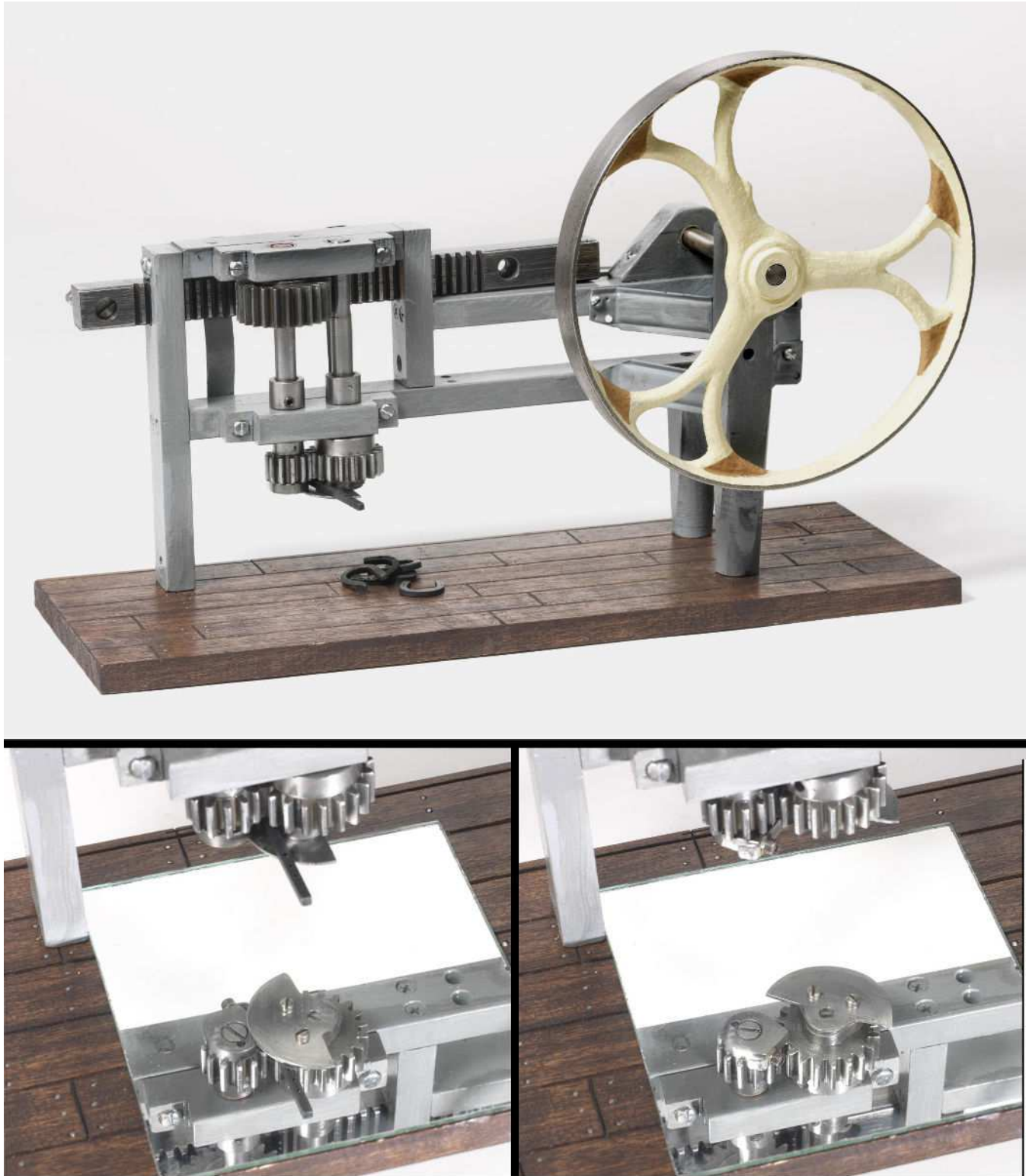


Figure 8.6. Model of the machine for the third process, made according to the patent drawings and specifications. Top: view of the machine with a prepared horseshoe blank inserted prior to bending. Finished shoes are visible where they have dropped from the machine. Lower left: Underside of the machine with a mirror showing the blank in place ready for bending. Lower right: Underside with mirror showing the bending mechanism open after the completed shoe had dropped from the machine.

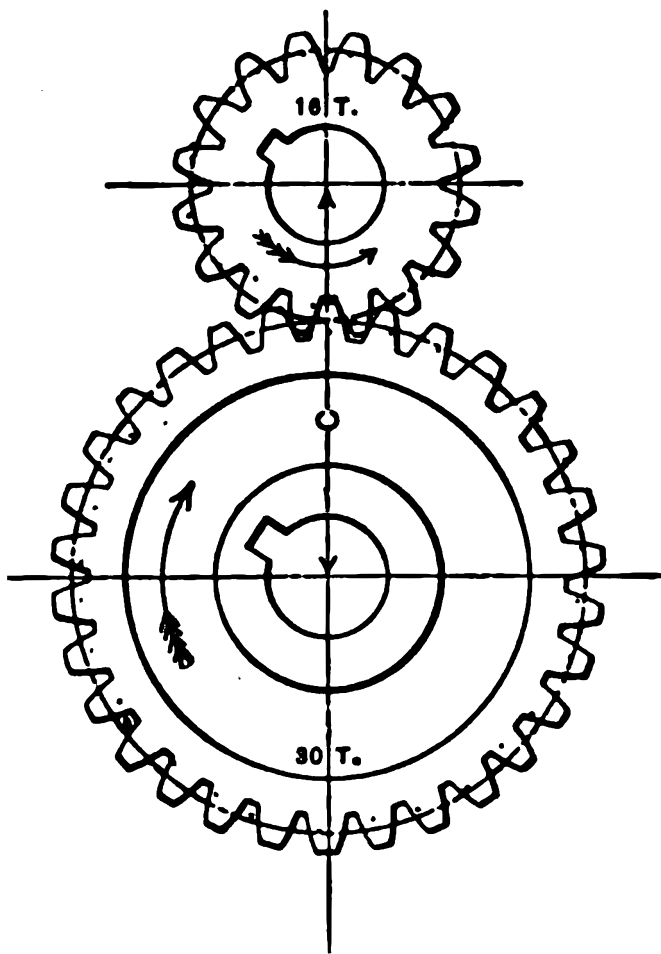


Figure 8.7. Pitch line between a 16 tooth and a 30 tooth gear. This is an imaginary line between two intermeshing gears, along which the surfaces of the teeth move at the same rolling velocity as if the gears were two smooth rollers turning together. The basic principle of designing gears involves drawing two such smooth rollers touching each other at this line and then drawing the gear teeth to connect them, as is shown here (Orberg 1915).

I was at first uncertain about the placement of the “U” or horseshoe shaping dies (Figure 8.5, center, labeled “No. 3 Fig. 3”). The dies of machine #3 had to be positioned on either a vertical or horizontal axis, but it was at first unclear to me from the drawings which was intended. I decided to build the machine with the “U”-turning die on a horizontal axis. There seemed to be many reasons at the time, but one of the main reasons I chose the horizontal axis was simply that it would be easier to build.

Studying the patent and drawings took a tremendous amount of time, but actually building the model required only around 40 hours. After a few setbacks, I was ready to try my horseshoe machine. The model was crudely built and I really didn’t think that it would work, but I was amazed to find that I was able to make a horseshoe from $\frac{1}{8}$ inch steel bar stock! I was so excited that, after that, if it was a piece of iron in my shop and it did not move, it became a horseshoe.

The first horseshoes I made were in a simple “U” shape, not like a formed horseshoe. Not finding any reference to the forming of the shoe heels, I concluded that after the horseshoe was swaged, a worker manually turned the heels of the shoes inward. In my 2005 article on Henry Burden’s 1835 horseshoe machines (Rawls

2005), I surmised that the last manual operation was to turn the end of the horseshoe inward though that was not specified in the patent.

About two years later, I purchased a two-volume set of Appleton’s Dictionary of Mechanics, which included a printed copy of Henry Burden’s 1835 horseshoe machine patent and drawings (Byrne 1852, vol. 2, pp. 11-14). This was much easier to read than the hand-written original. I compared the specifications given in Appleton’s to my transcription of the original patent. I made a few minor corrections, but did not find any significant differences. A few weeks later, I decided to read Appleton’s version of the patent one last time. At the final paragraph, I stopped after the first sentence. Suddenly, in my mind’s eye, I could visualize the complete machine for turning the horseshoe into the U shape. I had been wrong.

The machine indeed turned the finished horseshoe with swaged heels inward. Burden had used a vertical axis to swage the shoes. With a vertical axis the perfectly formed horseshoe, when released from the “nipper” or clamp, would drop freely from the swaging die (Figures 8.6 and 8.7). If the heels had been swaged inward on a horizontal axis, however, the finished shoe could not have been removed from the die. I began to build a

new horseshoe machine model with a vertical axis, and wrote an updated article on Burden's machine related to the turning of horseshoes on a vertical axis (Rawls 2008).

Using $\frac{1}{8}$ inch heated bar stock in the model proved to be difficult. Because of its small size, the bar stock could not retain the heat as long as needed, which eventually caused me to break one of the machine journals (the part of a shaft contained within a bearing). I also knew that using heat during a public demonstration was not an option because of the fire hazard and danger to the onlookers, and I had to find a replacement material. I found that solder worked the best. In spite of these problems this machine, which performed the third operation in the series, was relatively easy to understand and build.

THE PROCESS IN THE 1835 PATENT

With the horseshoe machine models working, and with Burden's patent description, I am now able to describe the operation of the 1835 horseshoe machines. The mechanics of a flywheel link and attachment possess the properties known as top dead center and bottom dead center: the two points in the rotation where the link and connection come to a stop. With this pause at the dead centers, the machines in processes #1 and #3, once set in motion, could be loaded continuously without stopping the machine. In the patent specifications of process #2, Burden stated that one would load and then start the machine, but I believe that this machine also may have been run continuously, loading with the dead centers, without stopping to load each piece.

The operation of the first machine, for rolling and forming, was as follows: the machine stop and dies were adjusted for the size of the horseshoe being made. As the moving frame neared the end of the return cycle, moving towards the rear (left in Figure 8.3) of the machine, the moving jaw and side steel (Figure 8.3, magenta and light blue, respectively) were in an open position. A worker manually pushed a long bar of wrought iron stock between the side steels to the preset stop (brown). Burden's description from the 1835 patent states that when "...a piece of iron (previously rolled to the desired size) were introduced between the side steels or irons LL..." said iron would be cut to length by the cutting chisel (Figure 8.3, "No. 1 Fig. 1", dark blue). This may be an early improvement to the machine, as it appears to differ from the original 1835 method as described in Burden's later 1843 patent:

In the machine as originally patented by me the rod or bar of iron from which a shoe was to be made was cut off above the gripping dies or side steels between which it was to be gripped and held while it was rolled and fashioned by the segment-swages, and after being cut off it was allowed to fall between them.

The 1835 patent drawing of the first machine (Figure 8.3, "No. 2 Fig. 2") shows a horseshoe blank in the process of being swaged in process #1. A set of cams closed the moving jaw and kept it from opening during the swaging process. The bar was cut to length by the cutting chisel (Figure 8.3, dark blue). The moving frame, having reached its furthest travel, began the forward cycle. The iron, confined on the sides by the side steels (light blue) was swaged by the top and bottom vertical dies (yellow) as it traveled. At the end of the forward cycle another set of stops or cams would trip and open the moving jaw, releasing the cut and swaged iron bar to fall below the machine. A long piece of wrought iron bar stock was processed in this way until it was completed. The cut and swaged pieces were then moved back to the furnace to be reheated in preparation for swaging in process #2.

The sequence continued with the reheated blanks being brought from the furnace to the machine set up for process #2 for creasing and punching. The creasing and punching operation was described as follows, based on the assumption that the machine ran continuously during the swaging process: the stop of the creasing and punching machine was set to length and the top and bottom dies were adjusted for the size horseshoe to be grooved and punched. As the travel of the moving frame neared the end of the return cycle, a worker placed the heated bar between the side steels. The cutting chisel was not needed for Process #2, because the blanks had already been cut to length, and it may have been disabled or removed for this operation. The moving jaw closed, and during the forward movement the bar was creased and punched. Figure 8.3, "No. 2 Fig. 3" shows a horseshoe in the process of being grooved and punched. When the stops or cams opened the moving jaw, the grooved and punched bar dropped through the opening in the moving frame and was returned again to the heating furnace to prepare it for process #3.

The last machine of the process, which performed process #3 (Figures 8.5 and 8.6), turned the wrought iron bar into the horseshoe shape. As in the other two processes, the machine was operated by reciprocating motion, with a rack (Figure 8.5, green) that provided circular motion to the horseshoe turning dies: two swaging dies (yellow and magenta) operated by shafts (blue) built on a vertical axis. After being swaged and released from the die, the horseshoe dropped to the ground.

As I mentioned above, Burden made the gears connected to the turning dies eccentric so as to have the pitched line describe the same curve as the shoe. To keep the horseshoe blank close to the swaging dies a cap (Figure 8.4, light green) one inch thick was used. As the dies rotated into position, a lever struck the end of the cap opening the "nipper" (vice or holder: purple). The reheated swaged bar was inserted in to the

nipper and the dies rotated, swaging it into a horseshoe. When the dies had completed their rotation the nipper lever again struck the cap, opening the nipper and releasing the swaged horseshoe. The eccentric gearing did not make a complete revolution but returned back to its starting position at the end of the cycle. The finished horseshoe was transferred to the storeroom.

THE 1843 IMPROVED PROCESS

In 1843, Burden patented a new horseshoe machine (U.S. Patent No. 3,261) combining operations #1 and #2 of the 1835 patent in a single machine that would run continuously during the swaging operation (Figure 8.8). This patent improved the manufacturing process and eliminated one reheating of the wrought iron bar. These improvements were important because:

1. The combined machine operations eliminated one reheating cycle, saving on the cost of fuel and maintenance of the furnaces as well as the time and labor spent in transporting the wrought iron bars to and from the furnaces.
2. They eliminated the problem of placing the swaged bar from machine #1 incorrectly into machine #2.
3. The combination of the two machines created improved accuracy in swaging the horseshoes.

In the 1843 patent, Burden described problems he encountered with the 1835 machine that were corrected by the new patent: during the swaging process, the iron had often not been properly drawn out by the swaging dies. This prevented it from being swaged to the required thickness and width for the horseshoe. The 1843 patent corrected this deficiency by giving the swages a greater extent of motion than the moving frame in the same length of time. The dies were then able to exert a rubbing or drawing force on the iron, thereby filling the space between the side steels. Burden was able to accomplish "greater extent of motion" by arranging the die shafts so they were not parallel to each other (Burden 1843).

The 1843 patent also improved the cutting-off process by passing the wrought iron directly in between the side steels and cutting it on a level with and at the outer end of the dies. The moving jaw then closed and the moving frame moved forward, allowing the iron to be swaged by both of the top vertical dies and the bottom dies. As in the earlier patent, when the forward cycle finished, a set of cams or levers opened the moving jaw and the horseshoe blank dropped through an opening in the moving frame.

THE 1857 ROTARY HORSESHOE MACHINE

The Mexican war increased the price of horseshoes from 5 cents to 50 cents a pound (Gates 1981, 19) providing considerable incentive for improving the manufacturing process. Although the 1843 patent had greatly improved the efficiency of the process, Henry Burden continued to look for ways to make it even more efficient and profitable. Simply combining the first two machines was no longer enough. The basic design of the original process embodied limitations that could not be overcome. One of these was simply that it involved more than one machine and therefore two heats were necessary to finish a shoe and space was needed for two machines and their drive pulleys on the line shaft that provided the machinery with power. The other limitation was the reciprocating nature of the machines themselves: the first half of a machine cycle produced one straight blank or one finished shoe, and the return half of the cycle was wasted energy and time.

To overcome these two problems Burden worked out a new method using a single machine that combined all three processes, employing rotary motion so that the entire power cycle was used. Because of the circular motion of the machine, he was able to design it to produce two finished shoes per revolution rather than one.

The swaging and bending processes used in the new machine were very different from those used in his 1835 machines, having evolved somewhat in the 1843 machine. In 1857 he received U.S. Patent No. 17,665 for his "Improved Machine for Making Horseshoes," specifically "machinery for horse and mule shoes," which is the one for which he is most remembered.

The new machine improved the process in several important ways:

1. Only one "heat" of the iron was needed because the 40 foot bar of horseshoe stock came directly from the reheating furnace through the rolls into the horseshoe machine to produce finished shoes.
2. The energy wasted in the return stroke of the reciprocating machines was eliminated by the constant revolving motion of the new machine.
3. Two shoes, rather than one, were produced by a single cycle of the machine.
4. The shoes were bent before swaging and punching rather than after.

In the patent application, Burden stated: "The wheels S', C' and K2 are each one half the diameter of c and revolve twice, making two shoes to one revolution of the latter." With this information I selected a train of gears with the proper gear ratio (1 to 2), pitch and diameters. The diameters of the gears would determine the size of

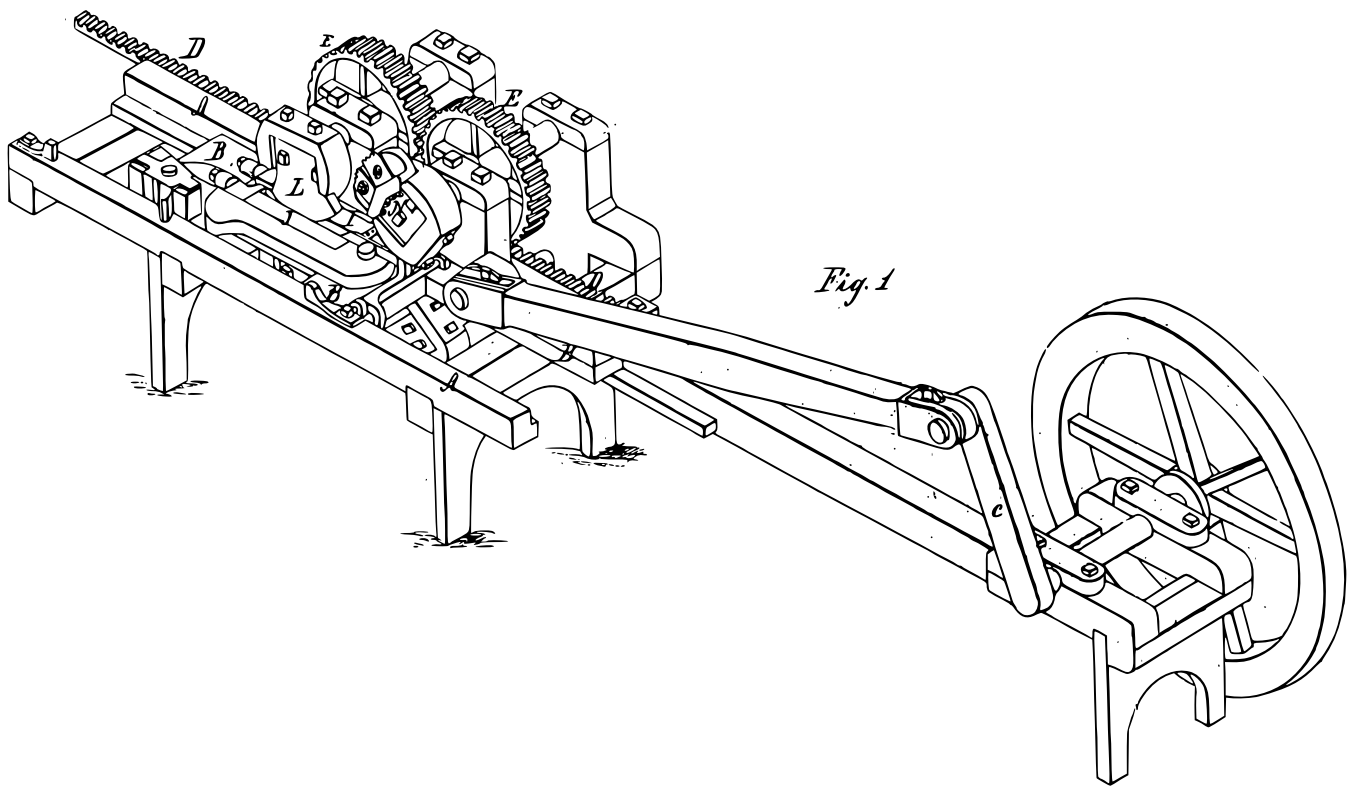


Figure 8.8. The 1843 machine combining processes 1 and 2. Stock was fed in at the left end and cut, swaged, grooved and punched ready to be bent into a horseshoe. The top swages have evolved from the 1835 form so that they revolve and are beginning to resemble the form they would take in the 1857 rotary machine (after the patent drawings in Burden 1843).

the machine model. Using the largest gear I was able to calculate the ratio and proportion to the patent drawing.

The patent referenced a scale of two inches to the foot, which was confusing at first because the machine would have been very small. I eventually learned the patent drawings were of the patent model (now curated by the Albany Institute of History and Art: Figures 8.9 and 8.10) and not the actual machine. Patent models were not required to be operational, but mainly to illustrate how the invention worked. They were also used when comparing similarities or differences with other inventions, and when suing for patent infringement.

A patent could use parts or components similar to those used in another patent as long as the new patent stipulated that those components were not being used as defined in the earlier patent, but for a different purpose. Burden's patent of 1857 referenced a prior patent, No. 301, for the use of rotary dies in forming horseshoes: "The most prominent of these is the device patented to Barzillai Young and Samuel Titus in the year 1837."

THE CONSTRUCTION OF THE DIES

Burden made the dies from cast iron or steel, as before, in pieces so that they could be adjusted, removed, repaired and replaced. The large diameter internal wheel

held two adjustable dies, located 180 degrees from one another (Figure 8.11, yellow). The large wheel dies formed the inner edge of the upper side of the shoe, leaving it concave or slightly thinner on the inner edge. The forming, creasing and punching dies (blue and green) were also made in pieces, the depth of the creases and nail holes adjustable by means of bolts and screws. Potential problems with backlash (clearance or lost motion in gears) and alignment of the swaging dies called for an innovative solution, so Burden modified the two top die gears so that the alignment and backlash could be adjusted when needed.

The new machine included several other innovations that were new to the process as well: a starting mechanism, an automatic feeding mechanism, an automatic stop mechanism called an “indicator,” and a flattener to remove the curve in the shoe caused by the radius of the large wheel dies.

FEED PROCESS

The indicator (Figure 8.12 and 8.13, dark green) was designed to prevent a piece of stock too short to make a horseshoe from entering the machine and damaging the mechanism. It rested on the top of the bar stock (bright red) being fed into the machine by the feed rolls (light



Figure 8.9. Henry Burden's 1857 patent model of the new rotary horseshoe machine, seen from the feed side. The model exhibits some minor damage perhaps from the 1877 Patent Office fire or storage barn fire in 1943. The model has been carefully cleaned and repainted (photo by Allison Munsell, Albany Institute of History and art).



Figure 8.10. 1857 patent model showing the drive gears with their 2:1 ratio. The flywheel and hand crank, seen in the patent drawings, once attached to the shaft of the upper right gear, have been lost, probably in the fire that damaged the model (photo by Allison Munsell, Albany Institute of History and art).

yellow), at exactly the distance from the feed rolls as the length of the shoe blank to be cut. When a piece of iron stock, too short for a shoe, went past it, the indicator and link would drop down, engaging a catch and stopping the feeding mechanism.

The wrought iron stock (Figures 8.12 and 8.13, bright red) was fed into the machine by the feeding rolls (light yellow) which turned continuously, driven by beveled gearing (also light yellow) with a gear ratio of 1 to 2. The upper feed roll assembly was bolted to the machine frame, while the lower feed roll was fastened on the movable frame (orange). The movable frame's movements provided the start and stop capabilities for the feed mechanism. The feed roll shafts were connected by spur gears of equal gear ratio. When the "T" catch (Figure 8.12, blue-green) was positioned on the right side, the feeding process was operational. When the handle assembly (handle and projection, Figures 8.12 and 8.13, light green) and indicator (dark green), "T" catch (Figure 8.12, blue-green), and moveable frame (Figures 8.12 and 8.13, orange) were in the positions shown in Figure 8.10, the feed process was stopped.

SETTING UP THE MACHINE

The distances from the indicator on the handle assembly (Figures 8.12 and 8.13, dark green) to the feeding rolls, (yellow) and from the cutter (Figure 8.13, light blue) to the stop (Figure 8.13, dark blue) were adjusted for the size and length of the horseshoe. A worker then lifted the handle assembly (Figure 8.12 and 8.13 light green) and secured it to a spring hanger (aqua). A helper

took a wrought iron bar of stock (bright red), approximately 40 feet long and "rolled square in cross section," from the rolling mill and placed it in the cast iron feeding trough which was made in approximately 12 foot sections (dark grey). The worker then moved the wrought iron stock up to the cutter (Figure 8.13 light blue). The handle assembly (Figure 8.12 and 8.13 green) was lowered on top of the wrought iron stock with only the indicator (dark green) contacting it.

The automatic feed stop and machine start cycle were designed as part of the feed mechanism. The horseshoe machine's large flywheel, powered by shafting and leather belts, would be running prior to engaging the feed start handle (Figure 8.12 pink). The "T" catch (dark blue-green) is shown in the left hand position with the feeding process stopped. When it was turned to the right, the feeding process was operational. The handle assembly (Figure 8.12 and 8.13 pink), "T" catch (blue-green), and the movable frame (orange), connected to the cutter lever (Figure 8.13 light blue) and moving with it as a unit, operated together when starting or stopping the feed process.

The machine was designed and built to perform each operation in a specific order and sequence. In order to start the feed cycle, it was imperative that the cutter was closed and the feeding rolls separated so the stock could be placed in the proper position for the cycle to begin. These operations were started by the ratchet cam (Figure 8.12 and 8.13 light green).

Vertical Section at B.b. Plate I.

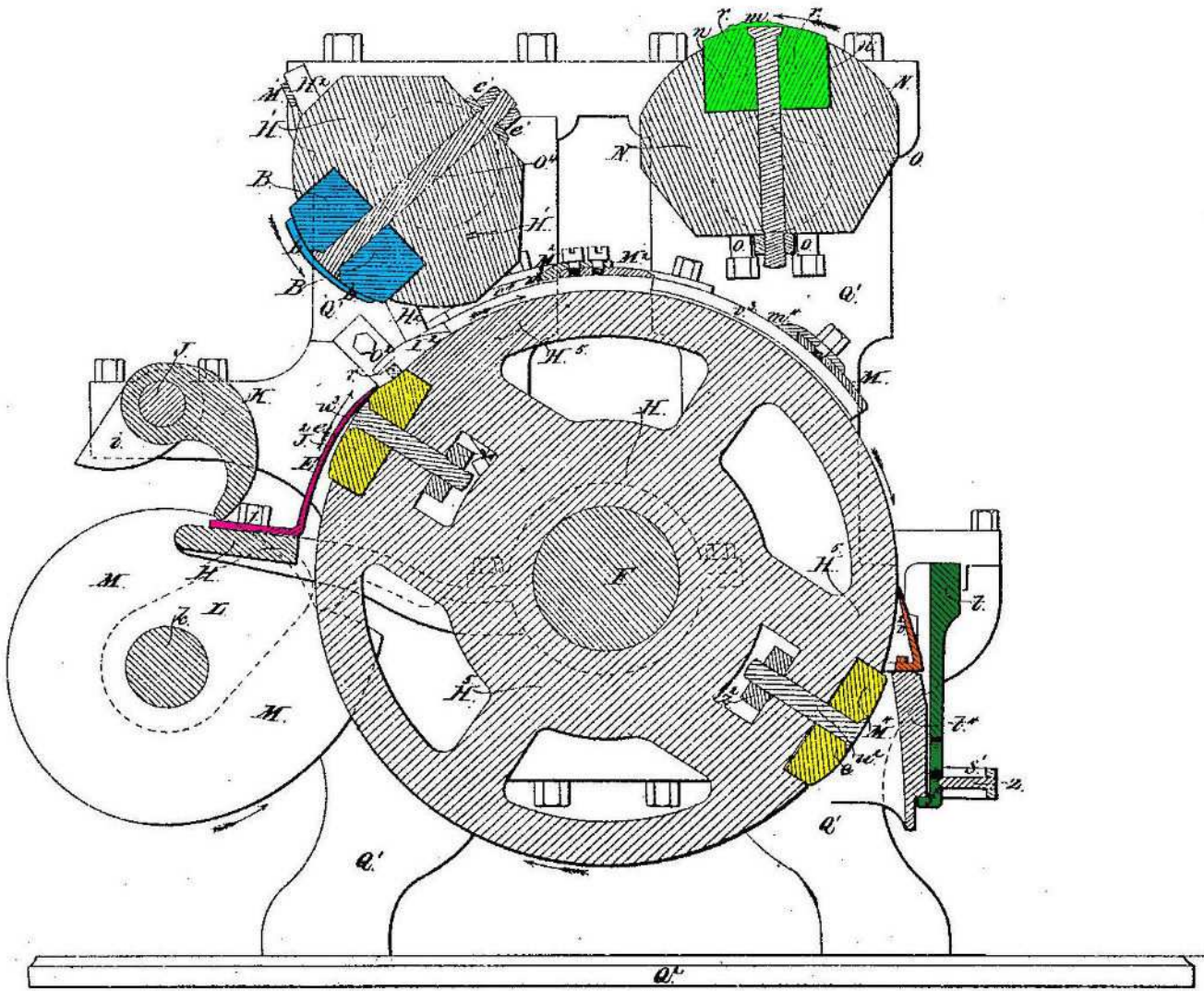


Figure 8.11. Cross section of the 1857 machine showing the large wheel with lower swages (yellow) and the upper shafts with top swage (blue) and grooving and punching swage (green). The bending tongue and its frame (magenta) are at left. The scraper and flattener (orange and dark green) are at right (after the patent drawings in Burden [1857](#)).

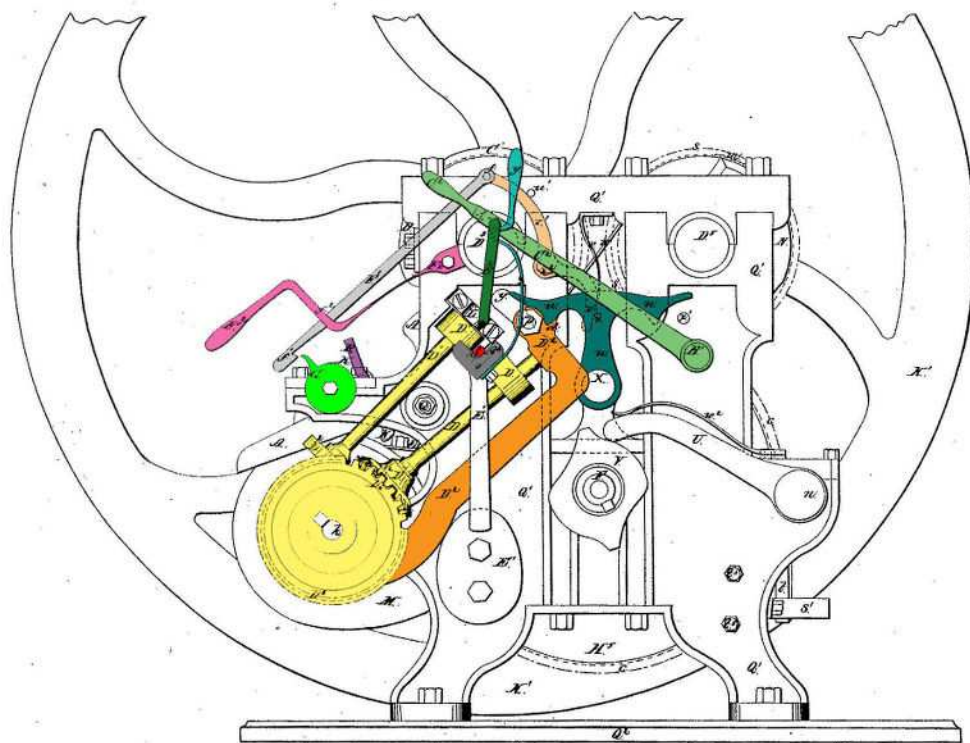


Figure 8.12. View from the feed side showing the operator's controls and feed mechanism (after the patent drawings in Burden 1857).

PUTTING IN THE STOCK AND STARTING

A length of wrought iron, approximately 40 feet long, "rolled square," was taken from the rolling mill without reheating and placed on the cast iron feeding trough and positioned against the closed cutter (Figure 8.12 and 8.13 red). The indicator (dark green) was then lowered on top of the wrought iron bar. The feeding rolls had to be engaged at exactly the proper time so that the machine cycle would start in the proper sequence. This would be very difficult for the attendant, so Burden developed a mechanism to ensure that the sequence started correctly.

To start the feed process, the operator pressed down the start handle to the stop (Figure 8.12 purple). The notch in the connecting link engaged with the ratchet cam (Figures 8.12 and 8.13 light green). The connecting link and lever (light grey and light orange), fastened beside the start handle, moved down, pivoted, and engaged with a projection on the "T" catch, moving it to the right-hand position, releasing the moveable frame and starting the feed process. The rolls closed and the cutter opened.

STOCK MOVES INTO PLACE AND IS CUT TO LENGTH

Once turning, the feed rolls moved the wrought iron past the cutter through a set of moveable guides (Figure 8.13 dark brown) to the stop (dark blue). The move-

able guides supported the wrought iron on three sides. The projecting edge of the bending tongue (Figures 11 and 13, magenta) supported the wrought iron on its center face. Once the iron was fed to the stop, a cam shaft activated the cutting arm lever (Figure 8.13 light blue), the wrought iron was cut to length, and the movement of the feeding rolls was temporarily suspended.

THE STOCK IS BENT

The bending tongue immediately moved up against the center of the iron and carried it forward. The bending tongue, traveling upward with the iron restricted on the sides by the moveable guides (Figure 8.13 dark brown), formed the iron into a rough "U" shape around it.

The primary shaping dies were in pairs revolving on an upper shaft (Figure 8.11 and 8.13 blue) against the large wheel dies (Figure 8.11, yellow; Figure 8.13, dark yellow). The upper die formed the plane even surface of the underside of the shoe while the lower die, mounted on the large wheel, was convex to form the inside. As the bending tongue moved upward, the lower die on the large wheel moved along with it so that when the iron was formed into the "U" shape it was already directly over the position it would occupy on the lower die. After the shoe was gripped between the upper and lower dies, the moveable guides pressed in the heels of the shoe against the lower die and within the flange of

Front Elevation.

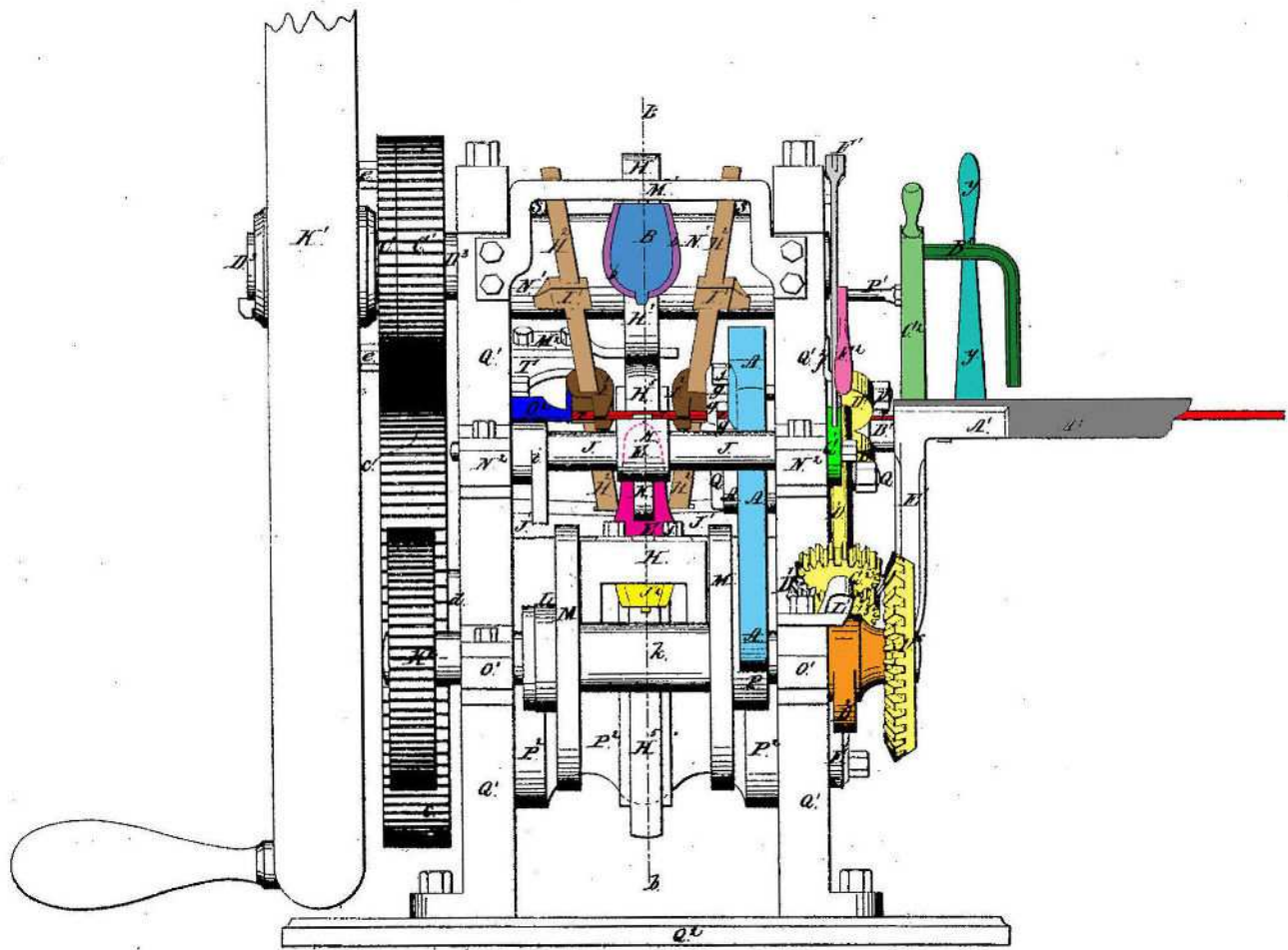


Figure 8.13. The drive gears C, C' and K² are visible at left. The hand-cranked drive wheel for the patent model at left (now missing from the patent model) was replaced on the full-sized machine by a belt-driven flywheel. The bottom of the large internal wheel is visible at lower center, with one bottom swage (yellow) partially visible. The bending tongue and frame are shown in magenta. The first top swage (blue) is visible at top with its flange (purple) meant to keep the shoe from squeezing out to the sides and deforming. The feed trough is at right with a piece of bar stock (bright red) protruding from it (after the patent drawings in Burden 1857).

the upper die. Two movable standards (Figure 8.13, light brown) provided the inward traverse of the moveable guides (dark brown) that formed the rough “U” shaped iron into the final horseshoe shape.

FORMING THE SHOE FROM THE BENT STOCK

The 1857 patent describes why most rotary horseshoe machines had proven a failure due to the wrought iron being forced out from under the swages. A horseshoe should be formed with the toe wider than the heels and front much thicker than the Interior beveled edge. When the wrought iron is first formed around the bending tongue, however, the natural tendency is the opposite: for the iron to compress, thickening the inside and stretching and thinning the outside. To alleviate this condition, the 1857 patent states that the toe of the shoe must

be at exactly the correct height before being gripped by the swaging dies, allowing the iron to “flow inward” (the 1865 re-issued patent states “flow backward”) forming the toe and shoe correctly.

As the toe was gripped between the dies, the bending tongue had to immediately be drawn back to avoid being caught between the dies. The bending tongue return cycle was started by a cam activating the return lever. In order to adjust the maximum height reached by the bending tongue, packing or shims were inserted beneath the bending tongue frame.

SWAGING

The upper swaging die flattened the surface of the underside (bottom) and outer edge of the shoe. The inner edge of a properly formed horseshoe should be formed

thinner than the outside. This contour created a problem in forming shoes using rotary swaging dies, which tended to squeeze the iron out from between them. Burden solved the problem by casting a flange on the outer edge of the upper die (Figure 8.13purple). The flange height was approximately the thickness of a horseshoe. Because horseshoes swaged with rotary dies are liable to adhere to the upper die, a section of the flange toe was relieved for the passage of a steel scraper that ensured that the shoe remained with the lower die.

CREASING AND PUNCHING

The horseshoe was next swaged by the creasing and punching die (Figure 8.11 green). The creasing and punching dies were made in pieces as in the earlier patents. An attendant checked the depth and position of the creases and holes, and the die was adjusted to the size of the horseshoe being made. As one horseshoe was creased and punched another length of wrought iron was drawn into the machine.

SCRAPING AND FLATTENING THE FINISHED SHOE

Another steel scraper was used to separate the shoe from the creasing and punching die so that it remained with the lower die on the large wheel. Because the shoe was formed by the large wheel during the swaging operation, the horseshoes were formed with a slight radius conforming to the radius of the wheel. This radius was removed by the flattener at the end of the cycle. A "V" shaped scraper (Figure 8.11 orange) removed the shoe from the dies on the large wheel to fall into the flattener (dark green). At the same time a cam and lever caused the flattener to open, receiving the shoe, and then close, flattening it. When the flattener opened again the shoe was pushed off onto an endless chain or conveyor belt below. The operation of the machine may be seen in the working model, shown below in Figures 8.15 and 8.16.

COOLING THE MACHINE

An engraving of Burden's 1857 horseshoe machine in use (Figure 8.14) shows a vertical pipe and hand valve above the rear of the machine. I would suggest this may be a fine mist water spray to improve the finish on the shoes or a water coolant to keep the swaging dies cool. It may also be a combination of both. "Plenty of water is always dripping from the machine" (Proudfit 1904, 50).

THE FINISHED PRODUCT

The finished horseshoe was then moved to the storehouse. Although the nickel-plated horseshoes given to

individuals as mementos when the iron works closed Ca. 1939 were stamped "BURDEN," Burden's horseshoes were not normally stamped with a size or Burden trademark. Instead, they were shipped in wooden barrels marked "100 lbs Burden's swaged horseshoes" with the size marked on the barrel's top (Figure 8.17).

Burden advertised the quality of his "number three iron" used in making the shoes, as may be seen in a brochure from the office of the Burden Iron Works (Figure 8.18 and 8.19): "...the best of American Refined Horse-Shoe Iron..." was used in the shoes, "...any of which will be found to bend double cold without breaking." It goes on to say, "Let any one [sic] shoe a horse on one side with these shoes and on the other side with the best hand-made shoes, of the same wearing surface and thickness, and he can judge for himself which he would prefer."

THE 1862 MACHINE AND THE 1865 RE-ISSUE

In 1865, Burden obtained a re-issued patent for the original 1857 machine (U.S. Patent No. RE1,998, Figure 8.20). A re-issued patent could not be used to extend the date of expiration of the original patent, but could be granted for other specific reasons, such as to correct problems in the original application. If an inventor claimed too much, his patent could be declared invalid in a lawsuit. If he claimed too little, someone else could appropriate the unclaimed intellectual property (Cooper 1991, 33).

In 2010, I was researching material for the upcoming symposium at the New York State Museum when I located documents from an 1864 patent infringement suit (Fisher 1871, 477-8) in which Burden was suing Corning and Winslow for infringement of his horseshoe machine patent of 1857. Burden specifically claimed infringement of the second and sixth claims of the patent: "The mode of bending the rod and placing it in its proper position between the swaging-dies" and "The means ... for flattening the shoe" (Burden 1857). The defendants claimed that Burden's patent did not specifically describe the placement of the bending tongue in relation to the large wheel die, and also that the placement of the wrought iron bar had already been patented or was common knowledge. In the final judgment, Burden was entitled to a decree for an injunction and account in respect to the sixth claim and no further.

Henry Burden undoubtedly requested the patent re-issue because of this suit, in order to make his patent claims more specific. The revised patent specifications more clearly defined the movement and operation of the bending tongue. They specified that to properly swage horseshoes, the bending tongue and U shaped iron should be "a little in advance" in relation to the large wheel die (Burden 1865). When the iron was first

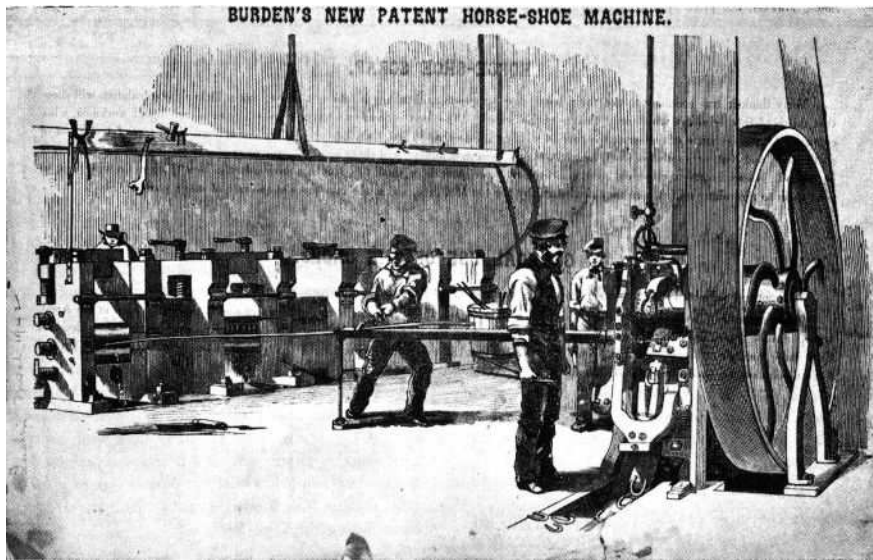


Figure 8.14. Burden's 1857 horseshoe machine in operation, as seen from the rear. The leather drive belt is visible running from the flywheel on the machine to the line shaft overhead. Stock is being fed directly from the rolls at left into the side of the machine. The "V" shaped scraper can be seen removing shoes off the large wheel dies to fall into the flattener. Finished shoes may be seen dropping out onto a conveyor. Note the coolant pipe and valve above the machine (from Cunningham 1951).



Figure 8.15. Working model of the 1857 rotary horseshoe machine, as seen from the feed side, with a bar of stock lying in the feeding trough waiting to be drawn into the machine by the feed rolls. Photo by John Yost, New York State Museum.

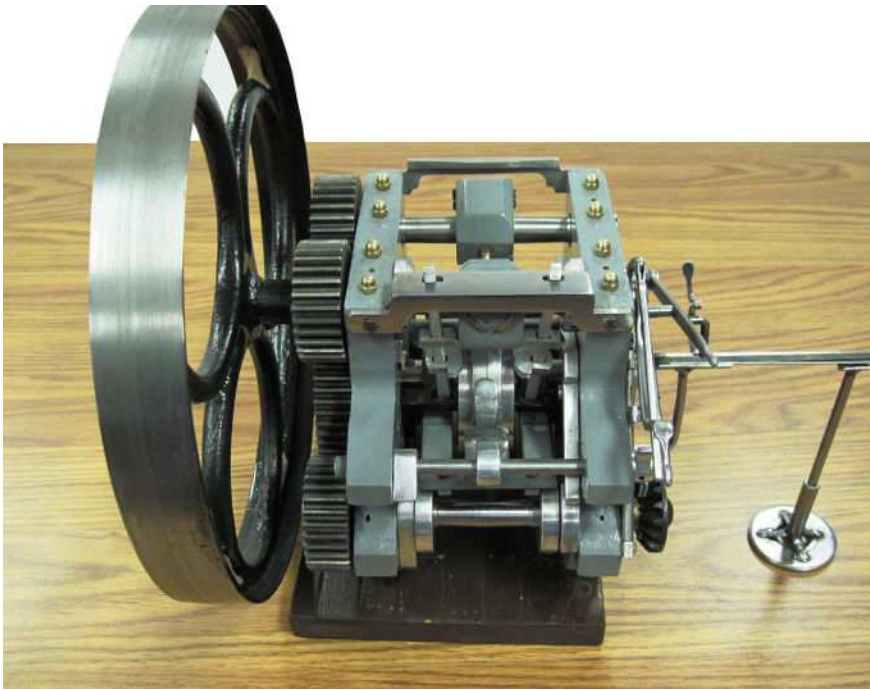


Figure 8.16. Working model of the 1857 rotary horseshoe machine, as seen from the front looking down. The machine is ready to start. The bar of stock (in the feeding trough at right) is ready to be drawn into the machine by the feed rolls, where it will be cut to length just above the bending tongue, visible in front of the large wheel at center. One of the upper dies is visible under the frame above.



Figure 8.17. Burden Horseshoe keg with the shoe size marked "Medium Fore." Courtesy of the Burden Iron Works Museum. Photo by John Yost, New York State Museum.

gripped by the dies "a little in advance" provided the space for the wrought iron to be spread backwards forming the toe and the shoe correctly.

The re-issue also took into account a change that had become part of the production process by that time, the elimination of complete machine-punching of the holes, described in the 1857 patent, in favor of partial punching and finishing the process elsewhere by hand: "My machine is designed to take long rods, such as are discharged from the rolling mill, and make them into horse-shoes, complete except the punching..." The shoe was creased by the machine but only partially punched, then delivered "in the room or place where they are to be punched." I found this description confusing, because the 1857 patent had clearly stated that the shoes were completed, punched, and delivered to the storeroom straight from rolling mill without reheating. Nowhere in the reissued patent was the full sequence of the newer process described as employing two separate machines, probably because the applicant was not allowed to add anything new to a re-issue application.

In 1862 Burden had patented a new machine with improved swages (U.S. Patent No. 35,746; Figure 8.20) in order to address a difficulty he had experienced in producing shoes with his machine: "In the class of machines for making horse and mule shoes that have revolving dies a great difficulty has been experienced in giving a proper shape and finish to the outer edge of the shoe, in consequence of the creaser forcing the iron out of shape and frequently splitting it in the process of creasing and punching, and on this account the crease and holes in shoes could not be made as near to the edge as was desirable (Burden 1862)." The patent consisted of supporting

Office of the **BURDEN IRON WORKS.**

As it is most generally uninteresting and unintelligible to give a description of a machine without models or drawings, it may be sufficient to state here *what* it does, if not *how* it does it.

Burden's Patent Horse-Shoe Machine takes a bar of iron as it comes from the rolls of the mill and converts it into shoes of any desired pattern, at the rate of one a second, and would do so all day and all night long, could the iron be rolled and given to it without stopping.

It makes the shoes of the same pattern with perfect uniformity, and distributes the iron precisely as it is required.

QUALITY OF THE IRON.

None but the best of American Refined Horse-Shoe Iron is put into these shoes, any of which will be found to bend double cold without breaking. However, the quality is a matter soon and satisfactorily tested. Let any one shoe a horse on one side with these shoes and on the other side with the best hand-made shoes, of the same wearing surface and thickness, and he can judge for himself which he would prefer.

ECONOMY OF THESE SHOES.

The saving by the use of these shoes is not less than fifty per cent. The rapidity by which they are made—the small cost of attending the machine—its enormous capacity (one of them making thousands of tons a year)—enable us to give an excellent article at a price which, at an early day, must inevitably cause them to take the place of all hand-made shoes.

A little reflection, we think, must make this clear to any one who has used them. No one who has seen the machine doubts it. Some, however, will profit by it sooner than others; for prejudices do not die out at once, but by degrees.

GENERAL USE OF THE SHOES.

It is not to be doubted that very soon these shoes will come into general, if not universal use.

The thousands of horses used by the cavalry and artillery of the United States and Austrian Armies, and the still greater number of mules used in the army transportation trains, are all shod with them. They are used by the principal omnibus and horse railroad lines in the cities of this country and by the leading horse-shoers throughout the Union.

Shoes are packed in kegs of 100 lbs. each.

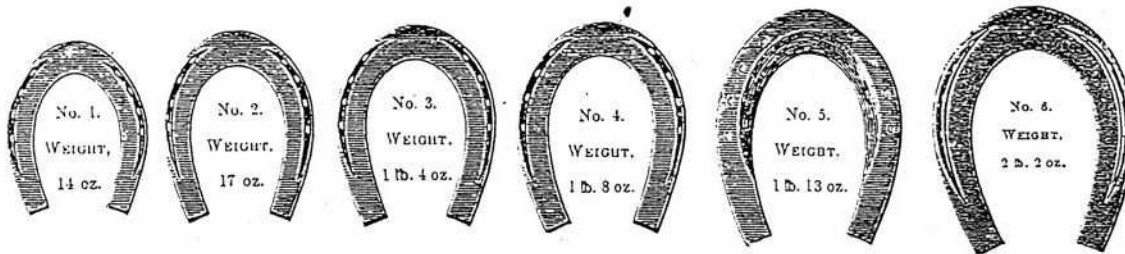
All sizes of horse-shoes, from No. 1 to No. 6, and all sizes of mule shoes, from No. 1 to No. 4, will be furnished, single numbers in a keg.

In addition to these single numbers, we will furnish one assortment, namely, Nos. 2, 3, and 4 horse-shoe, assorted forward and hind, in each keg.

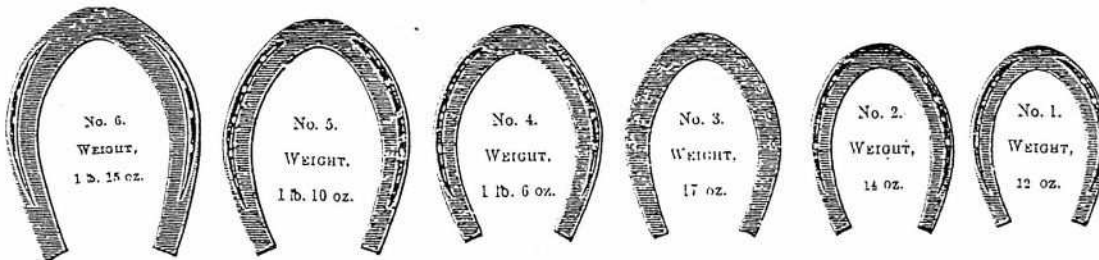
Figure 8.18. Brochure from the Burden Iron Works advertising Burden horseshoes (Courtesy of the Burden Iron Works Museum).

BURDEN'S HORSE-SHOES.

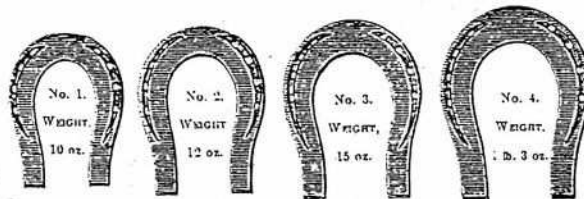
Forward.



Hind.



Mule Shoes.



Inquire for **BURDEN'S SHOES**, and be sure that the kegs are marked **BURDEN'S SHOES**, as a number of unsuccessful attempts have been made to counterfeit them.

For Sale by the Hardware and Iron Merchants throughout the Country.

Please inform us by letter when you receive this circular.

ADDRESS, H. BURDEN & SONS,
TROY, N. Y.

Figure 8.19. Brochure from the Burden Iron Works showing the various sizes and shapes available. Note that the heels of these shoes have been left square, lacking any toe and heel calks, which had to be applied by the farrier to suit the horse and type of work it was to perform (Courtesy of the Burden Iron Works Museum).

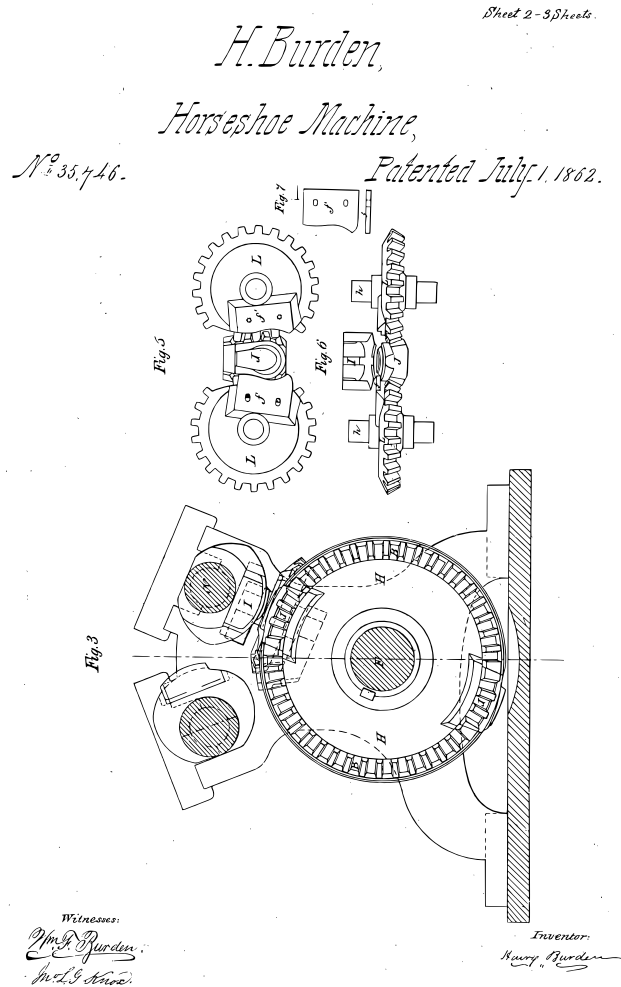
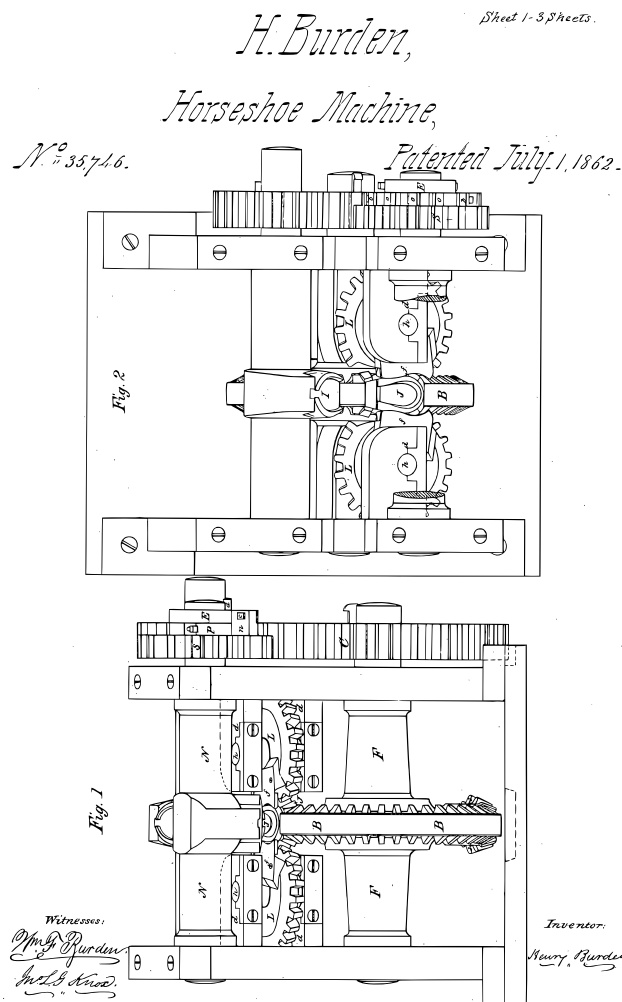


Figure 8.20. The 1862 patent drawings for the swaging machine, showing the side swages and their location on the machine. The machine itself is essentially a modification of the 1857 machine, but for simplicity only the specific modifications to be patented were shown. The third page, detailing the gearing, is omitted here (after the patent drawings in Burden 1862).

the outer edge of the shoe with side supports made of cast steel or chilled iron while it re-swaged a previously formed and punched horseshoe. Some of Burden's 1857 machines were modified with this improvement: "My improvement consists in a new mode of supporting the outer edge of the shoe during the operation of creasing and punching, by which those difficulties have been removed and a more perfect shoe made than was otherwise practicable (Burden 1862)."

Since a patent had been issued in 1860 to N.C. Lewis for a special arrangement of four eccentrics in forming bars or blanks for files and also in shaping the blanks from which horseshoes were to be made, Burden felt it necessary to specify in his 1862 patent that it was not for forming or shaping horseshoe blanks: "I do not use my rolls for drawing out or shaping blanks of any description, but merely for finishing horseshoes which have

been previously prepared and bent into the proper shape by other means (Burden 1862)."

After the shoes were formed in the original machine and hand punched, they would be moved to the swaging furnace, brought to heat, and then swaged in the new machine, which improved the surface finish and removed any imperfections in the shoe. The sides and heels were swaged using the second top die and side swages. The 1862 patent specifies two large bevel gears fastened on each side of the large wheel and another set of top side bevel gears fastened between the side frame and the large wheel (Figure 8.20). Burden modified the large wheel bevel gears and the side bevel gears to give it a pause or stopping motion while swaging the horseshoe.

The 1862 and 1865 patents each described in detail the operation of the machine for which the individ-

ual patent claims were made, but neither one fully described the process of which it was part. Margaret Burden Proudfit, however, described the whole process in her father's biography (Proudfit 1904), apparently from memory, many years later, making it clear that the 1862 machine was a "swaging machine" and represented a separate operation. She stated that after falling from the original machine, a shoe was

...carried by an endless chain of linked pieces of malleable iron to the punching room. In the latter are seen a long line of men seated astride of the saddles of the punching machines making the nail-holes through the indented marks previously put in the creased part of the shoes. Thence they are conveyed in hand-cars to the swaging furnaces in which they are placed before they are swaged.

Boys are at work here, taking with tongs the heated shoes from the furnace and putting them singly on the revolving dies of the swaging machine. After the heated shoe is seated upon one of these dies, it is carried to the top of the machine where it is stopped for a moment; a top die descends on it and two side steels swage the sides of the shoe, removing all bulges and making the outside edges of the shoe perfectly smooth; thence it is carried farther to the opposite side of the machine where there are two other side swedges [sic] which swedge up the heels of the shoe...

...after which, the shoes are carried away on an endless chain as before, allowed to cool, inspected, and sent to storage. (Proudfit 1904, 76)

I have used hand lever punch presses for punching holes in shoes, investigating the dies to use in a punch press. The experience was trying at best! When I made an insert to put between the shoe and press, the process was much easier. I found that a black heat, approximately 450 F., with beeswax as a lubricant, worked best. One of the biggest problems I experienced occurred when I was heating the shoe to a red heat (1550-1650 F) because too high a heat and continuous exposure can take the temper from a punch die.

Burden had apparently been too ambitious in designing the 1857 machine to finish the shoes in a single operation and had to improve the process by adding two further steps, punching by hand and finish-swaging in the new machine. The re-issued patent necessarily took these changes into account, but was only meant to describe the operations of one of the two machines used in the process.

THE "CENTENNIAL" MACHINE

Several years later, I was at the American Precision Museum attending their annual engineering show. I was browsing through their books and I found one that looked interesting: *The fascinating World of Early Tools and Trades, selections from the Chronicle*. The very first article was "Hoofbeats of Destiny," by Anna K. Cunningham, published in the Chronicle in 1951. The article was about Henry Burden and his horseshoe machines, and told of the Burden Company sending a replica of the horseshoe machine to the 1876 Centennial Exhibition in Philadelphia. It included a quotation from an irate New York Times reporter questioning why Burden's machine was not in its proper place in Machinery Hall, and gave a description of the machine and furnace. There was also a wonderful plate of the horseshoe machine in full operation. My first thought was, "Here we go again," and I began looking for more information about the model. I searched numerous books and literature on the 1876 Philadelphia Centennial Exposition, hoping to find pictures or other information about Burden's machine, but did not find them. I did eventually learn that Burden's machine was displayed in Agriculture Hall instead of Machinery Hall.

Researching material for this symposium, I stumbled onto new information on the Centennial machine. In the Reports on Awards from the Centennial I read that Burden's Horseshoe Machine was a small model, making horseshoes perhaps the size of a quarter, from rods of block tin. The display also had a variety of Burden horse and mule shoes (Walker 1880, 12).

In 2009 during a lecture at the Burden Iron Works Museum, I had met Marty Pickands, an archaeologist for the New York State Museum. Marty and I e-mailed back and forth on iron founding and other related subjects. One e-mail I received really got my attention. Marty wrote that he had been telling someone in the museum's history office about my horseshoe machine models. He was told, "Oh, yes. We've got one of those." It turned out to be Henry Burden's horseshoe machine model from the 1876 Philadelphia Centennial (Figures 8.21-8.26).

I went to see the model in the State Museum's Rotterdam, N.Y. Warehouse. It is beautifully made, but not exactly like Burden's 1857 horseshoe machine patent model. It has also been slightly damaged at some point in the past. A bevel gear from the feeding mechanism is missing. Where the left moving standard was attached to the frame, the casting is broken. The front top cross brace is also broken but a section remains attached to the machine. Inside the machine's storage box is a deformed horseshoe. I thought, "Was it damaged while attempting to make this horseshoe while the machine was out of adjustment?"

The Centennial machine differs from both the 1857



Figure 8.21. The Centennial machine and display stand seen from the operator's side (photo by John Yost, New York State Museum).

Under the horseshoe machine was once a small drawer to catch the miniature horseshoes as they came out of the machine. The box at the bottom held the tin rods of stock. Wrenches, an oil-can and spare dies kept with the machine in a separate box are displayed on the stand.



Figure 8.22. The Centennial machine from the visitors' side (photo by John Yost, New York State Museum).

patent and the 1865 re-issued patent. I have had several theories about its origin based on the fact that Henry Burden died on January 19, 1871, several years before the exhibition. I wondered if perhaps he was not the one who actually designed this version of the machine. His son, James A. Burden, after all, was also a prolific inventor, and studying his horseshoe patents, I could see the father in the son's work. Eventually I found a reference that cleared up this mystery. Beverly Gordon (1998, 82) states that a booth was operated by the Burden company at several of the "Sanitary Fairs" held in major cities during the Civil War in order to raise funds for the United States Sanitary Commission.

The booth exhibited not only horseshoes but also examples and illustrations of other Burden products. The exhibit included a model horseshoe machine that would produce miniature horseshoes as lucky charms. Gordon illustrates a photograph of the Burden booth at the Second Northwest Fair in Chicago, showing what appears to be the "Centennial" machine, evidence that the model was produced during Henry Burden's lifetime, at least as early as 1863. It would then be a slightly earlier design, incorporating refinements made since 1857, including the shift to the separate punching and finish-swaging operations but predating the design illustrated in the 1865 patent re-issue.

I had spent years developing and improving my models based on the patent documents in order to understand how the processes worked, and the rotary machine took the longest of all. One of the best things for me in finding Burden's original models is that when I could compare my model to them I found that they were very close in design and operation to the model I had developed.

Over the years I had spent developing my models we had gone from not knowing "How did they make the horseshoes?" to studying the process, building working models and locating two actual examples of Henry Burden's horseshoe machines. I would like to say the search is over, but it's far from true. My horseshoe machine models are not perfect reproductions of the patent drawings. It's a learning process and I'm still learning new things about Henry Burden's horseshoe machines and the man himself. I'm still searching and who knows what we will find next.

ACKNOWLEDGEMENTS

I would like to thank Dr. P. Thomas Carroll, director of the Hudson-Mohawk Industrial Gateway at the Burden Iron Works Museum for inspiring me to build these models by saying, "I would give my right arm for someone to make a working model." I have yet to collect on

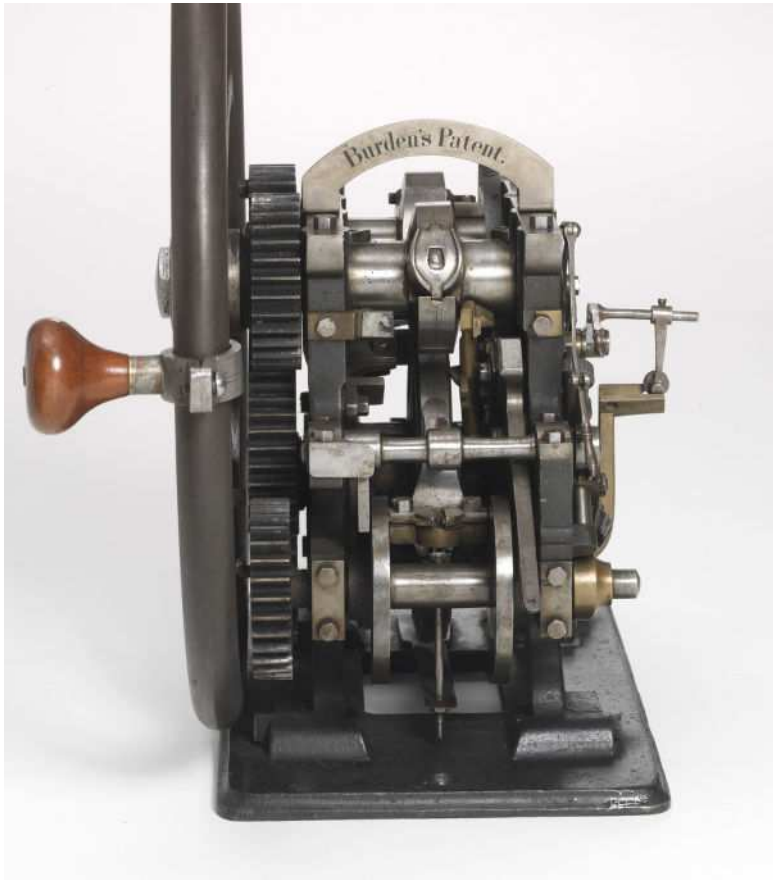


Figure 8.23. The Centennial machine from the front. A die on the upper roll is visible, with its relief notch insuring that the horseshoe was retained on the lower large wheel dies. Some interior damage is visible just below the upper roll (photo by John Yost, New York State Museum).



Figure 8.24. The Centennial machine from the feed side. The large beveled gear on the brass movable frame that once drove the feed mechanism is missing. The "indicator" is fitted with a small wheel at the bottom (photo by John Yost, New York State Museum).



Figure 8.25. The Centennial machine from the drive wheel side showing the 1:2 ratio of the gears. The gear at lower right powered the bending tongue and feed mechanism. The hand crank would have been replaced with a large belt-driven flywheel on the full-sized version (photo by John Yost, New York State Museum).

Figure 8.26. The Centennial machine from the rear, showing the large wheel that carried the lower dies (not visible). The line machined on the large wheel was to aid in adjusting the swaging dies to the center of the wheel. The "V" shaped scraper that pulled the shoes free to drop into the flattener is visible below the large wheel, but the flattener itself is hidden behind the "U" shaped yoke at the bottom (photo by John Yost, New York State Museum).



that debt! I would also like to thank him and Michael Barrett, curator at that museum, for providing materials related to the history of the machine and allowing me to use a copy of the Burden horseshoe brochure and a photograph of one of their Burden horseshoe kegs. I would also like to thank Tammis K. Groft, Executive Director and Chief Curator at the Albany Institute of History and Art, for graciously allowing me to study Henry Burden's 1857 patent model and Alison Munsell of that institution for taking photos of the model for me to use in this article. Also, I would like to thank Dr. Robert Weible, Chief Curator of History Collections at the New York State Museum, for allowing access to the "Centennial" horseshoe machine model, Jeff Stringer for arranging for me to examine it in the Amsterdam warehouse of the State Museum and bringing it for exhibition at the symposium, John Yost for photographing it and Andrew Meyer for making the videos of my models in operation. I would also like to thank Marty Pickands of the New York State Museum's Cultural Resources Survey for hosting the symposium and encouraging me to write this article.

Most of all, I would like to thank my wife, Ann Marie Rawls, for her years of support and patient tolerance of my obsession, and my grandson, Christian Deno, for his enthusiasm.

REFERENCES

- Beach, A. E., ed. 1873. *The Science Record*. New York: Munn & Co., Office of the "Scientific American". (Cited on page 147).
- Benton, C. J. G. 1862. *A Course of Instruction on Ordnance and Gunnery; Compiled for the Use of the Cadets at the United States Military Academy*. New York. (Cited on page 149).
- Burden, H. 1835. Making Horseshoes. U.S. patent 9250X, filed Nov. 23, 1835. (Cited on pages 146–150).
- . 1843. Improvement in Machines for Making Horseshoes. U.S. patent 3,261, filed Sept. 14, 1843. (Cited on pages 153–155).
- . 1857. Improved Machine for Making Horseshoes. U.S. patent 17,665, filed June 30, 1857. (Cited on pages 154, 155, 157–160).
- . 1862. Improved Machine for Making Horseshoes. U.S. patent 35,746, filed July 1, 1862. (Cited on pages 162, 165).
- . 1865. Machine for Making Horseshoes. U.S. patent RE1,998, filed June 13, 1865. (Cited on page 160).
- Byrne, O., ed. 1852. *Appleton's Dictionary of Machines, Mechanics, Engine Work and Engineering*. New York: D. Appleton & Co. (Cited on page 152).
- Cooper, C. C. 1991. *Shaping Invention*. New York: Columbia University Press. (Cited on page 160).
- Cunningham, A. K. 1951. "Hoofbeats of Destiny." In *The Fascinating World of Early Tools and Trades: Selections from the Chronicle*, 1991st ed., edited by E. Pollack and M. Pollack. Apple Valley, Minn: Astragal Press. (Cited on page 161).
- Deyrup, F. J. 1948. *Arms Makers of the Connecticut Valley: A Regional Study of the Economic Development of the Small Arms Industry, 1789-1870*. Vol. 33. Smith College studies in history. Northampton, Mass.: Smith College. (Cited on page 149).
- Fisher, S., ed. 1871. *Reports of Cases Arising Upon Letters Patent for Inventions Determined in the Circuit Courts of the United States*. Second Edition. Cincinnati, Ohio: Robert Clarke & Co. (Cited on page 160).
- Gates, A. 1981. "For Want of a Shoe—Henry Burden's Horseshoe Machine." *Civil War Times* 20:5. (Cited on pages 145, 154).
- Gordon, B. 1998. *Bazaars and Fair Ladies—the History of the American Fundraising Fair*. Knoxville, TN: University of Tennessee Press. (Cited on page 167).
- Hebert, L. 1836. *The Engineer's and Mechanic's Encyclopedia*. London: Thomas Kelly. (Cited on page 147).
- Orberg, E. 1915. *Spur and Bevel Gearing*. New York: The Industrial Press. (Cited on page 152).
- Proudfit, M. E. B. 1904. *Henry Burden, His Life and a History of his Inventions Compiled from the Public Press*. Troy, N.Y: Parfaets Press. (Cited on pages 145, 147, 160, 166).
- Rawls, R. 2005. "Henry Burden's Horseshoe Machines." *Society for Industrial Archeology Newsletter* 34 (2): 14. (Cited on page 152).
- . 2008. "Burden Horseshoe machine update." *Society for Industrial Archeology Newsletter* 37 (4): 5. (Cited on page 153).
- Reznek, S. 1969. *Burden Iron Works*. Historic American Engineering Record NY-7. Washington, D.C: National Parks Service, Office of Archeology and Historic Preservation. (Cited on page 145).
- Vogel, R. M., ed. 1973. *A Report of the Mohawk-Hudson Area Survey*. Smithsonian Studies in History and Technology. Washington DC: Smithsonian Institution. (Cited on page 146).
- Walker, F. A., ed. 1880. *United States Centennial Commission, International Centennial Exhibition, 1876. Reports and Awards*. Philadelphia: J.B. Lippincott & Co. (Cited on page 166).
- Weise, A. J. 1886. *The City of Troy and Its Vicinity*. Troy, N.Y.: Edward Green. (Cited on page 146).