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Early Copper Smelting In the Lake Superior Region:A Case Study of the Isle Royale and Ohio Mining Company, 1846-1852

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EARLY COPPER SMELTING IN THE LAKE SUPERIOR REGION: A CASE STUDY OF THE ISLE ROYALE AND OHIO MINING COMPANY, 1846-1852

By

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I would also like to give a special mention to Isle Royale itself, but will allow the words of Aboriginal poet Pauline Johnson to do it justice instead:

"Land of the silver birch, home of the beaver.
Where still the mighty moose wanders at will.
Blue lake and rocky shore, I will return once more."

Abstract

The lodes of native copper found in the Lake Superior region presented new opportunities for investors and miners alike. Making these opportunities pay required the unique challenges presented by the region's remoteness and unique geological formations to be overcome. A primary way in which these newly emerging companies overcame these challenges was through successful vertical integration of the copper refining industries. Smelting came to the region early, but met with little success as the workers first needed to retool their skills and experiences to the demands of the region's mineral deposits. In 1848 the Isle Royale and Ohio Mining Company commenced their short-lived copper furnace operation near the settlement of Ransom on Isle Royale. The archaeology and history of this furnace provides insights on a newly emerging industry, technological adaptation, and social and labor relations within this remote but rapidly emerging industrial frontier.

Chapter 1 – Introduction and Research Design

Introduction

Reassembling the social and material contexts of frontier living in the United States using archaeological and historical methodology is both challenging and rewarding. Frontier living creates an environment that is characterized on one hand by scarcity and isolation and on the other hand by plenty and the formation of unique community structures. The scarcity is reflected in the lack of goods and services on the frontier, which were once taken for granted elsewhere. The plenty is often reflected in the form of vast amounts of untapped natural resources such as timber, metals, and animal game. This duality of scarcity and plenty presents a number of challenges to the practicing archaeologist.

The industrial age and the westward expansion of the United States provides us with an opportunity to study complex human socio-technic systems in these environments of isolation. In many senses, industrial archaeology on the frontier can be more complicated than frontier historical archaeology. Chiefly, while the human agents participating in frontier industry need to be concerned with day-to-day living and survival, this is not enough in the case of industries along the frontier, as the various enterprises will not survive if they fail to successfully reproduce capital. Therefore, the endurance and ingenuity required for human survival on the frontier must then be transferred to the industrial process. This creative process must be directed towards finding quick but efficient solutions and local alternatives to those things once taken for granted and now rendered uncommon by the isolation of the environment.

The technology of these industrial settings are complex and often highly demanding in the amount of attention required by the workers to ensure that the machines and processes run without error. This is quite true in many of the stages of mining and ore processing, but is best exemplified by the processes of smelting metals and, of particular interest to this thesis, copper. The complexity of smelting demands that skilled labor be present. While many stages in the smelting process can be completed

with relatively unskilled labor, the monitoring of the furnace itself cannot be left to untrained eyes. At the beginning of the industrial age, this knowledge was passed down through apprenticeship. As the years wore on and people began to understand smelting in a scientific sense, this informal process of learning through apprenticeship was replaced with university coursework topics such as mining, engineering, and metallurgical studies. Our ability to understand how well these early metallurgical engineers understood the science behind their craft can be facilitated with formal archaeological investigations. This is exemplified well in the archaeology of the smelting works of the East Tennessee Iron Manufacturing Company in Chattanooga, Tennessee (Council, Honerkamp, and Will 1992).

Mining is an isolating business and is frequently a driving force behind frontier expansion, as mining locations have to be established where the ore bodies lie in order to deliver those minerals to already established industrial and commercial centers. The industrial communities that form in these places reflect the conditions of this isolation and become “islands of industry in a sea of trees” (Lankton 2010:29). While this analogy was intended for the Lake Superior copper region, the core of this statement holds true for most American mining ventures.

Mining is also a costly business, demanding large investments of capital to sink the actual mines and to fund the acquisition of industrial machinery. Copper mining on the frontier faces a large obstacle in that copper fetches nowhere near the price of silver or gold; thus it has to be mined and shipped to market in large quantities in order to be profitable. A primary tactic of copper companies that are highly successful in reproducing capital is to concentrate and refine the copper as much as possible before shipping it away for market or further refinement. For instance, there was a strategy of using a smelter to produce matte of around 60% copper and 40% non-metallic minerals and exporting that to more industrialized locations in England or the Northeastern United States. This approach was used by the relatively primitive (in an industrial sense) Chilean copper industry in the first half of the 19th century. It was this Chilean copper that initiated the first large copper smelting boom in the United

States (Hyde 1998:22). The ultimate goal of most copper firms is to control all refinement stages from ore to market-ready copper and to have these stages all carried out as close to the mines as landscape and society allow. In isolated areas this tactic significantly reduces shipping cost and could be a primary determinant in profitability. What we see in the construction of the copper furnace on Isle Royale is an early attempt to increase the intensification of Lake Superior copper refinement in the Lake Superior region itself.

Even with the massive boulders of pure fissure copper that characterized the first successful mines in the area, the poor navigation routes quickly brought concentration techniques to the forefront of investor discussion. In the beginning the fissure mines of the region were satisfied with stamping the copper and shipping the fines and reduced masses away in barrels over Lake Superior. The rich copper content that the fissure mines yielded allowed the mines to pay dividends to investors, or more commonly in the formative years re-invest capital to boost production, while being content to ship their barrel copper to be smelted in established industrial centers such as Baltimore and Boston (Hyde 1998:22). This was the tactic employed by the Pittsburgh and Boston Mining Company to smelt the mineral coming from their Cliff Mine, which established a smelting work at Pittsburghh (American Railroad Gazette 1848:582). However, even the well-established smelting works back east took time to wrap their heads around the smelting of native copper. The Point Shirley Works of Boston first attempted to employ a reverberatory furnace to directly smelt large pieces of mass copper, however this damaged the furnace lining causing the Shirley Works to switch tactics. They then tried to cut the pieces of mass copper into smaller chunks and smelt them in a blast furnace, however the cost of labor required in cutting the copper up drove the smelting fee up to $80 a ton (Morin 2013:25). By 1850 the problems with melting native copper were starting to be solved. In 1850 an independent contractor opened in Detroit. John Grout's Waterbury and Detroit works implemented a joint reverberatory and blasting works to work Lake Superior copper. The reverberatory was used to produce a marketable copper, while the blast furnace was used to smelt the slags and free the copper trapped within. The joint use of

reverberatory and blast furnaces by Grout would set a trend in American copper smelting that would last for seventy-five years (Morin 2013:26-27). The fissure veins in the Lake Superior region are unique but the more profitable grades of rock in the region (amygdaloidal and conglomerate) were opened to mining the need to bring furnaces to the Keweenaw soon became apparent, as these grades of rock had significantly more non-metallic minerals present in them (Morin 2013:23).

In a testament to the difficulty in profitably mining and refining copper on the frontier, the region saw one of its first copper furnace's in one of its most isolated places: Isle Royale. However it should be noted that in a sense Isle Royale is both isolated and not isolated. The Island shares a number of traits with the other areas of Michigan, open seasonally, that had begun to attract miners. All these areas could only be accessed by boat traffic during some months of the year, especially in the early days prior to railroad development. During the initial phase of copper speculation, the places most truly isolated were the inland regions of the Keweenaw and elsewhere in the Upper Peninsula. Isle Royale's isolation is unique in that, unlike areas such as Copper Harbor, when the lake freezes up, the island loses all contact with the outside world for between five to six months.

The copper industry of Isle Royale, which produced no firms of great success, often takes a back seat in the larger historical narrative of the Lake Superior copper region. This is somewhat disappointing to see as Isle Royale had a significant role during the opening of the region to mining. Many of the firms that arrived on the island quickly began working on ways to overcome the difficulties presented by the island's isolation. By 1847 the Siskowit Mining Association (later the Siskowit Mining Company) had followed in the footsteps of its mainland counterparts and erected a gravity stamp mill to produce fines that they hoped could be shipped at a profit. They were followed shortly after by another enterprising firm: The Isle Royale and Ohio Mining Company (IR&O). Isle Royale and Ohio quickly established the Ransom location in 1847 and its furnace operation in 1848. So it was that the two firms, Siskowit and the Isle Royale and Ohio, sharing complementary technologies, entered

into an agreement in which the Isle Royale and Ohio Mining Company would melt the stamped material of the Siskowit Mining Company (Whittlesey 1847:). At this time the melting of native copper ores was unprecedented. While this may not have been a major issue for early melting of the large masses of float copper performed in well-established industrial centers in the American Midwest, Isle Royale mining tended to target amygdaloidal copper deposits, meaning that significant quantities of non-metallic minerals would have to enter the furnace. The melting on Isle Royale, among the earliest in the region, served as the bud of what would eventually become a blossoming copper production industry on the mainland.

Site Location and Geology

Isle Royale (Figure 1.1) is a national park unit located in north-central Lake Superior. The archaeological site excavated by the 2015 Michigan Technological University is officially designated by the State of Michigan as 20.IR.0043 Ransom Mine Site. This site sits on the southeast side of Isle Royale in the Mott quadrangle, Eagle Harbor Township, Keweenaw County in the State of Michigan. 20.IR.0043 is in close proximity to another archaeological site: 20.IR.0045 – the Daisy Farm site (Figure 1.2 and 1.3). Ransom Mine represents a component of the Island's industrial past, while Daisy Farm represents a component of the Island's pre-contact past. Daisy Farm's topography has made it an ideal location for inhabitation for centuries and numerous pre-contact finds have been made in the area including recent surveys by the Midwest Archaeology Center between 1987-1990 (Clark 1995). The name Daisy Farm dates to the era of the early twentieth century when the Island was a popular resort location. The Daisy Farm area was used to grow flowers for the local establishments that catered to the Island's tourists.

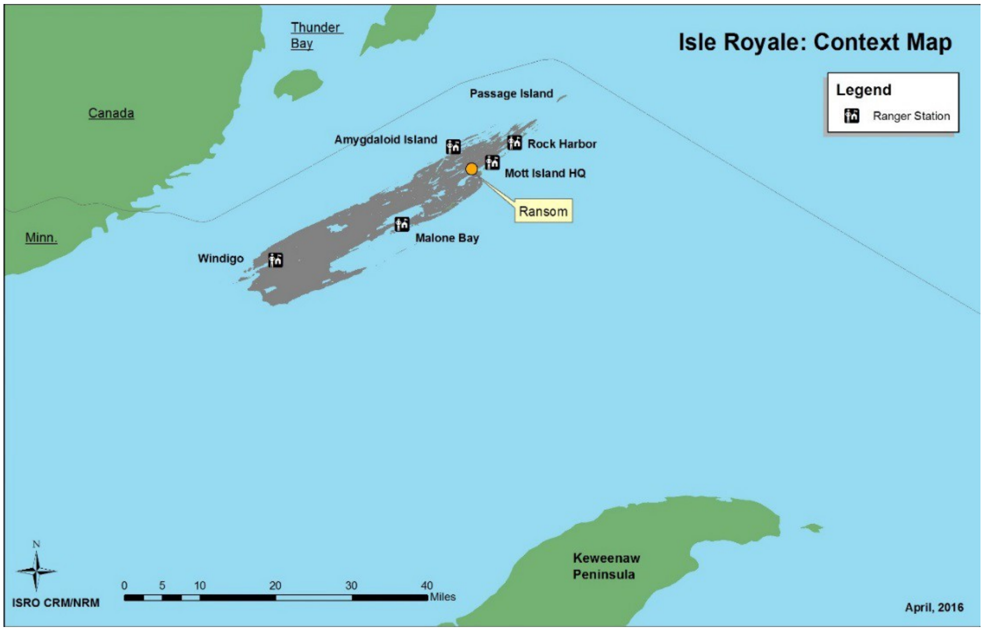

Figure 1.1 Location of Isle Royale within Lake Superior. Reproduced with permission by the National Park Service.

Figure 1.2 Daisy Farm as it appears today. Reproduced with permission from the National Park Service.

Larry Lankton organizes the mining the Lake Superior region as being carried out in three phases: prospecting, development and production (Lankton 2010:19). The mining which occurred on Isle Royale during the initial years of the region's opening was mostly dedicated to the prospecting stage. However, firms like the Isle Royale and Ohio Mining Company and the Siskowit Mining Company reached the second, or

development stage, in which enlarged crews opened up the prospects deemed most potentially profitable (Lankton 2010:19).

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Isle Royale exhibits two distinct geological rock formations: igneous rock and sedimentary rock (Figure 1.4). The igneous rocks of Isle Royale are composed mostly of highly homogenous volcanic flood basalt (Huber 1975:10). It is these ancient flood basalts which contain the Island's copper bearing amygdules and are classed as Portage Lake Volcanics (Huber 1975:13). Although mass copper was removed from Isle Royale, the majority of the Island's copper deposits are amygdaloidal, not conglomerate or mass, and the companies that opened mines on the Island were gambling on the same "subterranean lottery" as their mainland counter parts (Lankton 2010:8-9). The igneous rock formations on occasion exhibit pyroclastic flows, made different from the basalt layers in that they are laid down at a much faster rate (Huber 1975:14). The conglomerate rocks are comprised of consolidated silt and sand particles mostly created through the impact erosion events had on the basalt formations (Huber 1975:13). All of the Isle Royale and Ohio Mining Company mines were located on the amygdaloidal basalt, while the sedimentary Copper Harbor Conglomerate would have provided an excellent source of building materials.

The Geology of Isle Royale

Figure 1.4 Geology of Isle Royale. Portage Lake Volcanics shown in red, Copper Harbor Conglomerate shown in orange. Maps from the United States Geological Survey.

The name "Ransom Mine Site" should be addressed, along with the other nomenclature used in this publication. None of the mines operated by the IR&O had this name. The term Ransom comes from the name of Leander Ransom, the man the company selected to oversee the initial development of the location and acted as the company president in 1849. Little remains of the small settlement on the surface, and the IR&O mines are located within a several mile radius of the furnace. While the Park Service uses "Ransom Mine" to refer to the archaeological resources of the industrial mines and the furnace, I will employ different terminology. Ransom will only refer to the small settlement on Rock Harbor that acted as a hub for the IR&O Company's mines. Only a few of the mines opened by the IR&O mine have names that survived in historical knowledge, including the Lucky Bay Mine, Epidote

Mine, Datolite Mine and two other which remained unnamed, or had names which were not recorded (Foster and Whitney 1850:143-144). In general these will be referred to as the IR&O Company's mines. When discussed, the furnace will be referred to as the Isle Royale and Ohio Mining Company furnace or just simply as the furnace.

Project Background

The presence of a furnace was first significantly documented in 1986 when Michigan Technological University (MTU) conducted a survey of archaeological resources for the Park Service. The furnace site became the focus of several mapping exercises designed to facilitate the education of students during that year's field school for the Industrial Archaeology program. No excavation was carried out at the site that year and surface artifacts were noted but not retained.

The excavation of the IR&O copper furnace occurred in the summer of 2015 as part of that year's MTU field school for the Industrial Archaeology program. Seth DePasqual, Isle Royale's Cultural Resource Manager, had expressed interest in partnering with MTU for the purpose of excavating this archaeological site. The opportunity arose in conjunction with a separate MTU contract to conduct a National Landmark of the Minong Mine area, well known for its pre-contact mining pits. The students and staff who participated in that project also conducted the archaeological excavations at 20.IR.0043. Between the 17th and 22nd of May, the author traveled to the island to perform a brief survey of the site in order to establish a methodological approach for the excavation (figure 1.5). Excavation began on the 27th of May and ran until the 11th of June, and again on the 18th and 19th of June.

Research Design

The research into the IR&O furnace will have characteristics similar to other traditional archaeological assessments of industrial settings along with a study aspect revolving around archaeometry. Both of these approaches will be used to correct current weaknesses in the historical narrative of the Lake Superior copper

region and in our application of the archaeological sciences to the study of industrial archaeology. It is a premise of this work that the role played by the Isle Royale mines is undervalued in the current historical narrative of the Lake Superior copper region. Furthermore, the role played by the IR&O Company during the initial years of lake superior copper mining is central to re-evaluating the role that Isle Royale played in the history of this region. In experimenting with melting native copper, the IR&O made a valuable contribution to the industry. Their operation, like all separate Island mining endeavors, was economically unsuccessful, but the knowledge required to successfully exploit native copper could not have come without ambitious attempts such as these to do so.

Smelting entered the industrial age as a mysterious craft but exited it as one of the central pillars of the chemical sciences. The chemistry of smelting became an important topic in both the professional and academic spheres of the industrial age, and a major component of these discussions was the formation of slag. In iron smelting, the chemical makeup is comprised of much more than pure iron content and needs to consider items such as carbon content and the ductility of the metal. The chemistry of the finished product of copper smelting is simple; it is pure copper, and all other elements should be absent. The chemistry of the copper slags is much more complicated than that of the pure copper and changes during and between smelts. If understanding the chemical makeup of copper slags was of vital importance for forgemasters of the industrial age, can this same material somehow serve industrial archaeology?

Figure 1.5 Preliminary visit to the site. May 2015

What was the layout, design and technological operation of the IR&O furnace?

Many questions surround the copper furnace erected by the IR&O Company, and no historical source describes the operation in specific details. As mentioned before, the erection of the copper works on Isle Royale represents a step forward in Michigan copper production as it contributed to the sum of technical knowledge regarding the working of this geologically unique copper source. A central context to understanding why the IR&O Company furnace was significant and thus deserve our attention comes from understanding that native copper mining was an industry in its infancy during the decade of 1840. The men sent to work these mines and furnace had little idea what to expect from this endeavor. No doubt analogies were drawn from existing mining and smelting knowledge. The assumptions inherently made about the smelting of sulfide and oxide copper ores could not be wholly transmitted to the native copper industry. Old knowledge had to be reassessed, and this would only come through experimentation with the technologies derived from this knowledge.

The copper in the region is "native" copper, meaning that it is not chemically bonded to other elements. Therefore the process is better described as "melting" rather than "smelting". Smelting implies a much more complex chemical reaction that separates copper from any elements it may have been bonded to prior to its introduction to the furnace. In the case of Lake Superior copper, no such other elements exist, and the copper needs only to be sufficiently heated to reduce it to a state in which it can be profitably cast.

Prior to the introduction of the Bessemer furnace, the two primary furnace types of employed for copper smelting were the cupola style blast furnaces typical of German smelting operations and the reverberatory style of furnace characteristic of the Welsh smelting operations (Oliver 1956:585). Both these furnaces had their advantages and disadvantages, but when the IR&O Company opened its furnace in 1848, it was unknown how either of these technologies might best fit in the process of melting native copper.

The cupola style blast furnace consists of a round or square, upright furnace constructed of iron, brick and/or stone (Figure 1.6). When the cupola had been constructed and was ready to be put into blast, specific steps had to be taken. The cupola would be loaded from above, with the use of a structure known as a charging deck. The charge placed into the stack consisted of a combination of fuel, ore, and flux. In the case of later Lake Superior copper smelting, the ore was either mass copper or stamp work, the fuel was 1/5th anthracite to create a reducing environment along with 4/5th coke for heat; lime flux could or could not be added as Lake Superior copper mineral was generally self-fluxing (Hofman 1914:362).

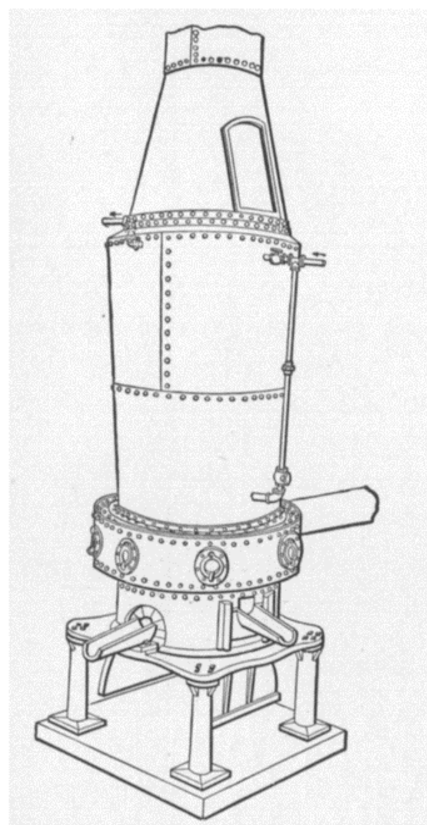


Figure 1.6 An iron plated cupola. From Hofman 1914:359

However, when parallels are drawn from the iron and steel industries of the 1840s, coke was often difficult to obtain in that sufficient quantity (Gordon and Malone 1994:155). Likely the operation on Isle Royale was using pure charcoal. However, charcoal lacks the weight of coke, and a weightier charge is preferable as it is more inclined to pull itself down through the slag already present and enter the hearth area where the separation of copper can occur (Peters 1887:249). In most cases both the slag and copper are tapped off periodically. The slag is best run off using water to granulate and carry if off into a larger body of water such as a lake or river (Peters 1907:163). If this is not an option, tapping it into large pots and dumping it off site prior to its complete solidification is required. The copper is normally tapped into ladles and cast into ingots. However the historical and archaeological records seem to indicate that the copper produced by the IR&O Company was pig copper. The furnace would have been tapped, and the molten copper would have flown directly onto a floor of sand and pooled into molds present in said sand. These two approaches are not mutually exclusive, and copper tapped into a ladle can be cast in sand, or in shoe or box molds.

The reverberatory furnace (Figure 1.7) differs greatly from the cupola in construction and operation. A reverberatory furnace would be a box-like structure, composed of brick and/or stone and reinforced with iron or steel fittings; the ceiling would be arched and constructed of refractory bricks (Willies 1991:102). Heat was generated by burning fuel in a fire-box. A fire-box was a smaller fore area of the reverberatory furnace where fuel was placed on a metallic grate and burned. As it burned the ashes would fall through the grate and into a pit below known as an ash-pit (Willies 1991:102). A large chimney at the rear if the structure, connected to the hearth by a flue, would create a strong draft, pulling the hot gases generated in the fire-box through the hearth area, where the ceiling would reverberate the heat onto the charge (Willies 1991:104). The charge was loaded into the furnace through an opening in the roof, then sealed by a covering of reverberatory ceramic (Howe 1885:44). Once charged and brought to heat, the furnace is rabbled or stirred with a wooden pole every few hours to mix up the molten charge; this process exposes non-smelted parts

of the charge which are protected by the molten slag and copper to the atmosphere of furnace (Howe 1885:44). To remove the slag, the furnace is slightly cooled, as to lower the temperature of the slag and decrease its viscosity Slag is then drawn out the side, through an opening placed as close to the chimney as possible, as to avoid a significant loss of heat. The slag flows into troughs of sand arranged so that the slag must pass over each ridge prior to entering the next trough, this facilitates the separation of any copper from slag that may have also been carried out during this tapping (Howe 1885:46). Once the slag has been skimmed the tap hole is opened, allowing the matte to be cast in sand or iron molds (Howe 1885:47).

A central question then becomes which type(s) of furnace were being employed at this site. American copper smelting primarily tended to use reverberatory and blast (later Bessemer) furnaces side by side for smelting all types of copper ores (Oliver 1956:585). Evidence for a cupola style furnace is strongly compelling. However, the evidence for the presence of reverberatory style furnace here is less compelling; however enough data exists to prevent ruling out the possibility. One of the undertakings of this document will be an assessment of the evidence available to support the presence of both types of melting.

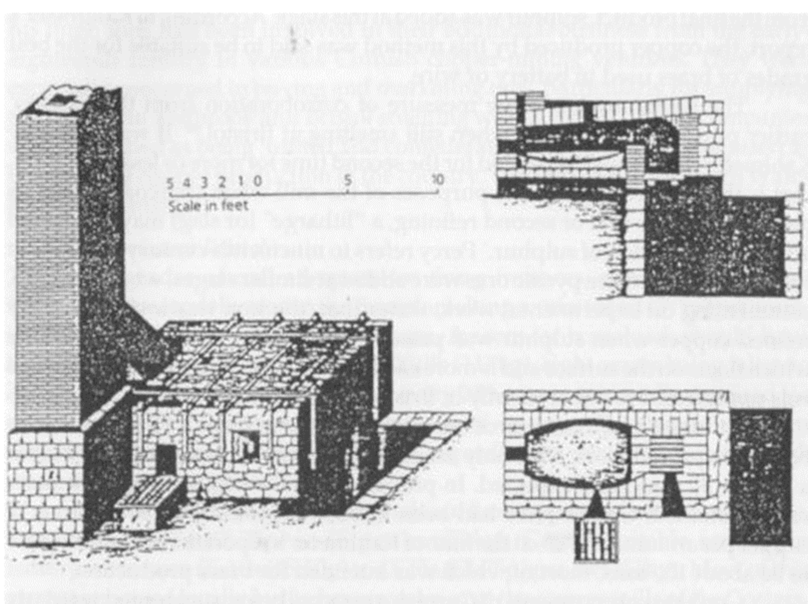


Figure 1.7 Typical layout for a reverberatory furnace. Original by Schluter 1738. From Day 1991:145.

How does this site fit into the historical narrative of America's first copper region and American copper smelting?

Isle Royale often takes a back seat in the narrative of America's first copper region. An assessment of the indexes of the authoritative texts on the history of the region reflect this. Two of Larry Lankton's books on the subject, *Cradle to Grave* and *Hollowed Ground* provide only a limited discussion of Isle Royale mining. *In Beyond the Boundaries*, Lankton offers a more detailed look at the subject of Isle Royale, focusing particularly on the isolation of the island and the impact that it had on the people attempting to settle it during the formative years.

David J. Krause provides a better treatment of the subject, discussing various aspects of the island in greater detail than Lankton; however, Krause does not detail either the IR&O Company or the important step forward their attempts to bring smelting to the region represent (Krause 1992). Bode Morin, does mention the Isle Royale and Ohio copper melter, noting that it is the only of the early copper furnaces in the Lake Superior region to retain any structural components (Morin 2013:157). The copper mining on Isle Royale needs to be reassessed as an important stage in the development of the larger Lake Superior copper region, and the IR&O copper mining and furnace works deserves to be a central part of that story.

The blending of two different cultural approaches to smelting, German and Welsh, produces a system that is uniquely American in that it reflects America's role as a cultural melting pot. The layout of the Michigan Smelter in Houghton, Michigan functions as a good representative of this blending (Figure 1.8). An assessment of known American smelting operations prior to the opening of the Lake Superior region supports the idea that American smelters employed exclusively one type of the smelting technologies discussed above, although as a trend, 75% of pre-1845 copper smelters were blast and 25% were reverberatory (van Lingen 2002:160-161). This approach of using one or the other type of furnace seems to change around the middle of the 1840s. In placing the IR&O copper works into the larger narrative of American copper smelting, it is important to know if it was a product of the pre-1845 style of

employing only one type or if it represents part of the new trend of employing both types of copper smelting.

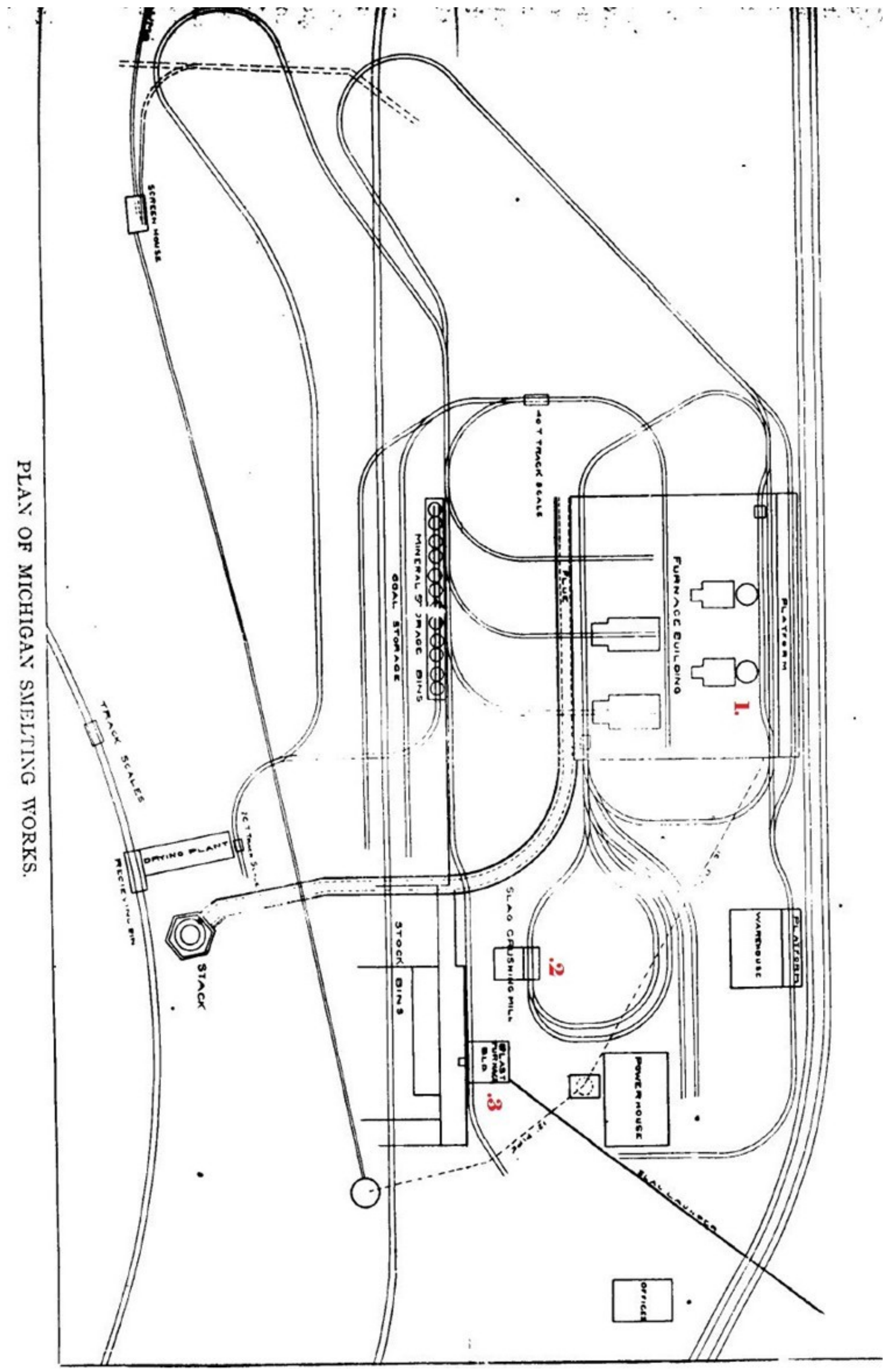


Figure 1.8 A plan view of the Michigan Smelter. Houghton, MI. 1905. The stampings would arrive by train and would be dumped into 50ft reverberatory furnaces (1). The skimmed slag would then be crushed (2). The crushed slag would be sent to a blast furnace. Mining and Engineering Journal Volume 79:443.

The man selected to run the furnace by the IR&O Company was known as Columbus Christopher Douglass, or C.C. Douglass. Douglass was the nephew of the famed geologist Douglass Houghton, and travelled with his uncle during the early geological surveys done of the Lake Superior region (Sawyer 1911:1532). After the IR&O Company ceased operation in 1849, Douglass traveled to the mainland and in 1852 the failed Island venture transfer into a successful successor company known as the Isle Royale Mining Company. In telling a history of the IR&O with this in mind, it can be shown again that the Island's brief mining history played an integral role in shaping the region and its copper industry.

What can we learn by performing a phase analysis of copper bearing slags from the industrial era?

The archaeological work conducted on Isle Royale provides an opportunity to perform an archaeometric analysis of the slags produced by the copper furnace. Currently, the literature on archeometric analyses of copper bearing slag is in want for the industrial age, and thus presents an opportunity for this research to break new ground in that field. Much more common in historical and industrial archaeology are studies of slags produced by the steel and iron industry.

One of the tasks of this research program a phase analysis of the slags produced by the furnace on Isle Royale based on x-ray diffraction analysis. X-ray diffraction was chosen to complement the crystalline structure of the glassy slags recovered during the excavation. This will serve multiple purposes. The chemical makeup of slags produced by copper smelting drew considerable attention during the industrial era, with some authors devoting entire chapters to the subject (Peters 1907:339-400). This has resulted in a significant body of literature being produced on the subject that can be drawn on by this research. However, the unique nature of the Lake Superior copper deposits provides a significant obstacle to the utilization of these historical sources. Since native copper deposits are so rare, detailed discussions regarding their melting and the chemical compositions of their slag are few and far between. Regardless, this chemical analysis will provide clues as to the melting process

employed on the island. Additionally, native coppers are not chemically bonded to other elements, such as sulphur or oxygen, and the uniqueness of mineral body in the region may be reflected in the slag samples. This research will build upon other studies of industry using x-ray diffraction and findings of this phase analysis can also offer a reflection of the usefulness of this technology to the study of our industrial past.

Thesis Framework

This document will be structured in such a way as to allow a valid synthesis of the archaeological, historical, and scientific research conducted. Section II will provide the historical contexts of the research project. The history of the Copper Country as a whole will not be addressed in great detail since this has been well established in the texts that have been listed above and elsewhere. The historical context will center on Isle Royale and how it articulates with the historical narrative of the Lake Superior copper mining region in its formative years. The site's history will be placed in the tradition of American copper smelting during the 1840s. To tell this story, specific details will be given relating the typical architecture and operating sequences of both blast and reverberatory furnaces during this time. Finally, Section II will contain a concise history of the Isle Royale and Ohio Mining Company. Drawing mostly on archival sources, the story of that company will be recounted. In order to better understand the conditions present at furnace site during the excavations, archival sources will be drawn on to fill in as many gaps as possible between the abandonment of the furnace and the excavations conducted.

Section III will present information about the archaeological investigation that occurred in 2015. This will satisfy the requirement of any archaeological endeavor to describe the methodology employed, and will include information relating to what was found during the excavation and the ways in which the strata of the various units articulate with each other. The artifacts will be itemized and presented in Appendix 1.

Section IV will be dedicated to a discussion of the x-ray diffraction technology that was employed and the methodology employed in selecting slag samples used for the research. The results of the study will be presented in this section followed by a discussion on what the technology may have to offer other industrial archaeologists.

Section V will be dedicated to a synthesis of the historical, archival, and archaeological research discussed in the previous sections to provide an assessment of the probable layout and operational procedures of the IR&O furnace. The physical layout of the furnace as observed during the excavation will be contrasted to separate American copper smelters.

Section VI will be dedicated to the conclusion of the research project. This section will simply reiterate the major research questions of the project and the conclusions that were provided by the various avenues of research followed.

Chapter 2 – Historical Background

Introduction

This research draws on information from both primary and secondary sources. The primary sources can be broken down into three categories: personal accounts, professional reports, and trade journal articles. The personal accounts are informal firsthand observations from some of the people who lived and worked on the Island at this time. The professional reports consist of official publications made by the firms working the Island and Government issued publications. The official publications by the firms tend to present the operations in the best possible light, whereas the Government issued publications are more focused on objective observations about the Island. It is fortunate for the history of this region that Josiah Whitney and John Foster, contemporary experts of mining and geology, authored works on the region on the Governments behalf. The Primary trade journal used here is the *American Mining Journal and Rail-Road Gazette*. A publication aimed at people involved with a wide range of industrial activities that contained multiple reports on the progress of copper mining in the Lake Superior region.

In one of the definitive secondary text on the subject, Robert James Hybels' *A Narrative of the Lake Superior "Copper Fever" 1841-1847*, the Island is only mentioned in passing, and no serious discussion of the industrial activities that occurred on the Island is presented. One factor that no doubt influenced this exclusion is the date range which Hybels choose to study. Hybels framed his study so that it would end at the passing of an Act by Congress and President Polk in 1847 to establish a land office for the sale of mineral lands in Michigan. However at this time most of the mines on the Island were still in the prospecting phase in 1847. The pattern that mining followed on the Island mirrors the same traits as mainland mining during the opening of this region, which was characterized by a high degree of experimentation and prospecting guesswork. Adding a more detailed history of Isle Royale to the wider history of the regions opening with the IR&O Company treated with the attention to detail that the mainland firms have received in past scholarly work, will add more depth to our historical understanding.

To date, perhaps the best treatment of Isle Royale's role during the America's first copper rush can be found in *Narrative History of Isle Royale National Park*. Having been composed by Karamanski, Zeitlin, and Derose and published in 1988, it highlights the importance the Island played in not only attracting mining firms but also some of the most educated minds in America at that time. This publication provides a paragraph or two dedicated to each of the firms on the Island during this initial boom phase of mining and discusses some of the geological features of the Island itself. The publication is part of the grey literature about Isle Royale. Much of the work that Karamanski and Zeitlin drew on came from even more grey literature produced by earlier scholars. The two drew heavily on unpublished work from Dr. Rakestraw.

While this region often falls into a historical narrative of being a frontier region, for many it had been home for centuries. The best accounts of the ways in which the native Ojibwe peoples used and viewed the Island is found in Timothy Cochrane's *Minong- The Good Place: Ojibwe and Isle Royale.* Particularly relevant to this discussion is his chapter devoted to the Ojibwe dispossession of the Island at the hands of the American government.

Two of the better sources for the discussion of native copper melting can be found in Hyde's *Copper for America* and Morin's *The Legacy of American Copper Smelting*. A more focused work such as this one is well suited to flesh out the role of the early experimentation with processing native copper that occurred on the Island, which is placed in the larger history of American copper smelting.

Isle Royale and the Opening of the Region

Isle Royale first came to the attention of the American public as a potential source of copper when Douglass Houghton made his first publication on the geology of the Lake Superior region, which included details of an 1840 visit to the Island during which he noted the presence of copper (Houghton 1840:261). Any serious attempt to

open copper mines on the Island could not come until the land had passed from Native American control to that of the United Sates.

The beginnings of industrial copper mining on Isle Royale have a slightly different origin story than on the mainland. When the treaty of La Pointe was signed in 1842, the wording surrounding the inclusion of Isle Royale was vague and unclear (Magnaghi 1977:287). Further steps in the negotiation process had to be taken prior to clearing all legal hurdles for the commercial exploitation of the Island's copper. Due to this confusion, North Shore Ojibwe, in particular the Grand Portage Band of Lake Superior Chippewa, had concluded that Isle Royale was not included in the treaty. Conversely the government agents at the Copper Harbor Mineral Agency and politicians back in Washington had the opposite opinion. The Grand Portage Band of Chippewa were not invited to the La Pointe negotiations and thus had not consented to the inclusion of Isle Royale, further it would appear that the government's negotiator, Robert Stuart, never mentioned Isle Royale either by its American name nor its Ojibwe name *Minong* (Cochrane 2009: 119-121).

This situation proved tense, and there was worry among the Americans that violence could break out in the region, catching the thirty-some miners already on the Island in 1842 in the middle of this conflict. The presence of miners on the Island at this time speaks to the poor communication between the miners, natives, and various government agencies during the initial boom; even the records of the IR&O Company report that, like the government, related investors at the time also believed that La Pointe had extinguished native claim to Isle Royale (Isle Royale and Ohio Mining Company 1847:1). The Federal Government was less willing to provoke the ire of the local natives, and the Superintendent of Mineral Lands in Michigan, General Stockton, ordered all the miners and prospectors off the Island in early August 1843 (Siskowit Mining Company No Date:1). The Grand Portage Band was in a bind; they had not signed the treaty of 1842, and thus were not eligible for treaty payments despite the fact that Americans were already exploiting their Island (Cochrane 2009:125).

Ultimately the situation was resolved without violence, however it was not resolved to the liking of the Grand Portage Band. The Grand Portage Band stated that it would acquiesce and sell the Island to the government, but would require $75,000 in payments of cash and goods over the course of twenty-five years (Cochrane 2009:125). The American government refused to budge on their belief that the Island had been ceded and argued, hypocritically, that despite living in American territory (as per the Webster-Ashburton Treaty) they were in fact British subjects. In total they received only $500 worth of goods from the government. The government considered this back pay for the Grand Portage Band having missed payments the previous year, and the Grand Portage Band would be eligible to collect future treaty payments. It is highly questionable that the Grand Portage Band was even aware they had agreed, in the eyes of the United States, to ceding the Island and their mainland homes (Cochrane 2009:131).

Hopes were initially very high regarding the potential for Isle Royale to produce copper. In fact, the articles of association for the Isle Royale and Ohio Mining Company contain in its introductory remarks that "the island had been known as the richest portion of the mineral region of Lake Superior" (Isle Royale and Ohio Mining Company 1847:2). This sentiment was common and reflected elsewhere, including in the articles of association for the Siskowit Mining Company. It turned out, in fact, that the Island would be among the least profitable of the mineral regions in Lake Superior.

By 1854 Whitney reported on the "extravagant notions [that] formerly prevailed with regard to the richness of Isle Royale" (Whitney 1854:283). This optimism fueled much speculation in the region. It is known that a large amount of dishonest prospecting had occurred in the Lake Superior region during this time. Much of this was due to a confusing and contentious system for leasing mineral lands (Hybels 1947:101). Many of the firms that were established on Isle Royale at the time seem to have been honest, as it appears from contemporary observations made by C. T. Jackson that most of them had at least one shaft in operation.

The Early Industrial Mines of Isle Royale

The mining ventures on Isle Royale (Figure 2.1) were mostly small endeavors. These ventures would consist of one or two shafts that never saw more than two years of mining. Very few of the locations worked reached past 100 feet in shaft depth. Infrastructure was equally modest; a few shanties located close to the shafts to house workers and supplies. The smallest of the ventures employed no more than a dozen workers who drilled, blasted and manually hoisted the mineral to the surface to be sorted out by hand.

The Ohio and Dead River Company worked a location on Washington Island, which was abandoned in less than a year. The Isle Royale and Chicago worked at Huginnin Cove, which was also closed within a year. Down the shore the Franklin Company worked a modest vein of copper in 1847. By 1848 that location was reported as abandoned (Lane 1898:4-5). McCulloch's Location at Todd Harbor was reported as being the only venture still active on the north shore in 1850. After opening three shafts to a depth of around 60 feet the copper disappeared and the Location was abandoned later that year (Jackson 1849:508-509). The Amygdaloid and Isle Royale Mining Company worked a location in Section 23. This location only yielded a mere 30 pounds of copper. The American Exploration and Mining Company were engaged in prospecting on a vein of "little value" on Amygdaloid Island (Lane 1898:8). The Scoville operations were linked to the IR&O Company, as Philo Scoville appears in the IR&O Company's articles of association as one of the first class of directors appointed to the IR&O Company (Isle Royale and Ohio Mining Company 1846:11). Scoville had some small buildings erected on the site including a house and a blacksmith's shop with a furnace for assaying copper. The ventures of the Shaw-Smithwick Mine were demonstrative of the need for the different firms on the Island to rely on each other for assistance and resource sharing. This mine was opened in 1847, having been discovered by a James Smithwick, and the work was supervised by Cornelius Shaw, acting as the mine's agent (Rakestraw 1965:5). This mine was closely linked to the Scoville Mine, and it is known that the two firms shared

resources such as tools and manpower (Karamanski and Zeitlin 1988:63). After 66 feet of shafting Shaw's copper pinched out, and work ceased in 1849. Duncan Bay was home to a handful of small efforts, although very little historical documentation survives about Duncan's work.

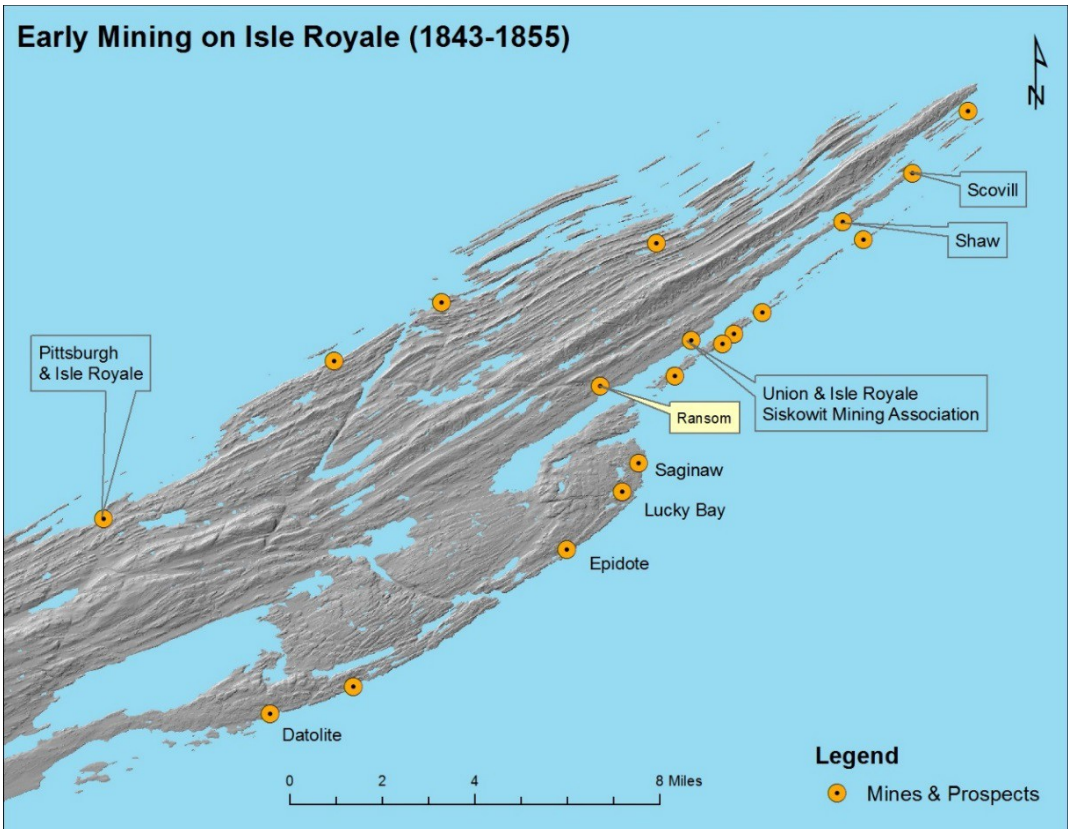


Figure 2.1 The location of some early mining operations. Reproduced with permission from the National Park Service.

The Pittsburgh and Isle Royale Company was one of the larger companies to operate on the Island during the initial copper rush. On the northern side of the Island, the site of the workings of this company can be found near the present day Todd Harbor Campground. Two shafts were in progress when Jackson visited the site in 1848, and the mine is known to have operated until 1853, making it one of the longest running enterprises of the initial mining rush on the Island (Karamanski and Zeitlin 1988:65). Foster and Whitney also reported on the workings of this firm in their 1850 report. The report refers to the company's amygdaloidal mines as the "best developed" of the Island's hard rock mines: by that date the firm had sent to market 4,483 lbs. of copper

at 75% purity, including a 700 lb. sheet of pure native copper (Foster and Whitney 1850:142). Whitney alone also reported on the Pittsburgh and Isle Royale Company in his 1854 *Metallic Wealth of the United States*. In this report he claimed that the main workings of the firm consisted of two shafts of an equal depth of 135 feet that were connected at the depth of 113 feet (Whitney 1854:285). It was at this connecting level that the firm had done most of its stoping.

This report also indicates that the firm had established a new shaft, number 3, about a mile south of its first two, which was reported to be at a depth of 223 feet. The Pittsburgh and Isle Royale Company was also one of the more heavily industrialized operations on the Island. Archaeological investigations conducted by Martin in 1986 revealed the remains of several structures at the location. Among the remains present were a dam, a stamping mill, a head race over 100 meters long, and a tramway connecting the stamp mill to a poor rock pile nearby (Martin 1986:22). It also appears to have been rather poorly managed in some regards. In his 1854 report, Whitney refers to the water pumping machinery as being “miserably defective” (Whitney 1854:285).

The Isle Royale Union Company had several land claims across the Island, which would prove profitable for its successor company, the Siskowit Mining Company (SMC). The mine is mentioned in the American Mining Journal and Railroad Gazette in an article dated October 13th 1847, as was part of a longer piece on the early copper mining in Michigan. What stands out as interesting is that this firm, which never amounted to much, staked a large number of claims. The report indicated that they laid claim to Sections 13, 15, 19, 24, 27, and 31. This firm also employed the scientific minds of Dr. John Hitz and Dr. Locke. It would appear that the Union Company was slowly absorbed by the Siskowit Mining Association (SMA), as by October 1848, locations 15 and 24 had already been purchased by Siskowit Mining Assoication (American Mining Journal and Rail-Road Gazette 1847:67).

These two mining firms are also linked in another way. The acting agent for the Union Company was a Mr. Charles Whittlesey, as is known from reports in the

AMJ&RG. Whittlesey partook in the early prospecting of the Island for that firm and then oversaw their mining operations. Based on the articles of association for the Siskowit Mining Company, Whittlesey was on the initial board of directors of the SMC and would remain a major player on the Island for most of the initial phase of mining. Whittlesey was a man of education and through his lifetime produced several texts on geology and copper mining in the Lake Superior region and the archaeology and geology of Ohio.

Eager to maximize capital gains, firms on the Island were no doubt willing to pay the compensation that educated men such as Hitz and Locke would have required to ensure they staked reliable claims. The employment of at least three different university-educated professionals in the prospecting and working of the Isle Royale Union Company mines highlights this region of America as an early frontier of both the material and the intellectual. A closer inspection of the smaller firms that existed on the Island, such as the Isle Royale Union, highlight the extent to which the region was a driving force behind the development of the formalization and application of geology as a scientific field in America.

The Siskowit Mining Company of Michigan is normally regarded as the most successful of the early mining ventures on Isle Royale (Karamanski and Zetilin 1988:65). The reformation of the company after merger of the Isle Royale Union and the Siskowit Mining Association made it a separate legal entity, but for the purposes of an historical study they should be regarded as the same venture.

Late in 1847, Whittlesey acting as agent for the SMC sent a letter back to investors. This letter, dated 7th of September, 1847, detailed his optimism for the mines that had been opened so far. This report also contains the first mention of the working relationship that the SMC was going to have with the IR&O Company. Whittlesey informs the investors back east that the IR&O was in the process of constructing a "first rate furnace", and that Whittlesey had arranged to have the SMC's copper melted by that firm. According to this report, the furnace of the IR&O Company was already planned, if not being constructed, during the tenure of Ransom and Blake.

Later the SMC reported that the IR&O Company had produced for them 2670 pounds of "badly smelted" pig copper (Siskowit Mining Company 1850:11).

Another letter was composed in May of 1848 and included a statement of the firm's operations on the Island, accounting for the progress that had been achieved over the winter. The investors back east would have waited several months for a report detailing the progress made during the winter months. This would have had an impact on the procedures that the companies would undertake, such as the issuing of assessments on outstanding stocks. This may be the reason why the SMC held its annual meetings on the 11th of May and the IR&O Company held theirs on the first Monday of May; this was the time when reliable communication lines were reopened across Lake Superior (Isle Royale and Ohio Company 1846:1 & Siskowit Mining Company 1850:6).

The best look at the progress that the SMC made during the years after its reincorporation comes from Whitney's Metallic Wealth of the United States. Published in 1854, Whitney reported on the state of the SMC workings as they were in the summer of 1853. The steam engine that the company had hoped to establish in their charter and bylaws was in operation, pumping water from the firm's shafts was well as running twelve head of stamps. Further gains were being made in that the stamp mill that the firm had erected was able to reproduce rock previously rejected for its low copper content. Whitney also provides in his report a cross section of the mine, showing that four different shafts had been opened (Whitney 1854: 284). These improvements to the mine were made possible by the levying of stock, estimated to have been in the order of $68,000. It appears that during the years 1850 and 1851 the mines of the SMC produced 30,921 lbs. and 37,363 lbs. of copper respectively. Whitney estimated, based on conversations with those present at the time, that 80,000 lbs. of copper had been shipped from the mine in 1852, followed by 38,473 lbs. for 1853 when he visited the site that summer (Whitney 1854:284-285).

A series of setbacks followed these gains in copper production. Around Christmas of 1853 the stamp-mill that the SMC had constructed burned to the ground (Ontonagon

Herald 1883:3). Furthermore, the vein that they had been chasing began to narrow rapidly as the mine descended, and despite the completion of a new stamping mill, the firm was forced to close down its operation in 1854 (Karamanski and Zeitlin 1988:71). The traces left behind by the Siskowit operations remain among the most visible landmarks of Isle Royale's industrial heritage.

Life and Labor on Isle Royale (1846-1855)

The workers and their families faced many hardships in coming to and living on the Island. The different people who lived and worked on the Island during these initial years of mining all had unique experiences on the Island, and developed different views of the Island. The few direct personal accounts of the Island show personal views as well as sharing some observations about how some of the other people living on the Island acted within this environment of extreme isolation. For some, life on the Island was among the biggest mistakes of their lives. An anonymous poem scrawled down in one of the books Ruth Douglass found to keep herself busy, dated to the 2nd of March 1847, reads as follows:

"Here on this lonesome spot, (confound the place,)
I Wish I had never seen it dismal face;
When Winter comes, the frighten'd Sun retires,
We sit in rags, and shiver round the fires.
The only breakfast for us every morn,
Is Cold Pork, Slap Jacks, or a mess of corn;
The Tempest howls, yet I must go to work
Although I'm shivering like a frozen Turk.
At night return after gorging slaw,
Lie down and slumber on a nest of straw."

The firms were evidently quite tight-knit, sharing tools, expertise and even holding joint claims. For the workers the factor that seemed to have brought them together was their ethnic backgrounds (Root 1998:82). The miners who came to the Island understood that living and mining in the newly opened Lake Superior region would be difficult. The workers came to the Island in search of employment and were willing to face these hardships. Those who chose to stay the winter on the Island were

placing their fate entirely in the hands of their employer. It was up to the firms to make sure that enough provisions had been accumulated for winter survival.

Figure 2.2 Lake Superior in the winter. The Island experiences total isolation for several months each year. Image Credit: Jeff Schmaltz, LANCE/EOSDIS MODIS Rapid Response Team, NASA.

The nature of the Island's isolation created a situation in which the only real hierarchy present was the one dictated by the capitalist business model of mid-19th century America. There were no government officials on the Island, nor were there any established religious institutions present. Virtually all authority stemmed from the business ventures themselves. Even Federal authority took a long time to arrive on the Island, for instance no elections were held on the Island during the 1848 presidential campaign, and the residents of the Island had to wait almost five months to discover who their new head of state was (Root 1998:80).

Due to the nature of the claims system, and other legally dictated requirements imposed by the State or Federal governments regulating businesses, the companies were free to operate nearly as they pleased, so long as the government was not being deceived and the property rights of the other firms remained unmolested. Ransom was not an incorporated town, but appears to have had its own rudimentary legal system in place. These rules were, according to Ruth Douglass, posted on a sign in the middle of settlement along with directions to places on note in Ransom. Unfortunately Ruth only imparts one of these rules to the reader: "traveling faster

than a walk over the pavements under a penalty of 10. dollars" (Root 1998:69). For perspective, William Tonkin, the Cornish superintendent of the SMC's locations paid his mine teams a tribute of $20 per fathom dug in 1850 (Rakestraw 1965:3). However, given Ruth's amusement upon discovering the sign, this rule may have been jovial rather than serious.

The Ransom Location, was the central node of what authority, acting as a *de facto* post office, seaport, and even the place where drunken miners were held to sober up. Despite the great power that the companies wielded over their workers, the relationship between them seems to have been tempered by the mutual need for survival. Ruth, and most likely everyone else on the Island seems to have been aware of their situation, both in regards to their high degree of independence and their need to lean on each other to survive, regardless of social class. This is best exemplified in an entry Ruth made on the 28th of November, 1848. C.C. Douglass had decided to extend IR&O Company property, including supplies, to help a worker of the Pittsburgh and Isle Royale Mining Company who had fallen ill while in the settlement established at the Ransom location. Ruth noted:

"We are so situated here, as to render it necessary, to assist each other all we can. It is very different living on an Island as we do here, from what it is to live in or near any Town, especially as regards being independent"

Ruth herself seems to have had mixed feelings about the Island upon her arrival. On the 30th of August she writes both "Arrived on the Royale Island at 8 in the Morning. looks very pleasant" and "When I arose in the morning we were in sight of the Island…The view thus obtained was anything but a favorable one for me…there was nothing to be seen but barren rocks". It is possible that her statement "looks quite pleasant" was actually a reference to the day's weather, and not a statement about the Island itself. Although for some on the Island, such as James Hubbard, winter was deemed quite bearable. Hubbard was an agent of the SMA who worked directly under the supervision of Charles Whittlesey (Root 1998:109). According to Ruth, he had already spent two winters on the Island, and as far as can be discerned stayed the winter of 1848 as well (Root 1998:78).

An overall assessment of Ruth's diary of her time on the Island seems to indicate that she rather enjoyed her time spent of the Island, but would have much rather remained home in Detroit. In particular Ruth seems to have greatly enjoyed the company of Mrs. Matthews, the wife of Mark Matthews and seems to have had a good rapport with Mr. Giddings, who she mentions quite regularly in her journal. Ruth and Mrs. Matthews went on several trips together, which included fishing, sailing and collecting agates.

As the winter of 1848 drew closer, both Ruth and the other people on the Island who knew that they were planning on staying through the season began to make preparations. Ruth makes it clear that the buildings of the Company were winterized by the men employees (Root 1998:77). These upgrades appear to include installing stoves in buildings, plastering walls, and installing new windows. It is unfortunate that Ruth makes no mention of the exact buildings being worked on, thus no indication of how the firm balanced, if at all, accommodating the mine workers with ensuring the comfort of higher ranking officials such as Douglass.

Ruth herself did several things to personally prepare for her winter on the Island including exercise. While not a formal regime of exercise, Ruth wrote on more than one occasion that she had spent extra time out and about when she already felt tired enough to retire; she knew that she would not be out much while the winter snow blanketed the ground (Root 1998:72). She also spent part of her free time canning food. The food was not produced on the Island, but appears to have been sent to Ruth by her mother, where upon Ruth decided to can the fruits and meats together (Root 1998:83). During the winter months Ruth appears to have passed the time playing with her dog, sewing, and reading (Root 1998:89).

The local Ojibwe peoples still retained traditional use rights of the Island after the 1844 compact, and were active on the Island at this time. Primarily these peoples were engaged in fishing, trapping, and copper mining. Shaw and Ruth indicate that trade occurred between the American miners and the Ojibwe, who mostly came to the Island from Fort William, in Canada. However the arrival of Europeans also brought

in a new cash based economic system which negatively impacted the stability of traditional Ojibwe practices. The boom and bust cycles of capitalism were particularly challenging. When fishing went bust, the Ojibwe would have to look for money in another industry, such as trapping or mining (Cochrane 2009:114).

Based on accounts historical accounts several of the people who came to work the mines at this time also brought their families with them. The most obvious case is the Douglass', and the trend seems to have been husband and wife pairs, with children being absent. One exception was the case of Shaw, with Ruth remarking that he was with his son for part of the 1848 season (Root: 1998:87) although this was most likely a business type of relationship, as opposed to a custodial, parental guardianship relation as Shaw's son was engaged in helping his father mine.

The Founding of the Isle Royale and Ohio Mining Company

While officially incorporated as the Isle Royale and Ohio Mining Company (Figure 2.3) on the 12th of May, 1846, the history of this unique mining venture began in the summer of 1843. The nine claims that were to become the property of the IR&O Company were initially drawn up by the esteemed geologist Dr. John Locke (Figure 2.4), who visited Isle Royale with the then mineral agent of the region to draw up claims that were officially sanctioned by the war department in September of 1843 (Isle Royale and Ohio Mining Company 1846:4). Hopes were high for the prospects of mining on the Island. The mineral agent reported to the War Department that the Island was to be the "richest portion of the mineral region", and Locke observed that the specimens collected far exceeded anything that been observed elsewhere in the area (Isle Royale and Ohio Mining Company 1846:4). Given that Locke had already completed his survey of the south shore of the mineral region, his assessment of Isle Royale's mineral wealth must have caused quite a stir and elevated hopes for the Island, with the official report of the Secretary of War declaring that, if judiciously exercised, the mining claims of Isle Royale would elicit a "magnificent fortune" (Isle Royale and Ohio Mining Company 1846:4).

Figure 2.3 A Stock certificate for the IR&O Mining Company. Courtesy of the Western Reserve Historical Society. MS 3196

It was with such hopes that the IR&O Company was formed around eight men of business and ambition: Philo Scoville of Cleveland; John C. Wright of Cincinnati; Charles Stetson of Cleveland; John Erwin of Cleveland; Charles Williams of Toledo; and John Allen of Cleveland (Isle Royale and Ohio Mining Company 1846:4). When founded, the Company held nine claims on the Island: 1, 2, 6, 8, 9, 10, 11, 34, and 43. At nine square miles each, the Company held mineral rights to 81 square miles of the Island, although a good portion of these claims lay under Lake Superior itself. The Company's stock was divided into twelve thousand shares of capital stock, each worth one twelve thousandth of the Company's profits and property (Isle Royale and Ohio Mining Company 1846:3).

<u>The Settlement Established at the Ransom Location</u>

The IR&O Company differed from other mines on the Island at this time in that they decided to have a central hub to facilitate the management of their mines, which was referred to as Ransom. The approach used by the other firms was to place auxiliary structures as close to their workings as possible. While the IR&O Company did have some infrastructure present at their mines they also constructed relatively significant

infrastructure elsewhere. It is known from the diary Shaw composed in 1847 while working on the Island that Ransom was a main entrepot for people and goods on the Island. Shaw recounts frequent visits to the Ransom location to pick up mail, tools, and hire or return additional hands as the labor demand at the mine warranted. The location of Ransom was chosen to help facilitate reliable shipping, both within and from outside the Island.

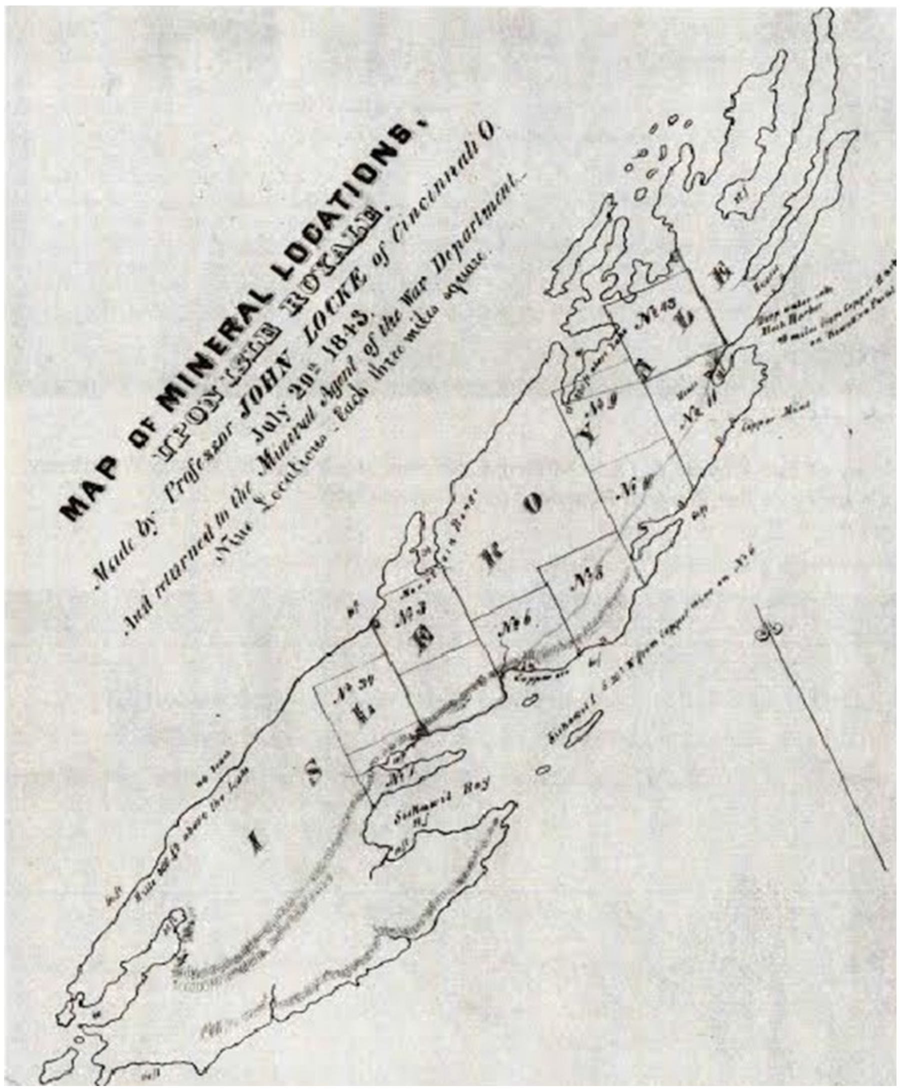


Figure 2.4 An annotated map of Isle Royale by Leander Ransom. This map shows the nine claims held by the IR&O Company staked in 1843. Courtesy of the Western Reserve Historical Society. MS3196.

While it appears that Mr. Leander Ransom, of Cleveland, was the first agent sent to the Island to work on behalf of the IR&O Company, he was followed shortly

afterwards by Mr. J.H. Blake. Ransom had gone there to undertake an initial survey of the Company's newly acquired land (Karamanski and Zeitlin 1988:71). He was followed shortly afterwards by Blake, who is reported to have departed for the Island with a steam engine and fifty workmen (*American Railroad Gazette and Mining Journal* 1847:488). While Karamanski and Zeitlin claim that Ransom handed control of the operations to Blake, a September 15th report in the *American Railroad Journal and Mining Gazette* seems to indicate that both men were active as agents of the Company at that time. Blake was overseeing operations at the Company's Epidote Mine, although the precise job of Ransom is neither stated nor implied (Ransom 1847:1). Many of the fifty men brought to the Island by Blake were employed in establishing the village of Ransom by clearing the forest and using the lumber for construction, and the actual oversight of this construction fell to Mr. Ransom.

There are two different but fairly detailed contemporary descriptions of the settlement at Ransom that survive to this day. The most through description of the buildings erected by the Company comes from Ruth Douglass. Shortly after her arrival, Ruth describes Ransom in fairly specific detail. Including the two story house that had been built for her and Columbus, Ransom was also home to several buildings constructed from "hewn timbers": a store, laboratory (likely for assaying mineral samples), a company office with an attached storehouse, engine house, and furnace & blacksmith shops (Root 1998:68). The "hewn timbers" Ruth describes are almost certainly the product of the Company's efforts to clear their property.

Another account of Ransom made while it was occupied is found in the land survey notes. William Ives was employed to survey the Island, and conducted his survey in 1847, leaving behind very detailed notes (Figure 2.5). Ives description of the site was recorded on the 21st of June, 1847. Ives describes the site as being surrounded by land cleared for gardening. The buildings present at the time of his observations were: a temporary wharf, four log houses and a log warehouse 55 by 33 feet (Ives 1847:220-221). Ives also speaks to the types of work going on at the site, putting the number of men present at 40, with most of the men clearing land, with a handful engaged in

mining at several locations on the Island (Ives 1847:221). In total Ives lists five buildings, not including the wharf, compared to Ruth's six. However Ives description is more precise, as Ruth uses vague terms such as "furnace and blacksmith shops" while Ives simply numbers the buildings. Although it is probable that the location continued to grow after Ives visited it.

[redacted]

[redacted]

Neither Ruth Douglass nor William Ives describe any of the buildings present as being constructed of brick. It is likely that there was some brickwork present at the site, as these bricks were referenced in another primary source. In 1876 Emmet Scott, an investor and land speculator from Indiana, invested a sum of money in the Minong Mining Company, which had acquired several claims on Isle Royale for the purpose of mining and timbering (Scott 1877:1). Scott kept a notebook in which he detailed

his daily activities while he was on Isle Royale. On one notable occasion, July 22nd 1877, Scott recorded that he "went up to old smelting works on Rock Harbor and brought back 2 loads of brick" (Scott 1877:5). Since none of the buildings were described as being composed of brick, it is very likely that their source was a chimney for one of the timber buildings described by Ruth, such as the engine house.

The Decline of Ransom

As the mines of the IR&O Company began to fail, Ransom also started to disappear. It would appear that its abandonment was not instantaneous though, as there is a single report of continued residential occupation at the site. Philadelphia investor Mr. A Myers made a trip to Isle Royale to visit the Siskowit mine locations in order to better assess his investment in the SMC (Myers 1851:1). While most of the time Myers spent on the Island was for business, some of it was for leisure including a day trip to "a mine abandoned from mismanagement" three miles down the bay from the Siskowit location(Myers 1851:3). The description Myers gives of the site, and its location three miles down bay from Siskowit it is possible that the location being described by Myers was the site of Ransom. While visiting, Myers and his companions took lunch with a family that was still residing at the location (Myers 1851:4). There was very little that would have attracted a family to stay on the Island after the closure. A report authored in 1853 by Truman Smith, then President of the IR&O Company's successor firm The Isle Royale Mining Company claims that the IR&O Company abandoned the Island in 1852 (Smith 1853:3). There is the possibility then that the family remaining at Ransom were caretakers, that is to say, people paid by a mining company to occupy the land so that the firm in question could have employed people at these locations on their books. This is done to either make sure that the rights ownership of that claim brings (eg. mineral or timber) are not violated, or because abandoned claims could be deemed forfeit by the War Department and would pass back into federal ownership (Hybels 1947: 87-88).

Unfortunately, information regarding the fate of what was built at Ransom is almost nonexistent after Myer's journal entry. In 1852 a German mining engineer, F.L.C

Koch visited Isle Royale and made a formal report back to the German mining community. He passed by to inspect some of the workings of the IR&O Company, even noting the remains of a copper furnace, although he does not specify the type of furnace that he observed. In a collection of his personal research notes, found at the Park Archives, Dr. Lawrence Rakestraw claims that Dr. A Cable informed him that the buildings at Ransom were burned in 1866.

The site of Ransom was further disturbed when it became a main encampment for the Civilian Conservation Corps. In the mid-1930s the CCC did a number of things while on the Island, including: building the Park headquarters, erecting fire and communication towers, building boat campgrounds and restoring existing resorts that were retained by the Park (Poirier and Taylor 2007:105-107). After the camp was disbanded, the site became Daisy Farm campground.

The Operations and Workings of the Isle Royale and Ohio Mining Company

Reports made by the IR&O Company are scarce, and it is the personal observations made by the people who were living and working on the Island at that time which prove to be the most informative. During their visit to the Island, Foster and Whitney describe many of the mining locations with good detail, and the mines of the IR&O Company did not escape their observations. In their 1849 report on the mining and geology of the Island, they reported that the Company had dug approximately 230 feet of shafts at five different locations. Much like the shafts opened by the SMC, many of the IR&O shafts were recorded as having been filled with water (Foster and Whitney 1849:143). However, a report based on a visit to the Island made by the assistant state geologist Alfred Church Lane, in 1896, indicates that the Foster and Whitney report may have been in error in ascribing particular mines to the IR&O Company. Lane based his report on historical research, visits to the Island, and interviews with some of the people who had worked on the Island during the initial phase of mining. Lane refers to these errors as "misprints" and claims that he had difficulty finding some mine workings in the areas described by Foster and Whitney (Lane 1898:13). Foster and Whitney may have been in error for two different, but

equally good reasons. Firstly, the Foster and Whitney report came right off the heels of the changes to the mineral land leasing system, which appears to have delayed the ability of the IR&O Company to begin working on the Island (Karamanski and Zeitlin 1988:59 and Jackson 1850:299). Secondly, as has been shown already in this chapter, there was much cooperation between the different mining companies, as labor and capital was moved between the different locations based on the speculations made by investors, geologists, and mining company executives. Both of these factors may have helped obfuscate the true ownership of the different mining locations.

There are four mine locations that can positively be attributed to the IR&O Company and one additional mining effort that may have been one of the Company's. Most of these workings were located south of Ransom, across the body of water known as Moskey Basin. It is possible that these different mine locations were worked at different times, and were not being explored simultaneously. Based on the writings of Ruth Douglass, it is obvious that both the Epidote and the Datolite mines were in operation at the same time (Root 1998:89). Karamanski and Zeitlin place the Datolite mine in the 28th or 33rd Townships, neither of those are listed by Jackson, Foster and Whitney or Lane as containing any of the Company's workings (Karamanski and Zeitlin 1988:60). Although the phrase "Datolite Mine" never appears in the works of Jackson or Foster and Whitney, it is a term used frequently by Ruth Douglass and A.C. Lane. Karamanski and Zeitlin place the Datolite mine about nine miles away from Ransom, as the crow flies. When the Lake was not frozen, C.C. Douglass and Mark Mathews would visit the Datolite mine via Mackinaw boat. However, in the winter Douglass was forced to snowshoe to the mine to inspect the workings there, returning "so fatigued as to be hardly able to stand" (Root: 1998:89). The Datolite mine appears to have escaped the attention of Jackson because it simply had not been opened when he conducted his investigation of Isle Royale, however it is also not mentioned in the later reports of Foster and Whitney either. Consequently their reports lack metrics and data regarding the mine, its location, or nature of the lode being chased there.

Of the mines actually described by Foster and Whitney, most reached a depth of 40 feet before work was halted. Based on geological assessments, at this depth the geological layer which composed the upper stratum that both the Datolite and Epidote mines rested on changed to a layer of columnar trap rock which pinched the copper veins to unworkable widths (Lane 1898:13-15, Karamanski and Zeitlin 1988:72). According to Lane, the veins worked by the IR&O Company dipped S.E. by S between 28 and 60 degrees, quickly dropping most of the mines under the body of Lake Superior. The initial veins of copper, between one and three feet wide (Foster and Whitney 1849:143-151), that had been discovered by Professor John Locke and then confirmed by Leander Ransom appeared very promising, but quickly pinched out and seemed to have required constant draining.

The Isle Royale and Ohio Mining Company Agents

The Isle Royale and Ohio Mining Company sent several different men to the Island to serve in various supervisory roles. These men were selected for different reasons and for different tasks, but all played an important role in the way that the IR&O Company developed. These men would have been selected by the Company board of directors for their perceived talents. Some of the agents that the Company sent to the Island are better known to history than others. Some like the gentlemen named "Reynolds" who was said to gone with Leander Ransom to plat out the Ransom for the Company is never mentioned outside of a few passing remarks. A brief narrative of the different individuals who ventured out into the wilderness on behalf of the Company will help place their roles, and the ambitions of the IR&O Company into better historical perspective.

Leander Ransom was the first man sent to the Island by the IR&O Company to fill a supervisory role. Leander Ransom had come to the region from Ohio, and appears to have become increasingly involved with the Company's affairs as the years progressed. While Ransom is not named as any of the incorporating members of the Company, nor on the initial 1846 board of directors, his signature appears along with the title of President on an annual report filed in 1849 by the "Isle Royale Mining

Company" (Ransom and Mather 1849:1). It is difficult to determine which Isle Royale Company the document is referring to. What is known is that the Isle Royale and Ohio Mining Company published its charter and by-laws in 1846, while the Isle Royale Mining Company published its in 1853. While not every point addressed within a firms articles of association is legally required, these documents do dictate specifics regarding stock distribution, the ability to levy assessments, and the power shareholders have over the company. Given that the report stated that "the actual amount of capital which has been actually paid on capital stock of said company" totaled $14,741 for the year 1849 (Ransom and Mather 1849:1), it seems more probable that the company in question was the Island-based operation. Given that the IR&O Company's operations were in full swing at the end of 1848, it is likely that they were still in business during part of 1849.

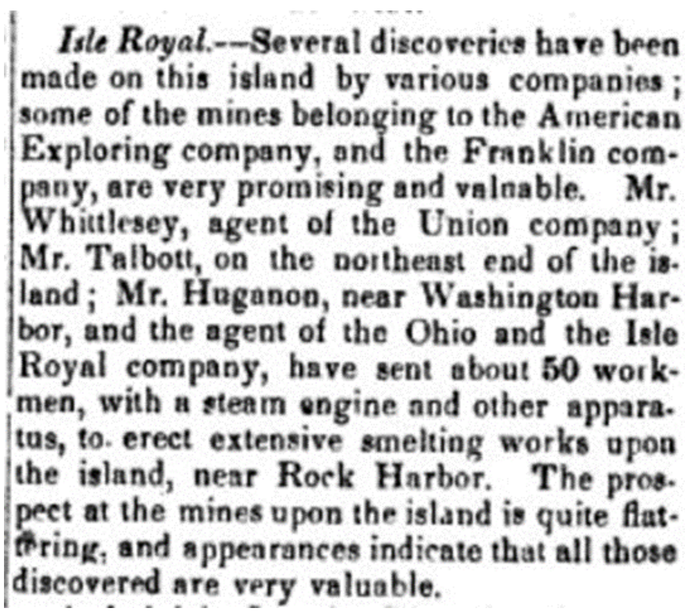
Leander Ransom's duties on the Island seemed to have related to preparing the Company's locations for more intensive exploitation. Land was cleared to house the necessary buildings at the Ransom location, several roads were cut across the Island, and samples were collected from several of the more promising locations that the Company had acquired (Ransom 1847:4). Based on the accounts provided by C.G. Shaw in his diary, composed in the summer of 1847, Ransom had brought his family to the Island and lived in the house that Ruth and C.C. Douglass later came to occupy. While Leander appears as the president of the Isle Royale Mining Company in 1849, the next publication known to exist and produced by the company, in 1852, makes no mention of him whatsoever and lists the President as Mr. Truman Smith as the President.

Ransom was proceeded by Mr. J. H. Blake, but it is obvious from the diary of C.G. Shaw that both gentlemen were in fact on the Island at the same time, as the three men and their families would take dinner together at Ransom. Whittlesey mentions Blake in a letter sent back to investors dated the 25th of May, 1848:

"The Ohio and Isle Royale have a furnace in course of erection, only two miles distant, the most expensive part of which is already completed, and will enable the energetic

and scientific gentleman (Mr. Blake) having charge of the works to do justice to the mineral to be smelted."

Ignoring for the moment Whittlesey's claim that the furnace was nearly complete almost three months before C.C. Douglass approached Ruth with the offer he received to go to Isle Royale to establish a smelting works, his assessment of Blake indicates that he was most likely sent to the Island to assist the IR&O Company in some scientific capacity, most likely mining or engineering related. An article printed in the July 21st, 1847, edition of the American Railroad Journal (Figure 2.6), indicated that an unnamed agent of the Ohio and Isle Royale Company arrived on the Island with 50 men, a steam engine and "apparatus" for establishing a smelting works upon the Island (*American Railroad Journal* 1847:488). The syntax of the article is strange, and the language makes it unclear if the 50 men all belong to the same company, or even if the smelting works were the undertaking of one or more companies. The article seems to indicate that it was Ransom who arrived on the Island with the equipment, while Whittlesey's report seem to indicate that it was Blake who was responsible for seeing that these technologies were properly set up.



Isle Royal.—Several discoveries have been made on this island by various companies; some of the mines belonging to the American Exploring company, and the Franklin company, are very promising and valuable. Mr. Whittlesey, agent of the Union company; Mr. Talbott, on the northeast end of the island; Mr. Huganon, near Washington Harbor, and the agent of the Ohio and the Isle Royal company, have sent about 50 workmen, with a steam engine and other apparatus, to erect extensive smelting works upon the island, near Rock Harbor. The prospect at the mines upon the island is quite flattering, and appearances indicate that all those discovered are very valuable.

Figure 2.6 July 1847 article from the Railroad Journal. From a longer article discussing copper mining on Isle Royale. Courtesy of the Michigan Tech Archives and Copper Country Historical Collection TN 1.M672.

C.C. Douglass was the next agent that IR&O sent to the Island. Douglass is the IR&O Company agent that is best known to history. Douglass was already familiar with the Lake Superior copper region, having visited the region with his uncle, Douglass Houghton to conduct geological surveys (Sawyer 1911:1532). Later, he worked as geologist for the Lake Superior Copper Company, inspecting a number of veins they had claimed near the Eagle River (Anonymous Author 1845:8). Douglass' geological knowledge and experience in the region was most likely what drew the attention of the IR&O Company, who offered him work on the Island to help run their furnace.

Ruth records that and IR&O Company Director, Mr. Giddings, visited C.C. Douglass twice to avail upon him to accept Company's offer of employment (Root 1998:65). They set sails for Isle Royale on the 17th of August, 1848. Douglass' had a geological background and his knowledge of, and willingness to live in the region, would have made him a good choice for assessing the Company's mines, but no one has found any evidence of formal or practical experience building or running furnaces.

The Douglass family arrived on the Island on the 30th of August, and Ruth reports that eight days later a "corner stone" was laid for a "furnace house" (Root 1998:69). It seems very unlikely that the entire infrastructure of the furnace was set up in only ten days. It would appear that the accounts of Mr. Whittlesey and the trade journals were correct in their assessment that the greatest portion of the furnace had already been completed by the time Douglass arrived on the Island. Four days later Ruth tells us that Douglass "has been much engaged in the smelting department". It is apparent that when Douglass was offered employment with the IR&O Company to "establish" a furnace, his job was to be getting the furnace running, as opposed to overseeing its construction.

After this initial flurry of furnace work, Douglass appears to shift his priorities over to inspecting the Company's mines. This may have been related to Mr. Matthews, superintendent of the very distant Datolite Mine, leaving the Island on the Algonquin on October 19th, 1848. During this time, Ruth only makes one more, and quite vague, reference to what was going on at the furnace. On December 1st, she tells readers that

there was a lot of activity in and around the engine house, and that "smoke ascends in thick clouds from its chimneys and also from the coal kiln at a little distance beyond". The continued running of the engine, along with charcoal production seem to indicate that the furnace may have been in blast as well.

Douglass reported ever decreasing prospects from the mines that were opened by the time he arrived on the Island (Root 1998:88). The IR&O Company opened an additional mine under Douglass' supervision, which Ruth describes as being a quarter miles north of her house and elevated about 100 feet above the Lake. A shaft matching that rough description was noted during both the 1986 archaeological investigations (Martin 1986:12) and again during the 2015 investigations.

The Isle Royale and Ohio Mining Company Leaves the Island

Douglass left Isle Royale in June of 1849 (Root 1998:113) and it appears that mining and furnace operations were ceased about that time. An annual report filed by Ransom and Mather on 29th of December, 1849, from their office in Cleveland indicate that the Company in was still functioning at the end of that year (Ransom and Mather 1849:1). This document lists the amount of capital raised that year at $14,741, and lists the debts of the Company at $0.

Based on the narrative account given by Truman Smith the Isle Royale and Ohio Mining Company did not abandon their claims on the Island until they had acquired new leases for land on the south side of Portage Lake, which occurred in 1852 (Smith 1853:3). However, the annual report filed by Ransom and Mather in 1849 lists their company as the Isle Royale Mining Company, and not the Isle Royale and Ohio Mining Company. This may indicate that between June 1849 and December 1849 the Company may have already undergone some restructuring. The fact that the Ransom and Mather letter was composed in Cleveland and not the Washington D.C. office that was the headquarters of the Isle Royale Mining Company show that a total transition had not occurred by that time.

In his yearly report, Truman Smith lists C.C. Douglass as the superintendent of the mines they had opened south of Portage Lake, while Mather was listed as the "late Treasurer." It would appear that rather than a total dissolution, the Isle Royale and Ohio Mining Company restructured, and began a relatively successful operation on the Keweenaw. The Isle Royale moniker would stick, with the Company under some variation of that name until closing after the government subsidies for copper production ceased at the end of the Second World War.

Chapter 3 – Archaeological Investigation

Previous Archaeological Exploration

The site of the IR&O furnace (Figure 3.1) first came under serious investigation in 1984 when it was visited by Michigan Technological University's Patrick Martin (Martin 1986:11). In 1986 the site was revisited by that year's Archaeological Field School. The area around the furnace was extensively mapped by members of that field school. The arrangement of the site was described in some detail in a technical report published in 1986 that assessed the archaeological potential of several of the island's campgrounds. While no excavations took place at the Daisy Farm Campground, the report recommended excavations at the furnace site due its "considerable potential" to offer new insights into the early days of the Lake Superior copper industry (Martin 1986:31).

This study is not the first of its kind conducted by the Michigan Technological University Industrial Archaeology program. During 2001-2002 Gary Van Lingen conducted archaeological explorations of the second mining camp that the Pittsburgh and Boston Copper Harbor Mining Company (P&BCHMC) had established at Copper Harbor, Michigan. These investigations, and subsequent thesis publication, included research into a masonry structure that was suspected of being used in some capacity as a furnace (Van Lingen 2002:5). Based on the historical narrative of the P&BCHMC, this structure would have been erected sometime during 1844-1848, making it contemporary to the operations on Isle Royale. In a similar situation to that faced by the Isle Royale and Ohio Mining Company, some of the P&BCHMC's mineral lodes were not rich enough to pay a profit when shipped unrefined (Van Lingen 2002:166). Van Lingen believes that this unprofitable to ship ore was *la roche verte* or, "green stone" in English. This ore would have been around 30% copper. The P&BCHMC was also mining other deposits of copper that could be shipped at a profit with little to no refining (Van Lingen 2002:171).

Van Lingen describes the structure observed as being a square masonry

foundation, with an opening on its southern face (Van Lingen 2002:6). The extent of the foundation, along with a significant portion of rubble found to the north of the structure, which Van Lingen refers to as "chimney fall" and the presence of firebrick were used to argue that building had served as either a smelter or as a roasting stall. However, Van Lingen concluded that this structure was not a smelting furnace (Van Lingen 2002:171). The basis of this conclusion was derived from several lines of archaeological and historical evidence. Archaeological investigations indicated there was no evidence of slag, smelting related tools, or processed ore. Historical investigations indicated the P&BCHMC did petition the army to build a smelter, but were denied.

Excavation Strategy

The site was laid out in a metric grid system. A grid datum was chosen based on a location on the site that was easily visible and faced little obstruction, the higher elevation functioning as a point by which the depths of all units opened could be measured. [redacted] The site was laid out using magnetic north as the primary bearing. Brush and foliage needed to be cleared before the site could be fully assessed for excavation potential; this was performed on the first day of field work.

The units were dug stratigraphically. Substrata were determined to be different from the preceding level based on the following: artifact density, artifact types, Munsell soil color, and soil density and texture. The levels were assigned numbers, beginning with 1 for the topsoil and duff, based on the order in which they were opened. The units were all hand excavated, using traditional troweling methods. All the soil excavated was screened through ¼" mesh. For materials such as slag, coal,

and wood, large samples were collected but the entire assemblage of these was not retained. All other artifact types were retained in their entirety. In total 12 1x1 meter units were excavated, all to a depth that was deemed satisfactory for their completion based on sterile soil or the presence of ground water. While all the units had an individual number based on their southeast location, groups of sequential units were assigned trench numbers.

In total five individua 1 trenches were opened. Across the site the terms "feature" and "structure" were commonly used. As a point of clarification, a "structure" refers to a masonry structure that was evident on the surface prior to the excavations. For instance, Structure 1 refers to the large, rectangular stone foundation immediately east of a small creek to the south of the site. A "feature" refers to a specific stratigraphic phenomenon. For example, Feature 1 refers to a large inclusion of waste material including coal, cinder, and ash found in Trenches 2 and 3. In addition to traditional 1x1 meter excavation units, this project also included opening 10 shovel test pits (STPs) across the site. The STPs were sunk near the close of the project, to glean information from the separate features where excavations were not carried out.

Trench 1, consisting of units 497N by 252E, 498N by 251E, and 499N by 251E, was opened in order to expose the east and west sides of a portion of both Structures 2 and 3. This trench facilitated the exposure of the area (approximately 1 meter wide) between these two Structures. The unique configuration of Structures 2 and 3 raised a lot of questions as to the function they served, and it was determined that by exposing the space in between them we might better ascertain their function and relationship to each other.

Trench 2, consisting of the units 492N by 252E, 492N by 253E, and 493N by 253E, was opened to expose Structure 1, suggested to have been a reverberatory furnace. After exposing the Structure by clearing the brush, deadfall, and conifer duff, it became evident that this structure consisted of fairly straight walls on both its eastern and western sides. The straight edge was targeted on the western side of this

structure at the point estimated to be the foundation's southwest corner. By exposing this corner and excavating down to its base, it was hoped that a good estimate of the size of this structure could be ascertained. In order to capture the corner of this structure the trench was given a distinctive "L" shape. The corner of Structure 1 was successfully exposed, as was its base.

Trench 3 was opened [redacted]. This trench consists of the units 499N by 252E and 500N by 252E. These units were opened because the eastern excavation of Trench 2 was obstructed by a large tree, and information was sought as to what had occurred directly to the east of Structure 3. This trench also exposed a sizeable segment of Structure 3, allowing for a good assessment as to its probable size across the rest of the site.

Trench 4 was opened in the large square depression named Structure 5. This trench consists of the units 499N by 256E, 500N by 256E, and 501N by 256E. The goal of this trench was to cut across this large depression in a way that exposed the high outside edge, the slope of this wall as it descended to the bottom of the depression, and the bottom of the depression itself. This cross section would expose all the main features of the depression and, it was hoped, provide evidence as to the function and construction date of this depression.

Trench 5 was designed to expose what is believed to have been the foundation on which the cupola furnace stood. This trench consisted of the units 502N by 247E and 503N by 247E. The goal of this excavation was to expose the architecture of the foundation for both its edges and its surface. Assessing the size and construction methods of the foundation was deemed important as it could provide evidence relating to the size of the blast furnace.

Table 3.1 A list of the Structures Identified at 20.IR.0043

Structure 1	Large rectangular foundation, possible site of reverberatory furnace.
Structure 2	The long, short foundational wall with an "L" shape east of Structure 1.
Structure 3	The long, short and straight foundational wall directly east of Structure 2.
Structure 4	The square foundation and the bottom portion of the toppled cupola stack.
Structure 5	The large square depression constructed of earth located directly south of the bottom portion of the toppled cupola stack.
Structure 6	The round stone foundation of a charcoal kiln located less than 80m to the east of Structure 5.
Structure 7	A square depression with an earthen foundation located directly to the west of the small creek abutting the site.

Table 3.2 A list of the Features Identified at 20.IR.0043

Feature 1	Conical mass of coal clinker and ash. Trenches 1 and 3
Feature 2	Two wooden boards running parallel to each other directly on top of a sand layer. Trenches 1 and 3
Feature 3	Fused mass of fire brick and mortar. Bottom of 500N by 252E
Feature 4	A depression to the southwest of Structure 1

[redacted]

[redacted]

Results of the Test Pitting Operations

Due to time restraints, small test pits were deemed necessary to augment the information gleaned by the traditional trench-style excavations. Three specific structures/features were targeted for test pitting. These were chosen based on a lack of historical documentation of their functions. Structures 6 and 7 were selected for test pitting as we desired to know their purpose but did not have the resources to open any formal units in them. Feature 4 was selected because of its close proximity to Structure 1 and because it appeared to have either been incorporated as a part of this

original structure or related to a subsequent disturbance. A total of ten test pits were sunk during this portion of the archaeological excavation, one in Structure 6 and two in Structure 7 and seven in and around Feature 4.

Structure 6

Structure 6 required only one test pit to be dug. Ruth Douglass stated on the 30th of September, 1848 that the men employed by IR&O were constructing a charcoal kiln, presumably to provide fuel for their engine, furnace, and blacksmithing works (Root 1998:73). Based on the work done by Martin in 1986, Structure 6 was presumed to be the location of this charcoal kiln. A single test pit was dug in [redacted] this Structure, closing at a depth of 62 cm when groundwater was reached. The only artifacts recovered from this test pit were samples of charcoal (Figure 3.2). Two types of charcoal were found in this pit. There were typical pieces of charcoal that one would expect to find in a good batch of the finished product. This was also accompanied by charcoal distinguished by an oily resin, characteristic of charcoal produced during the firing of a charcoal kiln.

Figure 3.2 Charcoal recovered from Structure 6.

Initially recorded in the 1986 survey as being an earthen mound, clearing the area revealed that it was round masonry structure composed of flat slabs of basalt. It was heavily overgrown and covered in soil which was most likely from the mound of earth that would have been covering the smoldering coals. The kiln was approximately 5m in diameter and 30cm. in height. The stone circle was incomplete, as it had an opening on its south side. It is probable that the Company had more than one kiln for charcoaling. Ruth records the first run of the furnace as occurring before the construction of the charcoal kiln, meaning that the Company would have had to have had some fuel on hand prior.

Structure 7

Test pits 01-02 were dug to turn up artifacts that might provide clues as to the nature of this building. Martin identified this structure as a "cellar hole" in 1986, and identified another cellar hole a short distance away which was not re-located during the 2015 field season (Martin 1986:13). Ruth Douglass describes several types of buildings existing in and around the Ransom settlement, including a storehouse, laboratory, office, blacksmith shop, and an engine house (Root 1998:68). Two test pits were opened and, despite their large size, no artifacts were recovered. Test pit one was 58 cm in diameter and 78 cm in depth while test pit two was 60 cm in diameter and 89 cm in depth. After having dug two sizeable pits with no returns, it was decided that the testing of this structure should be aborted and that resources be shifted to other areas of interest. The inconclusive results of this pitting prevented a determination of the structure's function.

Feature 4

The remaining test pits were focused on determining the nature of this depression. Only a few artifacts diagnostic of the 1840s were recovered from several of the units, but they all also contained significant artifact deposits dating the first half of the 20th century (Figure 3.3). Universally, the pits dug near or in this feature had a horizon of ferrous artifacts, especially cans, located in the 40-60 cm range below the surface.

This indicates that this pit feature was used extensively for dumping garbage after the furnace had been abandoned. This was most likely done during the Civilian Conservation Corps era or by early park visitors who occupied Daisy Farm. Despite this modern intrusion, some diagnostic artifacts dating to the 1840s were recovered included several machine-cut nails and a single piece of cream-colored ware.

Figure 3.3 Modern metal scraps and glass found during test pitting.

In test pit eight multiple pieces of slag were recovered, along with two pieces of sandstone which were coated with a fused material (Figure 3.4). There are two likely explanations for the nature of these artifacts. Either these pieces of sandstone were subjected to such an intense heat that they began to melt, or an already melted mass, such as molten slag, passed over and adhered to them. Their proximity to Structure 2 lends credence to the hypothesis that this building was a furnace, because both of the scenarios described would have required the blocks to have originally been in close proximity with an intense source of heat.

Figure 3.4 Sandstone with a fused material adhering to it. Recovered from Test Pit 8.

Results of the Trench Excavations

Structure 1

Structure 1 was a large rectangular, masonry foundation which measured 2.5x7.5m at it longest and widest. Prior to excavation this Structure appeared to be an amorphous mound (Figure 3.5). Structure 1 was a dry laid ashlar foundation, composed of local stones, both naturally formed and roughly hewn. Directly to the [redacted] of the Structure was a depression noted as Feature 4. Feature 4 appeared intrusive and its creation damaged a portion of the southern and western walls, providing an explanation for the large amounts of rubble present in the units opened near it. The upper layer of Trench 2 contained a 20cm. level of rubble identical to the slabs found on the surface (Figure 3.6), indicating the degree of post-abandonment ruination.

Figure 3.5 Structure 1 prior to excavation.

Figure 3.6 Basalt slabs from the top of Structure 1.

Structure 1 was visible across three units. These were units 493N by 253 E, 492N by 253E, and 492N by 252E. 493N by 253 E represented the top surface of Structure 1,

and was used to provide information about the floor area of this structure, as the hearth area of reverberatory furnaces have distinct floors characterized by fused sand on top of brick or stone. Such a floor was not recovered. The surface of the structure that was exposed showed that this foundation seemed to have been capped with a layer of thin, flat basalt stones (Figure 3.7). These stones were sitting directly on top of and within a larger masonry frame cut blocks of sedimentary rock such as conglomerate and sandstone. After ascertaining the nature of Structure 1's surface, attention was shifted to exposing a portion of the southern wall.

Figure 3.7 The surface of Structure 1

The majority of the artifacts were found 16-25cm deep. A wooden plank cut across the entire unit at this depth. The plank was approximately 10 cm wide and ran almost

parallel to the foundation (Figure 3.8). A collection of iron implements such as chisels, melted pieces of copper, and fragments of a crucible found at this level support the idea that this was a working surface near a furnace.

Figure 3.8 Trench 2 Level 3 in progress. Believed to have been the exposed surface when Structure 1 was in use.

The foundation's architecture, from surface to bottom, appears as such: a 7-10 cm layer of basalt slabs resting on a 30-40 cm layer of ashlar sedimentary blocks (Figure 3.9) including conglomerate and sandstone. This layer of sedimentary blocks sat on an approximately 20 cm layer consisting of large glacial boulders. That layer sat on top of a final layer of sedimentary ashlar blocks, which in turn rested on hardpan soil.

Figure 3.9 The upper 40cm of Structure 1.

Structures 2 and 3

Structures 2 and 3 (Figure 3.10) were very similar in design and are most likely two constituent parts of a building. They were dry laid ashlar foundations composed almost entirely of roughly hewn sandstone and conglomerate. They ran parallel to each other on a roughly east-west axis with a distance of 80cm. between them. At the western most terminus, Structure 2 had a corner, while Structure 3 did not, making it likely that Structure 2 was outer architectural component and structure 3 was and inner component.

Structure 2 (Figure 3.11) was visible in across two units: 497N by 251E, and 498N by 251E. Both the units opened over this structure revealed a clear view of the top, northern, and southern sides. The total depth of this structure was 90cm. with a width of 35-40cm, depending on location. Structure 3 (Figure 3.12) was visible across three units: 498N by 251E, 499N by 251E, and 499N by 252E. All major characteristics of this structure are identical to those of Structure 2.

The area south of Structure 2 and 3 was similar in soil and artifact composition. The top levels of the units opened here contained significant amounts of rubble, indicating that these structures were more substantial in height when they were first built. Beneath this rubble tools and hardware were found along with slag and fragments of native and melted copper. However the area north of Structure 3 was different. After

the rubble and topsoil had been removed, two pieces of wood rested on a layer of

yellowish sand appeared (Figure 3.13). It was concluded that this sand was used as the casting bed of the furnace and contained inclusions of native copper and finely grained oxidized copper particles.

Figure 3.10 Structure 2 and 3. Structure 2 is the southern wall and Structure 3 is the northern wall.

Figure 3.11 Structure 2.

Structure 2 rested on a natural layer of hardpan. It could not be shown what Structure 3 rested upon since a combination of groundwater and time restraints prevented excavations from reaching that level. Using total station measurements, the depth of the hardpan in Trench 2 was only 3 cm higher than the layer of hardpan in Trench 1, showing a trend that the IR&O Company dug their builders' trenches down to an equal depth before beginning construction.

During excavations of this working surface near these structure's (Level 4) numerous artifacts were discovered that related to industry. A large nut, washer and rusted rivet head were discovered, along with an intact axe-head. Similar to Structure 1, a wooden board was discovered at the working surface. The one found near Structure 2 appeared to have been burnt at some point. The presence of machine parts here suggests one was in use here during the IR&O Company occupation. This machine was probably an engine and/or boiler used to drive the blower for the furnace.

Figure 3.12 Structure 3.

Figure 3.13 Trench 3. The lumbered wood is visible resting on top of a layer of yellowish sand.

Structure 4

Structure 4 (Figure 3.14). was a rectangular depression ringed by a ridge of soil mound 3x7m in dimension. A single trench, number 4, was opened on this structure and consisted of three units: 499N by 256E, 500N by 256E, and 501N by 256E. The wall portion, designated as Zone A, consisted of a fine yellowish sand believed to have been the same material as that found north of Structure 3. Within this sand slag, native copper and a fused mass of melted copper and rock were discovered. A unique artifact was found in Level 1 of Zone A; a 91.4g mass of copper and earthen material was discovered. The copper was clearly liquid or semi-liquid at one time, although it is unknown if the non-metallic was a fluxing agent or the earthy part of the charge placed into the furnace. The depression portion of this structure was designated Zone B and consisted of a rich, dark soil (Figure 3.15). Zone A was stopped due to a lack of artifacts being found. After 10 cm. of sterile soil work was stopped, giving a total of 52cm. of excavation depth.

The artifacts recovered from Zone B included numerous metal scraps, alcoholic drinking vessels, personal items such as a comb, and miscellaneous garbage scraps (Figure 3.16). While Zone A did not have any CCC era artifacts within it, Zone B had IR&O Company artifacts including square nails and glassy slag. A curious brick was also discovered in this level. It appears to be a fragment of firebrick with a thin greenish glaze on it; furthermore, the outside edges of the brick do not appear to have been subjected to a great deal of heat, but the center of this brick is much lighter in color, a phenomenon of heavily burned bricks from this site It is probable that molten slag passed over this brick at some point. This dense layer of modern objects also included charcoal, clinker, and metal and glass objects damaged from heat. The area where the darker soil of Zone B abutted Zone A, was where the highest density of metal and plastic scraps were found, and the soil here had been stained orange from rust.

This structure was interpreted as being created after the IR&O Company occupation. It is likely that the yellowish sand layer that composed the ridge portion was initially distributed more evenly across the working surface of the smelter. The Civilian Conservation Corp then dug it out, creating the depression, which they then used to burn and discard their trash. Given that the furnace site was already littered with industrial and architectural remains from the IR&O Company phase, it would have made for an appropriate containment zone for the waste of the CCC.

Figure 3.14 North-east corner of Structure 4

Figure 3.15 Structure 4 post-excavation. Zone A is seen at the top, Zone B at the bottom. The area between was stained from rust

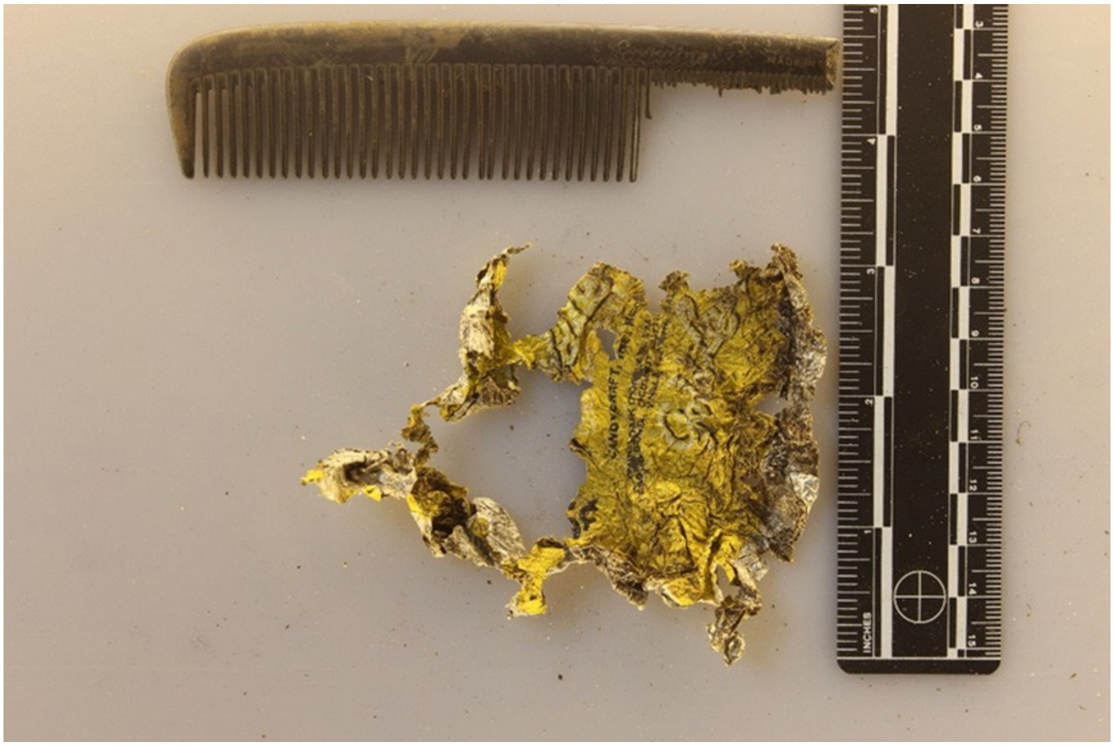


Figure 3.16 20th Century trash from Structure4.

Structure 5

Structure 5 (3.17) was the foundation that the cupola furnace sat upon and visible across two units: 502N by 247E, and 503N by 246E. Along with ascertaining the size of this foundation, excavators were also interested in determining if any remaining industrial hardware was still in place. Contemporary drawings of such cupola furnaces depict them standing on metallic or brick legs. The furnace would have been elevated above the ground so that the bottom can be opened up, allowing the furnace to be serviced when not in blast. 502N by 247E was opened to provide a glimpse at the southern face of the structure.

Structure 3.17 Structure 5. Note the close proximity of this structure to the fallen cupola (right).

Digging had to be halted due to groundwater seepage, but the portion that was opened revealed an ashlar foundation, composed mostly of conglomerate and sandstone, with smaller angular slabs of rock filling in some of the gaps. Few artifacts were found in the excavations at Structure 5. The area was characterized by small fragments of glassy slag, fire and redbrick, along with pieces of charcoal. It is uncertain if this foundation was wet or dry laid, traces of what appeared to be mortar were recovered from the dig, and adhering to some of the slabs. However, this substance could has have been the remains of a portion of the hearth termed “brasque” (Figure 3.18).

Figure 3.18 Detail of Structure 5. The white staining is possible brasque or mortar.

Brasque is a cement like substance composed of fine clay and charcoal, designed to withstand the heat of molten copper (Van Lingen 2002:158). While it is normally the substance which makes up the hearth portion of the furnace, it can also be used to patch up other parts of the furnace, restoring its ability to retain heat. Being dissolved and finely disseminated as this substance was, it is difficult to tell where its origin was. The presence of so much of this substance points to potential repairs being made to the furnace, and thus the condition it was in. If brasque was used in this fashion here, it indicates an understanding on behalf of the furnace operator on how to make repairs, and that the furnace was in need of those repairs.

503N by 246E was opened to expose the surface of Structure 4, and was only dug to a depth of several cm. Unlike Structure 1, which appeared to have sturdy outer walls filled with rubble, Structure 5 was composed of roughly hewn ashlar blocks throughout. Notable differences include numerous pieces of both fire and redbrick being discovered. None of the bricks appeared to be articulating with the rest of the structure in any coherent way. The presence of firebrick is more readily explained than the redbrick, but it may have been that this ashlar foundation was topped off with a layer of bricks to better ensure a level surface on which to mount the cupola.

Artifact Assemblage

Figure 3.19 Toppled portion of the cupola furnace.

The most telling of the surface artifacts was the fallen furnace (Figure 3.19) and damaged firebrick (Figure 3.20). The once round iron plating of the stack had warped into an oval shape, which best estimates put at 1.30m by .70m. The second part of the cupola stack was several meters away from the bottom portion and appeared to not have been brick lined. This piece was 1.65m long, but because of its heavily distorted shape no width could be determined. Based on the edges of the western portion of the smaller of the two pieces of the cupola stack it appeared that this smaller portion had been cut away and dragged some distance before that undertaking was aborted. Since the physical characteristics of the two pieces are identical (thickness, spacing of the rivets, etc.) it is almost a certainty that they were once part of the same technological system, although the absence of a brick lining in the smaller portion is puzzling. It is possible that the bricks contained in this section were removed or otherwise knocked out sometime after the site abandonment. This would help explain the ubiquity of these bricks around the site.

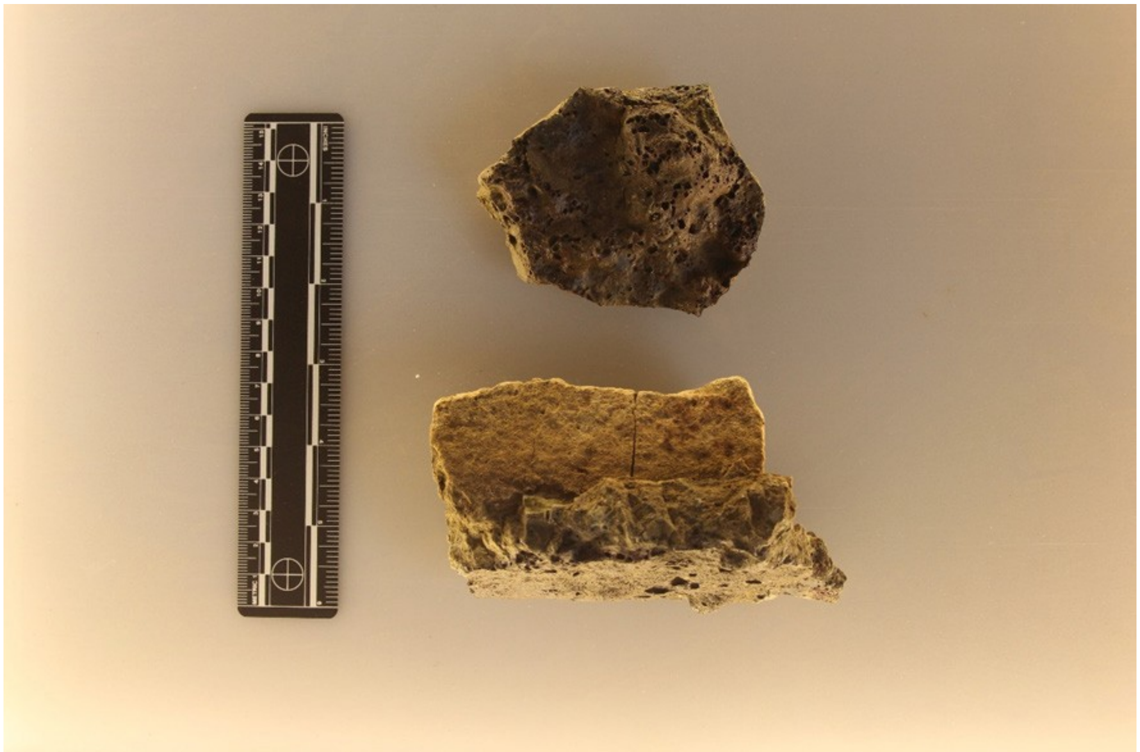


Figure 3.20 Heavily Damaged Firebrick recovered from within the cupola.

Slag was the next most obvious trace of smelting recovered. While a detailed analysis of the slags, including their color, texture and mass can be found in Section IV it is important to note in this section that we see two major types of slag. Most common are smooth, glassy pieces of slag which often exhibit conchoidal fracturing. The other type of slag which was more common resembles the types of slag recovered from a blacksmith's forge; very porous, black and bubbly in shape. However traces of copper oxide which cling to its surface point to its formation during a copper melt. In total 136 pieces of slag were collected during the excavations. Four fragments of a small crucible (Figure 3.21) recovered from Trench 2 were also significant artifacts that pointed to the copper melting which occurred at this site. These fragments, all found within Level 3 of the unit 492N by 253E were coated in a greenish glassy substance which penetrated deep into their fabric. Though a chemical analysis of this substance would be needed for confirmation, this greenish color strongly resembled oxidized copper. Using a pottery diameter chart, it was determined that this crucible would have been

approximately 10cm in diameter. A crucible this size would not have been used to pour the copper coming out of the furnaces for casting, but rather would most likely have been used to take samples of the molten product to the laboratory to have it assayed during the firing process.

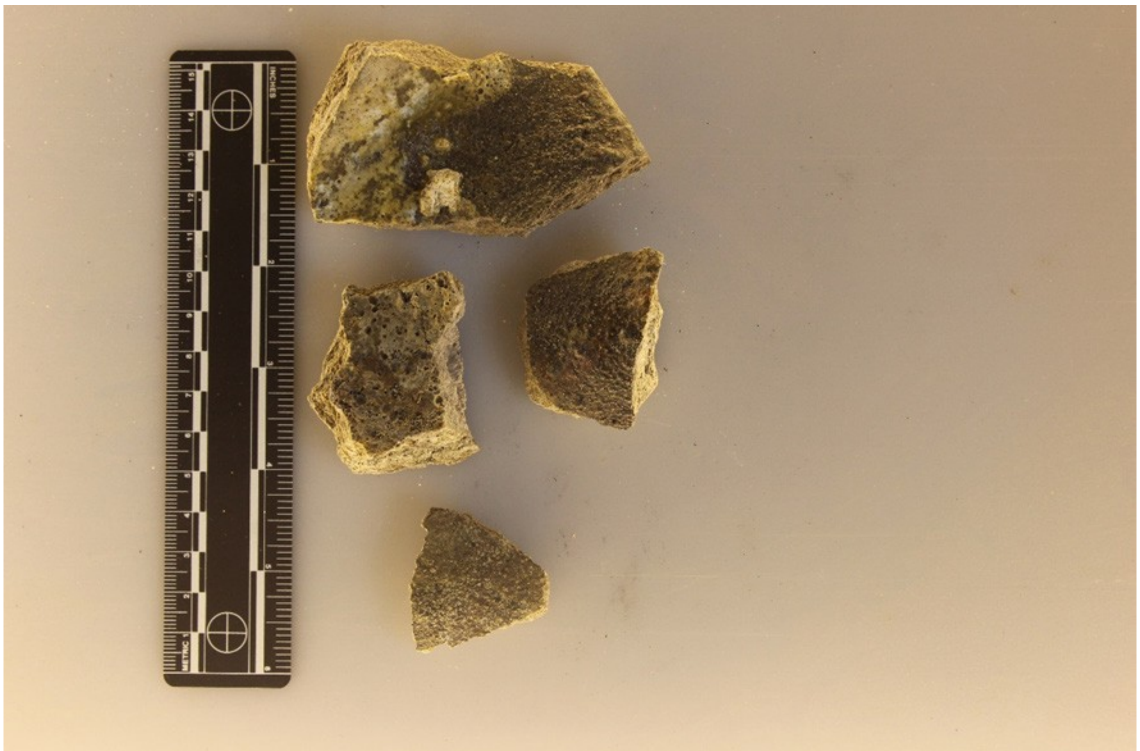


Figure 3.21 Fragments of the crucible recovered from Trench 2.

One interesting thing to note is that during a 1972 survey of Isle Royale's pre-Columbian archaeological sites, archaeologists recorded in their report that at an unspecified location on the Daisy Farm Site (20.IR.0043) an "unglazed miner's crucible" was noted. It is unknown if they retained the artifact (Cellar 1974:Not numbered).

Also recovered from this site during the 2015 excavations were eight pointed iron rods, no more than 15cm in length, which the archaeologists, Blake and DePasqual, determined to be chisels. Most chisels were recovered from Trench 2. While such tools could conceivably be used in mining or stone cutting, given their context it is believed that they were for furnace operations. After each blast of the furnace, and

gangue or slag that had solidified and adhered to the inside of the furnace would have been chiseled free by the laborers. All of the chisel points (Figure 3.22) were found within a few centimeters in depth away from what was believed to have been the working surface of the site at the location of what may have been the foundation for a reverberatory furnace: Structure 1. If Structure 1 had been such a furnace then the presence of chisels could be expected.

Figure 3.22 A square bodied steel chisel.

The twenty-eight pieces of copper recovered can be broken down into three distinct categories: native copper within its original stone matrix, copper *in statu nascendi*, and relatively pure copper freed from its stone matrix by melting. For a more detailed look at the breakdown of these copper finds by type and weight, please see Appendix 1. The copper recovered from the site occurred in three distinct places. Trench 2 was also the location of the flat piece of copper produced through stamping (Figure 3.23). Trench 2 was the source of much of the melted copper, which often exhibited the shape of small spherical droplets (Figure 3.24).

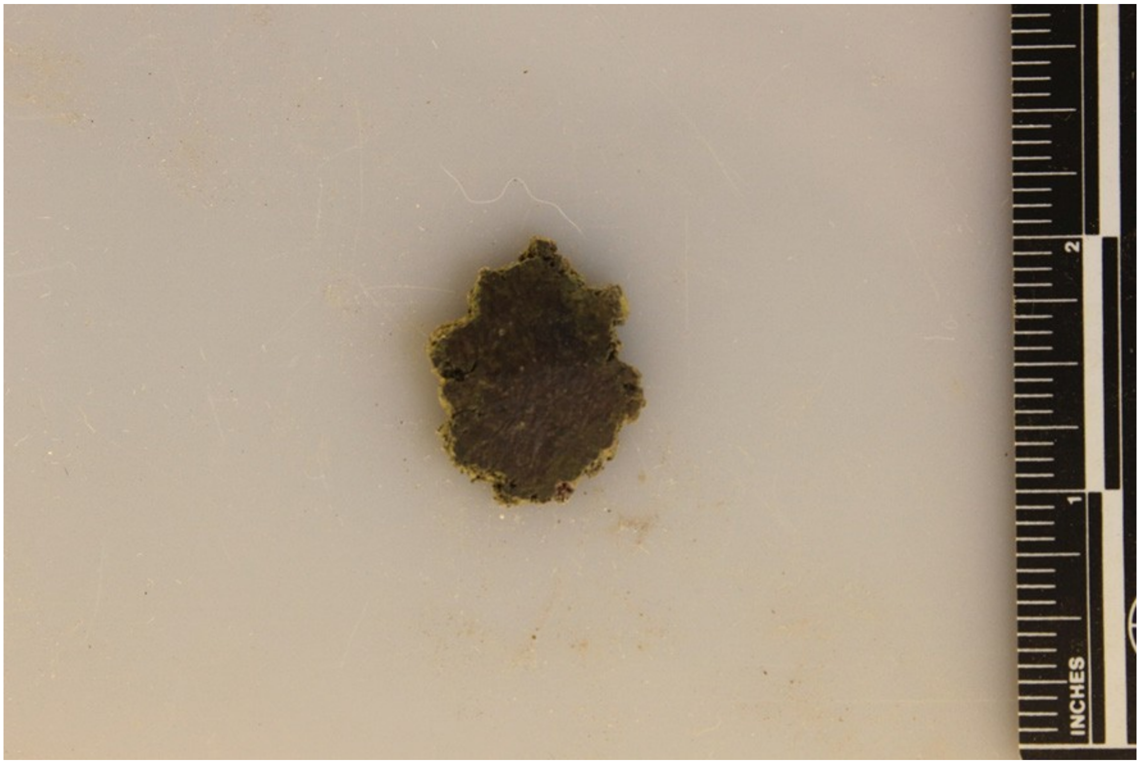


Figure 3.23 A flat piece of stamped copper recovered from Trench 2.

If Structure 1 was the foundation of a reverberatory furnace then it seems likely that Trench 2 was a logical area to find copper in. This is because in a reverberatory furnace the rabbling and pouring of the copper matte is done along the long side walls. The back of the furnace is limited in space due to the presence of the chimney, while the front contains the fire box and creating an opening for tapping or rabbling would be illogical due to the rapid loss of heat this would cause. The presence of relatively pure copper droplets along the long southern wall of this Structure lends credence to the theory that it may have been the foundation for a copper furnace. Although copper was found in a significant quantity near Structure 1 none of it was found at the base of the cupola furnace represented by Structure 4.

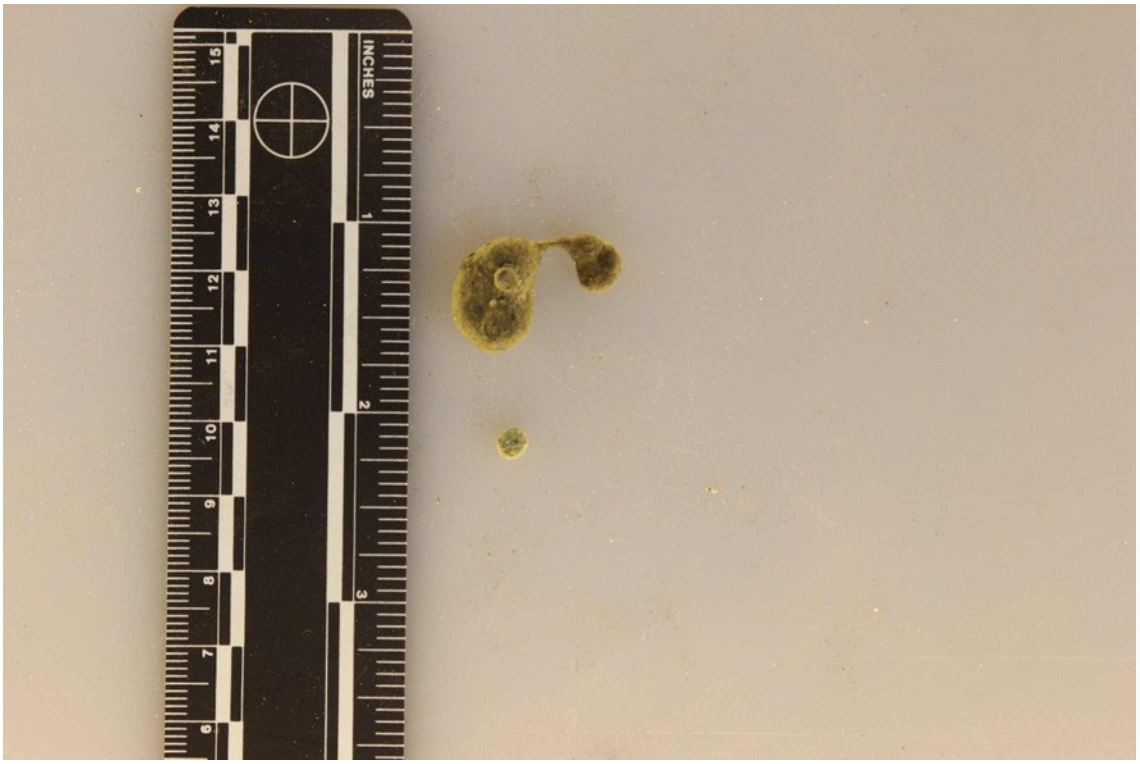


Figure 3.24 Droplets of copper recovered from Trench 2.

In the area north of the short stone wall that is Structure 3 several samples of copper oxide and sand were collected. No purer pieces of copper droplets were found here, but along with the oxide samples a piece of native copper still within its stone matrix (Figure 3.25). It is a possibility that the copper oxide and sand samples recovered from this area were the products of the casting of pig copper at the site.

The third place in which a significant amount of copper was recovered was in the foundation wall that represented Zone A of Structure 5. It was here that a significant piece of copper fused with gangue (91g) was recovered. This type of copper, clearly fired but not fully melted, is referred to in archaeometallurgy literature as being in statu nascendi, in English, "in the process of becoming". The presence of copper melting artifacts such as slag and matte recovered from within the wall of the earthen foundation raises the interesting possibility that this structure was constructed after copper melting had begun on site.

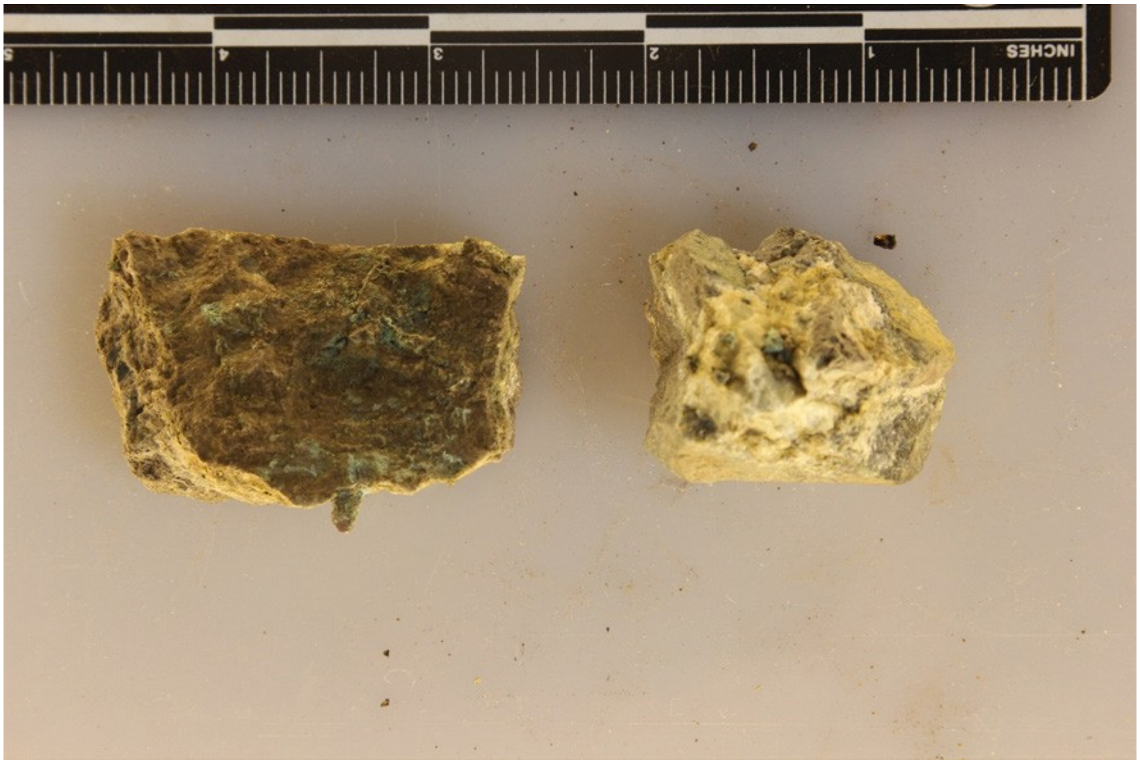


Figure 3.25 Native copper, quartz, and basalt. These may represent the state in which the copper entered the furnace.

There were just a few tools that related to mining, but their presence at the furnace is telling. Excavators discovered two pieces of octagonal drill steel (Figure 3.26), both of which were recovered in Trench 2. A pointed steel object, about 6cm wide by 2cm tall was also recovered. It is likely that this steel triangle is the bit of a steel drill, and matches some of the drill steels housed in the Michigan Technological University archaeological reference collection. Drills of this type would have been the backbone of the mining industry on the island and the inability of the different mining companies to procure them, either because of scarce supply lines or their inability to manufacture them on the island makes it likely that they were sought after commodities which would have been diligently repaired and reworked as they broke or wore down. In one such instance Cornelius Shaw records that he purchased the mining tools of a Mr. W. Williams for $17.02 in 1847 while he was on Isle Royale (Shaw 1847:5). This suggests that the scarcity of industrial tools on the Island played

a role in shaping the economic system on the Island and with the other mining areas opening up in the Lake Superior copper region.

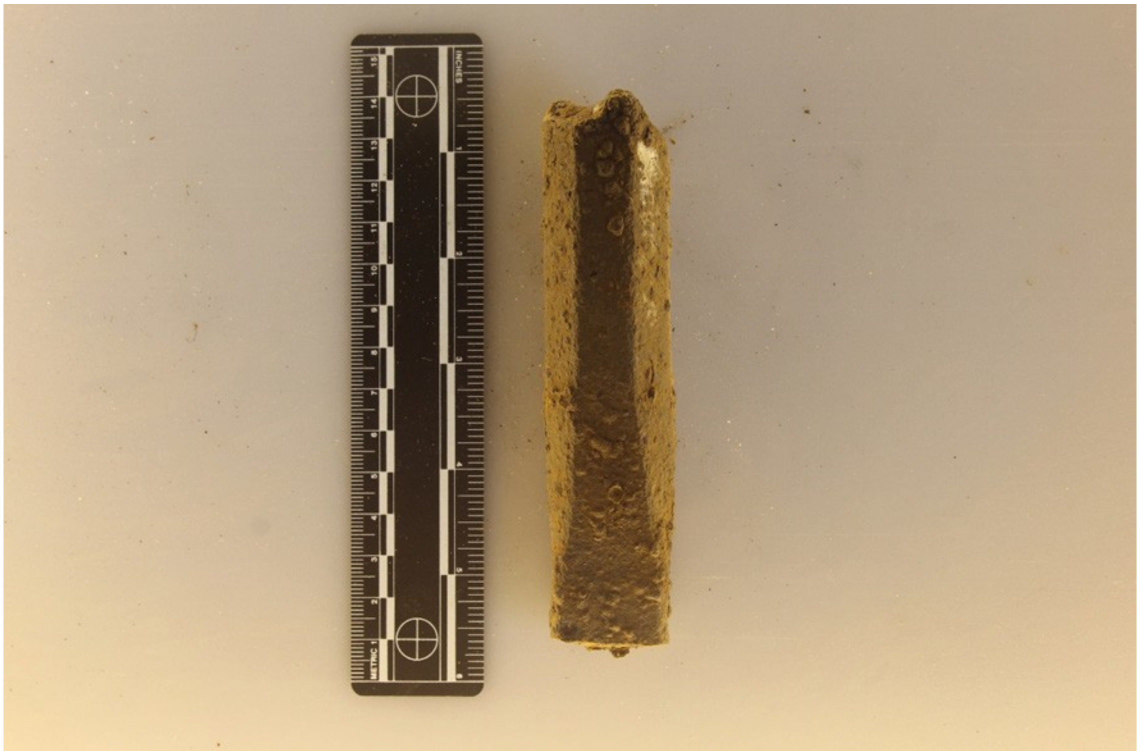


Figure 3.26 A fragment of drill steel recovered from Trench 2.

The mining tools arriving at Isle Royale were most likely passing through Copper Harbor first. The IR&O Company may have been ordering tools directly from Detroit and having them shipped up to Sault Ste. Marie and across the Lake, or they may have been placing orders with the Sutler's store at Fort Wilkins, which was the main commercial hub for mining goods and provisions in the Upper Peninsula at the time (Hybels 1948:96). Ransom would have served as the main entry port for Isle Royale and many commercial goods arriving from the Michigan mainland or elsewhere in the United States or British Canada would have been unloaded there.

The diary of Cornelius Shaw indicates that he went to Ransom on several occasions to acquire goods that may have been delivered to the Island for his firm or that he may have purchased from the IR&O Company or a mercantile third party. The goods that he was known to have acquired were: two kegs of blasting powder, one pound of

flour, rigging and iron, letters, turnkeys (for the extraction of a sore tooth), 250 feet of lumber, and then at a later date an unspecified amount of lumber (Shaw 1847).

Another tool which may have been used in the mining process was an oddly shaped iron rod. This rod had clearly been shaped by a blacksmith. It has a rectangular cross-section, roughly .9cm by .5cm and is 52cm long. One end of it is shaped into a spike while the other end has a convex bend 3cm wide by 3.8cm deep. This may have its sharp spike end driven into the wall of a mine shaft and the convex end could have been used to suspend a light source such as a lantern or torch.

There were also a number of tools discovered that while not directly relating to melting or mining can offer some clues as to what work was like on the Island. There are two artifacts which are believed to have been associated with the blacksmithing that occurred at the Ransom location.

The first of these tools is a wedge-shaped object that was discovered in the excavation of Level 4 of unit 492N by 253E (Figure 3.27). This object resembles a straight hardy, a tool employed commonly by blacksmiths for the cutting of hot metals (Watson 1977:39). Such a tool is indispensable for a well-equipped smithy and is commonly employed in cutting longer pieces of metal stock into the desired length of the new tool which needs to be produced. For instance this may have been the case when on the 20th of July, 1848, when Cornelius Shaw went down to Ransom to fetch "riggings and iron" for the mine that he was the agent of (Shaw 1847:23).

The other object resembles the jaw portion of a tong. This is a slightly arched piece of iron that is scarfed at one end and appears broken off at the other. Scarfing is the process of upsetting a flat surface of iron or steel as to increase its surface area. While this is commonly done in forge welding, the increased surface area adds significantly to the gripping ability of a pair of anvil tongs.

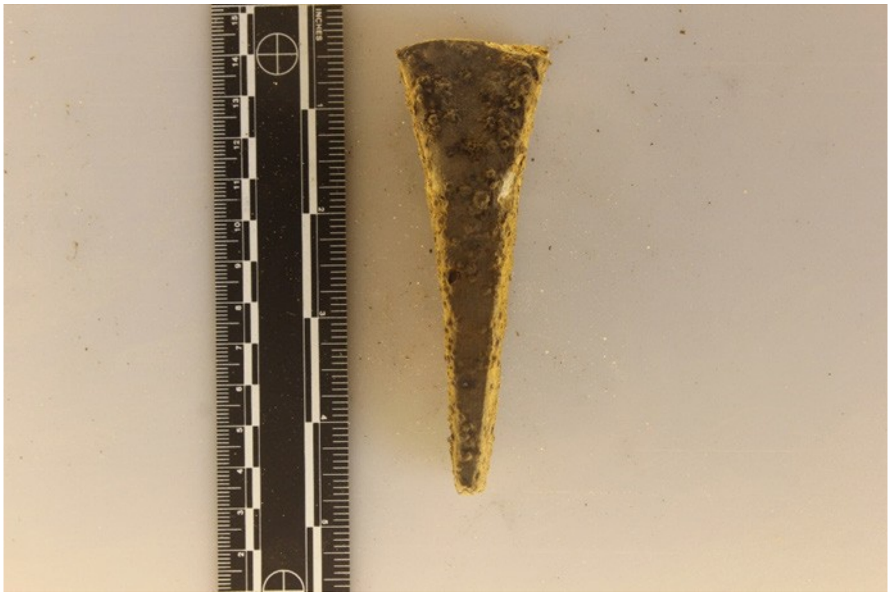


Figure 3.27 Iron wedge. This may have been a hot cutter used by a blacksmith.

Two significant utilitarian tools were also discovered on site. An iron shovel head was discovered during a pedestrian survey [redacted]. Although a tight date range cannot be ascertained the part of the shovel which holds the wooden shaft appears to have been forge welded. This points to a date in the 19th century rather than a 20th century date. Another tool discovered was an axe head recovered from Level 4 of unit 498N by 251E (Figure 3.28). This axe head appears to be of the Ohio or Michigan type, two very similar types. This is what one would expect to find on a site in this location at this time. Ohio was the source of the capital for the IR&O Company, although the Michigan type of head seems more likely because the transportation networks at the time were such that the goods arriving in the Lake Superior copper region were coming from the east, arriving at Sault Ste. Marie where they were distributed to the mining frontiers. An axe such as this one may have been used in the clearing of the area to provide lumber for the building projects, cutting firewood, or timber for the charcoaling operation that occurred at the site. In an environment as heavily wooded at the mining frontiers of Lake Superior, such a tool would have been common and invaluable.

Figure 3.28 Axe head recovered from Trench 1.

Chapter 4 - Phase Analysis of Copper Bearing Slags

Introduction

X-ray diffraction (XRD) relies on measuring the intensity of scattered x-rays that have bounced off of crystalline surfaces (Guinier 1963:3). The results of such an analysis are an indication of the chemical phases present within a sample, and unlike x-ray fluorescence not a direct count of the amount of those chemicals or elements which are present. In x-ray diffraction, samples are generally powdered in order to ensure a random alignment of all chemical phases present in the sample. This provides a high degree of standardization and repeatability in XRD research (Weymouth 1973:341).

For the purpose of this research, the three major types of slag found at the Daisy Farm site were analyzed for the purpose of assessing the chemical nature of copper bearing slags produced by industrial copper melting operations. This chapter will provide information that can be used to guide future research into the possible applications of technologies already well employed in non-industrial archaeologies, and suggestions for how future XRD tests with copper slags may be approached and improved.

Literature Review

Prior to destructive testing, a review of the available literature regarding the use of x-ray diffraction for the analysis of copper bearing slags was conducted. This review consisted of an extensive search through the databases of both JSTOR and Google Scholar, as well as historical texts on the subject of copper smelting.

The desire to perform this type of analysis was influenced by an article written by Robert Gordon for Industrial Archaeology. In this 2000 article, Gordon provides a detailed overview of the ways in which industrial archaeologists interpret the data they recover. Gordon identifies three different types of object-directed interpretation frequently utilized by the industrial archaeologist: personalization, engineering analysis, and archaeometry (Gordon 2000:103). When discussing the use of archaeometry, Gordon rightfully points out that many techniques, which are simply

and rapidly employed by other branches of archaeology are underutilized in industrial archeology studies (Gordon 2000:105). As the field of industrial archaeology expands, methods which have proven reliable in other branches of archaeology need to be tested against the material record of the industrial past to determine their applicability. X-ray diffraction is one of these technologies and, influenced by Gordon, the primary goal of this particular section is to add data about the applicability of X-ray diffraction to the study of industrial archaeology.

The primary standard for the collection and analysis of slags from archaeological contexts is Hans-Gert Bachmann's 1982 publication *The Identification of Slags From Archaeological Sites*. This text provided the basic foundations for the methodology employed and described later in this chapter. However for the purpose of this research, Bachmann speaks little about two important elements. Firstly, he does not discuss the chemistry involved in melting native copper, only other naturally occurring copper ores. Secondly, Bachmann only provides passing mention of copper slag produced using more modern, industrialized techniques as his focus of study tends to be on the ancient Mediterranean world. However, Bachmann does claim that modern copper slags are very similar in chemical composition to their ancient counter parts (Bachmann 1982:23). Bachmann himself provides no citations for this claim, but his authority in the field indicates that looking to the analysis of ancient copper slags would be a useful starting point for the industrial archaeologist.

This should be taken as good news by the student of industrial archaeology, as the author of this text had a very difficult time finding any scholarly work relating to the analysis of industrially produced copper bearing slags from an archaeological perspective. Most of the scientific studies of industrially produced copper bearing slags seem to be getting published in metallurgical journals, such as The Scandinavian Journal of Metallurgy and environment literature such as the journal Resource, Conservation, and Recycling, dealing with topics such as the recovery of metals from the slag products, or the environmental hazards posed by these slags. Even England, with its relatively well developed approach to industrial heritage,

tends to neglect industrial copper smelting in favor of the iron smelting industry. The Historical Buildings and Monuments Commission for England has produced a guideline for best practices for approaching archaeometallurgy, however its nine page chapter on copper and its alloys provides a two paragraph discussion on industrial copper smelting, focusing almost entirely on the technological process involved in reverberatory copper smelting, and only a single paragraph on the use of x-ray diffraction in archaeometallurgy. The text that would be more relevant to the student of industrial archaeology, *Science for Historic Industries: Guidelines for the Investigation of 17th- to 19th- Century* speaks to the potential of XRD for historical industries, but focuses mostly on approaches for pottery (English Heritage 2006:12). X-ray diffraction is commonly employed to study the glazes and clays used in the production of pottery, both prehistorically and historically (Weymouth 1973:339).

The archaeological starting point for this study was Myer and Betancourt's 2006 article *Petrography and X-Ray Diffraction of Slag and Furnace Chimneys.* This study looked at slags and furnace fragments recovered from the copper smelting operations located on Chrysokamino, Crete. The samples used were from a Bronze Age copper production facility, but if Bachmann is to be believed the slags from Chrysokamino could be used as a baseline for what might be contained within the slags recovered from the Daisy Farm excavations in 2015. Myer and Betancourt subjected two samples of glassy copper bearing slags to x-ray diffraction and discovered the following elemental phases: Akermanite, Diopside, Delafossite, Dolomite, Augite, Cuprite, Fayalite, and elemental iron (Myer and Betancourt 2006:292).

Scanning Methodology

The slag samples (Figure 4.1) analyzed were selected after the fieldwork had been completed, and the finds processed in a laboratory setting. In total 20 samples were initially set aside for x-ray diffraction testing. The chosen samples can be found in Appendix 2 and were classified by the following characteristics: mass in grams, volume in milliliters, their color when wet as determined by a Munsell color chart, the density of the piece in grams per milliliter, and their archaeological provenience.

Samples were initially selected if they provided enough mass through a single piece of slag. As such pieces were scarcely recovered during the excavations, the other samples consisted of multiple pieces of slag that exhibited similar color, mass, and archaeological provenience.

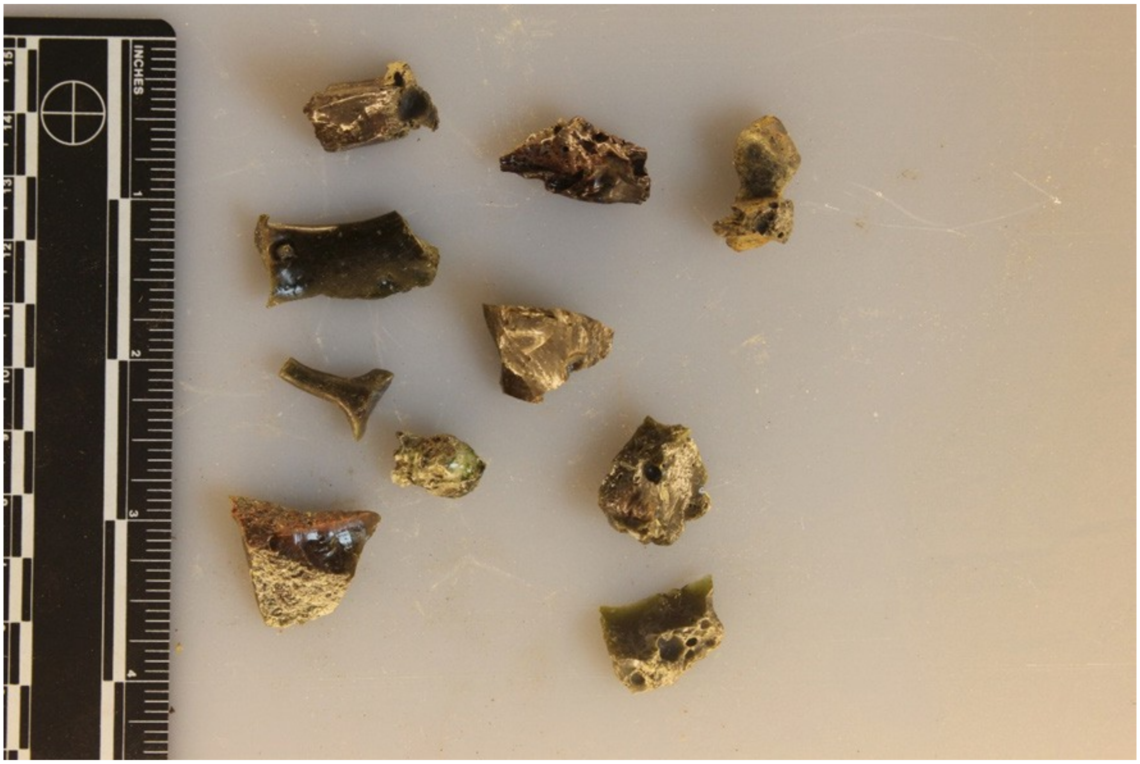


Figure 4.1 Glassy pieces of slag recovered from Test Pit 8. These are typical of the slags found in all units of excavation.

Each sample was powdered using the following procedure. Prior to powdering the specific sample, the sample container was thoroughly cleaned. First sand would be placed in the container along with steel balls, this was then placed in a SPEX 8000 mixer mill and shaken for two minutes. The powdered sand was then removed and the sample container was filled with ethanol and steel balls. This was then shaken again for two more minutes, emptied and dried using a compressed air gun. The slag sample was then placed in the cleaned container after being pre-crushed with a hammer. The slag samples were shaken in the mixer mill for 10-15 minutes, depending on their initial density. The powdered samples were then placed in sterile bags to hold them prior to the x-ray diffraction testing.

The x-ray testing itself utilized a Scintag XDS 2000 powdered x-ray diffractor. Since the use of x-ray diffraction to analyze samples of copper bearing slag from the industrial is a fairly novel approach, Sample 1 was selected for a trial run to ascertain a rough idea of what to expect from further testing. This trial run was performed using the following parameters: 5-65 Degrees with a scan rate of 2.00 degrees a minute. This provided evidence that these copper bearing slags were of a highly amorphous nature, as is typical of vitreous solids (Guinier 1963:64-65). Sample 1 was then re-assessed using the following parameters: 15-50 Degrees at 0.5 degrees a minute, to better assess the peaks present in that range. The degrees for scanning were selected based off the results of the initial testing. This approach greatly enhanced peak clarity, but could not be adopted as a means by which to approach the remaining samples. This was because it was unknown if the other samples would produce measurements which would be enhanced by narrowing the angles to 15-50. Therefore it was decided to run three more samples at 10-70 degrees at a stepped scan rate of 1 degree a minute.

These scans showed that the data generated was quite similar, and that it was most likely that reddish-black glassy slags were chemically homogenous. With this knowledge one more, Sample 5, was run at 13-70 degrees at a rate of 0.2 degrees a second to produce a high degree of clarity which would be representative of the 10R 2.5/2 "very dusky red" slags mostly recovered in 499N/256E.

Sample 20 was selected as a representative of the more porous and 10Y 5/4 "light olive" slags recovered from 502N/256E. This was the final slag sample tested, as all the major slag types were covered. Sample 20 was run at 13-70 degrees at a rate of 0.2 degrees a second, as it would give data ranges comparable to the other samples tested.

Peak Identification Methodology

The initial output generated by the scanning were cleaned to reduce background noise that would allow peaks to be more clearly defined. Smoothing was done with no K-Alpha stripping, as to maximize the intensity of X-ray emission. Smoothing the graphs was done with the use of a boxcar curve fit with five smoothing points with the filter width set at 1.5 degrees. The peaks were determined used the Scientag software with an EDS of 2 and a RM of 1.1.

Results

Several mineral phases could be identified in all samples scanned except for Sample 4. Sample 4's pattern was too amorphous to allow the software to detect any peaks that were present in the user generated database.

The slags produced at the Isle Royale and Ohio furnace consisted primarily of pyroxenes, which are inosilicate minerals and the major minerals in basalt rock formations. The most common pyroxenes observed were diopside (Figure 4.2), auguite, omohacite, and an unnamed mineral made up of sodium-calcium-chromium-magnesium-silicate. These minerals consistently produced the highest figures of merit in all five of the samples that had discernable peaks. None of the samples tested showed evidence for the presence of copper oxides or iron oxides, nor were there any detectable levels of elemental copper. However, hedenbergite was observed in Samples 1 and 5. Hedenbergite is a calcium-iron-silicate and may have been present in the slags at Daisy Farm as a product of the calcium rich fluxing agent stripping the iron and silica from the gangue, or as a natural product of the regions geological formations.

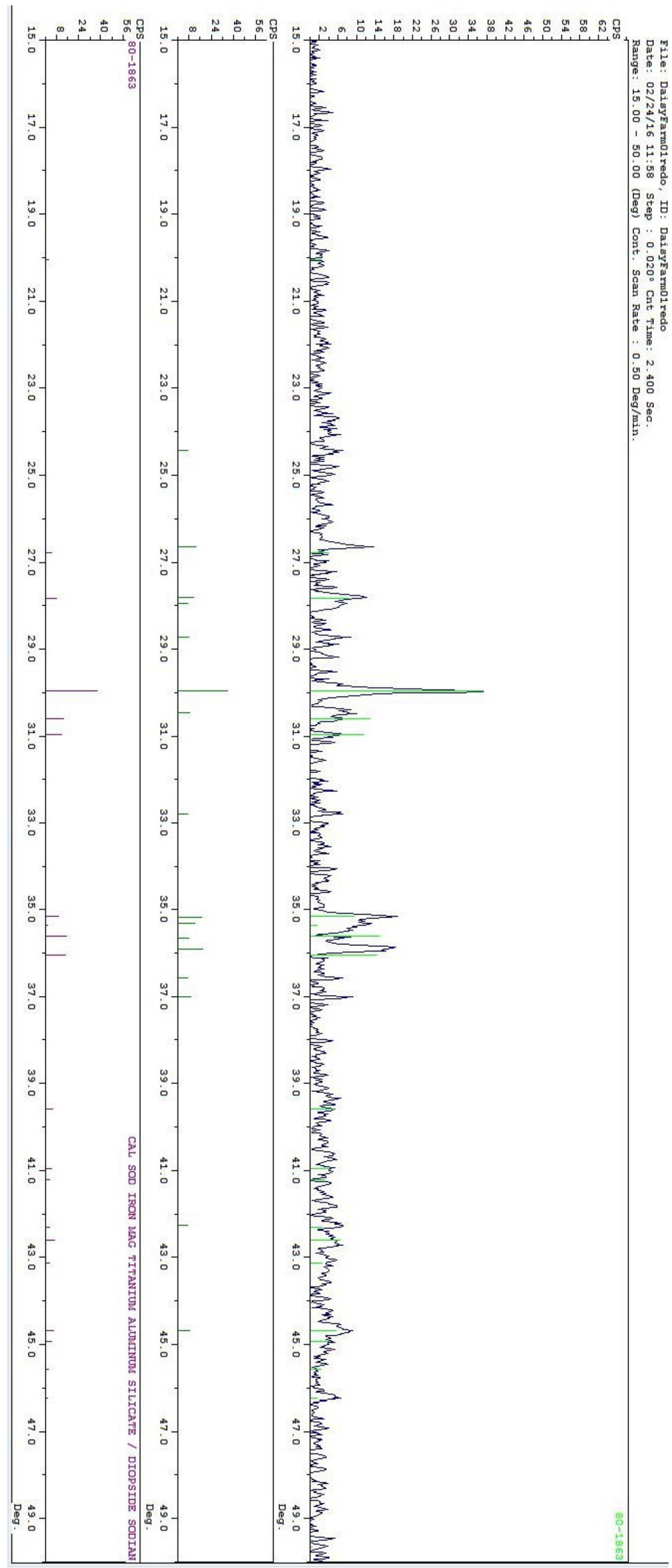


Figure 4.2 Phase analysis of Sample 1. Peak matching for diopside shown.

Two mines operated by the Isle Royale and Ohio Mining Company were named after specific mineral formations that were present in them: the Datolite and Epidote Mines. The mineral formations commonly associated with particular lodes of copper will be present in the slags produced by a successful operation. Further, identifying non-silica components of the slag was also deemed to be important. All samples were run against numerous phases of both epidote and datolite. Samples 5 and 1 showed evidence of datolite (Figure 4.3). Sample 20 showed evidence for both datolite and epidote (Figure 4.4).

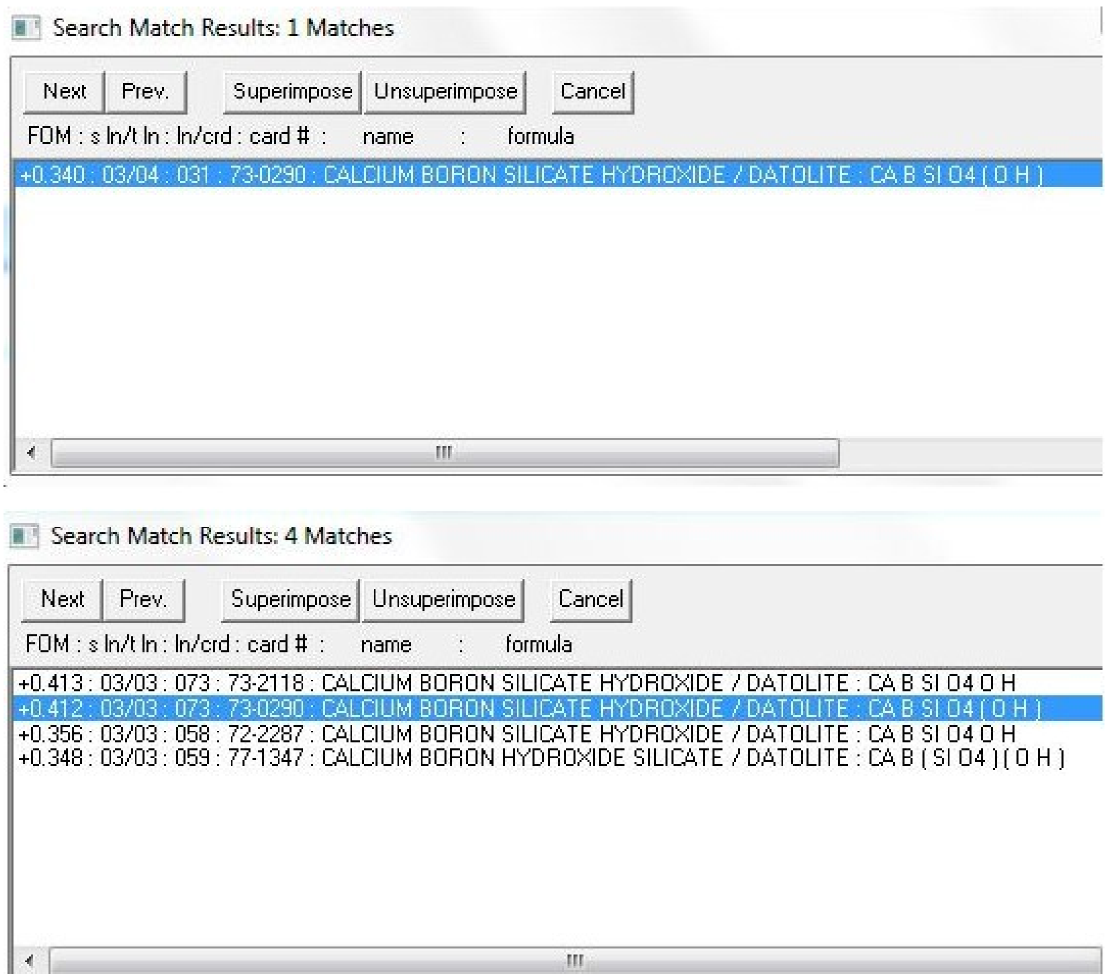


Figure 4.3 Results for datolite. Sample 1 (top) and 20 (bottom).

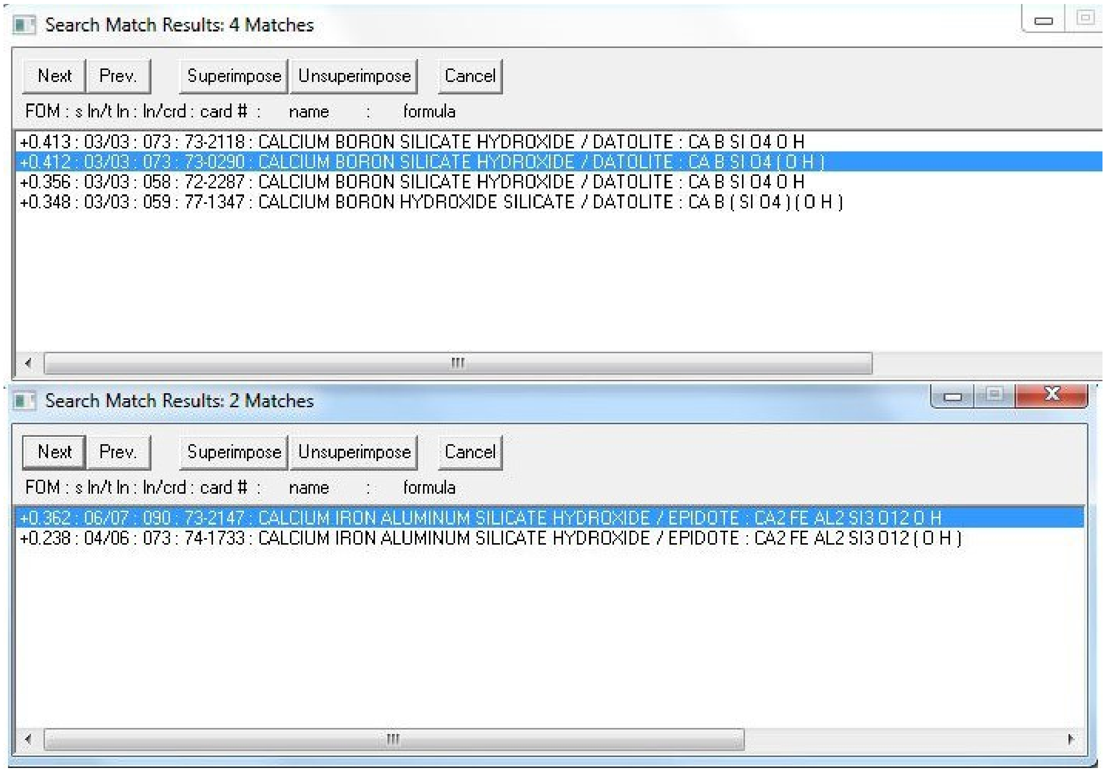


Figure 4.4 Matches for datolite (top) and epidote (bottom). From Sample 20.

Conclusions

The results of the tests that were run appear in Appendix 3. These results show the high signal to noise ratio of the copper slags recovered from the excavation at Daisy Farm. The amorphous nature of these vitreous bodies requires a very lengthy scan in order to reduce background noise. It is therefore recommended that industrial archaeologists be prepared to accommodate these extended scan times into their research plans.

A probable explanation can be made based on the presence of mineral phases of the slags associated with the basalt bodies the IR&O Company was mining and a lack of phases indicative of trapped copper, along with the archaeological and historical evidence considered. The presence of datolite and epidote in the slags may also point to a connection between the slags and the location that the minerals to be melted came from. It is logical to assume that as the prospects of the mines decreased, so did

the copper content of the mineral coming out of the mines, thus leading to furnace charges with increasingly lower percentages of copper, which may explain the sufficient crystallization of the pyroxenes, but a lack of sufficient crystallization in either copper oxides or elemental copper. Further, these lower grade charges could have easily had much of the copper separated out without yielding a pure copper, as some minerals present in the basalt formations such as quartz and iron melt at significantly higher temperatures than copper, which would have trapped them in the resulting matte. Such a scenario could have easily produced the copper matte recovered from Trench 4. There is little doubt that trapped copper remains in the slag, however not enough remains to provide a significant crystalline structure that can be easily detected against the background noise of all the other phases present.

The industrial archaeologist should also be aware of the technological processes that were used in the tapping and disposal of the slags. The slags recovered from this excavation showed that sand particles frequently adhered to the tapped slag and it is likely that the slag was tapped into a sand bed or directly onto exposed earth. In instances such as these, the phase compositions of the sand and soil inclusions will obscure data that provide evidence for the nature of the reactions that occurred within the furnace. This is particular true when the sand or soil contains a high degree of silica, which is also commonly found in the slag itself. Given the nature of slag samples recovered, which were of low volume, it was difficult to select samples based on their level of exposure to the tapping floor. The IR&O Company ran a modest operation, which likely lasted less than a whole year. The industrial archaeologist who has access to large heaps of slag such as those found in Butte, Montana or Hancock, Michigan should seek out samples so that the portions selected for powdering were only exposed to the atmosphere or tapping surface for a short amount of time. This will help minimize background noise during XRD analysis.

Knowledge of the mineral bodies being mined is also of great importance. Much more historical literature exists regarding the smelting of non-native coppers, which can provide very detailed information on slag compositions during the various stages

of smelting copper sulfides or copper pyrites. When assessing slags produced from the melting of native copper ores the associated geology of the mineral deposits are important to understand. Minerals commonly associated with native copper veins, such as epidote and datolite, are readily detectable the slags produced during native copper melting. However, each mine present in a region may have different secondary minerals present in their lodes, or in different quantities. In cases where there are only a handful of businesses smelting, but numerous firms mining, it could be possible to differentiate which slags were the product of specific mines, given sufficient knowledge of local mine geologies. Having access to records from drilling samples would be an asset to such research.

Taking the results from this test and comparing them to the observations made by Myer and Betancourt can allow for an assessment of Bachman's statements that modern copper slags closely resemble their prehistoric counter parts. Of the thirteen different minerals and elements listed by Myer and Betancourt in their 2006 paper, only four were found to be present in the slags at Daisy Farm: diopside, delafossite, augite and hedenbergite. However diopside and augite were the mineral phases that exhibited the highest degree of crystallization and were therefore the most readily apparent in the scans.

Finally it is recommended the industrial archaeologist start with a very robust list of possible phases, derived from geological knowledge and information derived from the types of elements and minerals present during the smelting processes employed. It is ideal to cast the net of possible phases as wide as it can be cast, thus ensuring that nothing is missed, or no peaks are mistakenly assumed to belong to specific phases.

Chapter 5 - Reconstructing the Operation of the Furnace

Evidence for the Blast Furnace

Archaeology clearly points to the use of a cupola blast furnace. The presence of the toppled cupola stack lined with damaged firebrick, and the ubiquitous presence of slag in all the archaeological units opened, and a tuyere found near the cupola (Figure 5.1) indicates that there was a cupola present that did go into operation.

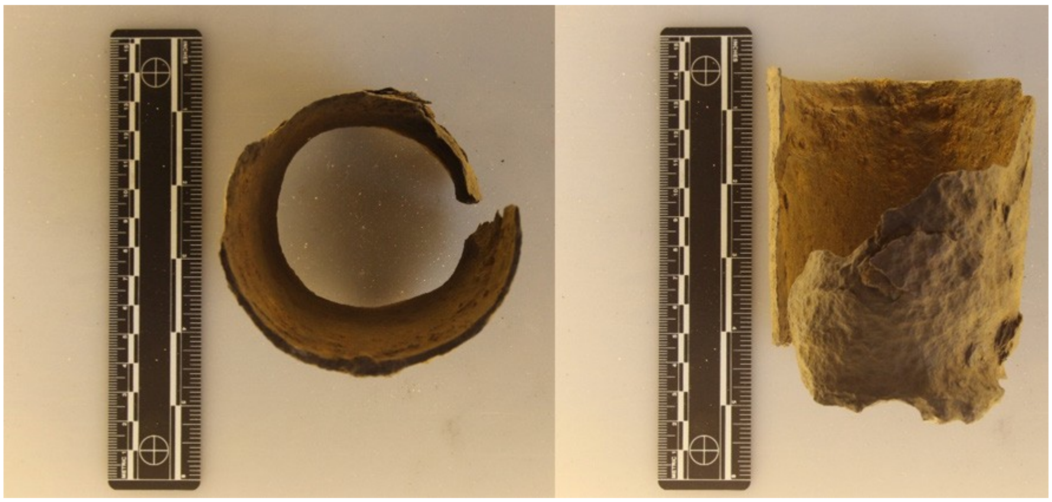


Figure 5.1 A tuyere recovered near the foundation for the cupola.

Evidence for and Against a Reverberatory Furnace

Based on historical accounts, the size of the furnace that may have been present at the IR&O furnace can be roughly estimated. Hofman provides a sketch of the changes in reverberatory furnace design and size during the 19th century (Figure 5.2). However it is known that significant variation did exist within these furnace types (Willies 1991:104). Unfortunately Hofman does not provide dimensions for the walls of the hearth or fire box, only dimensions of the internal areas of those two segments. The reverberatory furnaces prior to 1850 had, at their widest points, dimensions of 4' x 4' for their fire-boxes and 8' x 11' feet to 9' x 12' 4'' for the hearth areas (Hofman 1914:237).

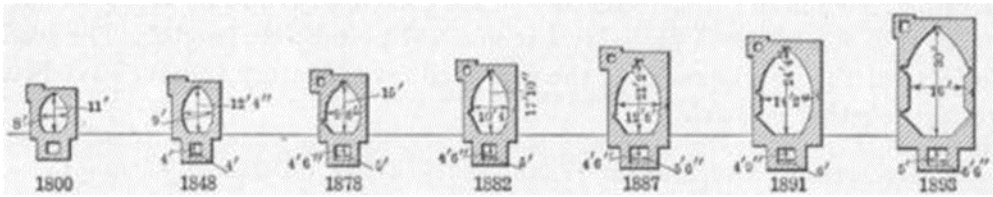


Figure 5.2. Development of reverberatory furnaces in the 19th century. From Hofman 1914:237.

These measurements dictate that the amount of surface area required for the construction of a reverberatory furnace during the 1840s to have been, at a minimum 88'-111' square feet. Additional square footage would have been needed for the walls and reverberatory linings. While Hofman does not indicate the dimensions of the walls in his diagrams, it could be assumed the walls are drawn to scale to the hearth area. If this were so, an additional 64' square feet would have been appropriate, raising the total surface area to 152'–175' square feet. The archaeologists participating in the 2015 excavations measured the dimensions of Structure 1 as 2.5x7.5m squared, or 201' squared. This calculation assumes that the south-west corner of Structure 1 was removed sometime after the year 1848 and not part of its initial construction. If the foundations were designed with this section not present, then the north-west corner may have been the foundation on which the chimney stood. The shape of this north-west corner would have been appropriate, given that square chimneys were preferred in the construction of smaller reverberatory furnaces, as they were erected quicker and were more economical for lower chimney heights than circular ones (Howe 1885:37). Under this configuration, the area available would have been 161' squared. This places the surface area of Structure 1 well within the reasonable limits of mid-18th century reverberatory furnace.

Despite the total surface area of the foundation falling within acceptable parameters, one additional point regarding required surface area needs to be addressed. As the technological process of reverberatory smelting progresses advanced, the ratio of furnace width to length shrunk dramatically. In 1800 the length is only 137% greater than the width, however, in 1911 this increases to 636% (Hofman 1914:237). The earlier the furnace is, the more square its construction, and Structure 1 is very rectangular in shape, with the length being 240% greater than the width, which, based

on Hofman's diagrams is more similar to a furnace from 1900 than 1848. Given the maximum width of Structure 1 at 8'2'' Hofman's diagrams showing approximately 4' widths for the walls in 1848 is not compatible with Structure 1. However, the north side of Structure 1 was not excavated and it is possible that the original plan of the foundation had a larger width, although the presence of artifacts found along the south wall seems to suggest this as unlikely.

Most of the supporting lines of evidence for Structure 1 being a reverberatory furnace comes from the artifacts found directly adjacent to it. There is also artifactual evidence that casts serious doubts that Structure 1 was a reverberatory furnace, notably the presence of significant amounts of clear window glass at the same level of excavation believed to have been the working surface (Level 4). There is absolutely no reason why a furnace of this nature would need glass windows, let alone windows so thin and fragile. If Structure 1 was the foundation of a building in which work was taking place in, such as an engine house or smithy, then windows would most certainly have been appropriate. Additionally, there was no archaeological evidence of the type floor lining that would have been employed in a reverberatory furnace. These floors were made up of several layers of fused sand and small amounts of copper. The surface of Structure 1 was completely bare of anything that resembled this material.

It should be noted that also that the operation of a reverberatory furnace, in contrast to a blast furnace, requires many more workers with very specialized skills (Van Lingen 2002:157). A reverberatory furnace also requires a significant investment of capital and time before it can be properly put into blast, and significant reconstruction after each blast has been completed, which requires ready access to firebrick (Van Lingen 2002:158). The need for more workers, with specialized skills, a very large investments of capital, and ready access to firebrick makes the prospect of a reverberatory furnace on Isle Royale at this time unlikely. If one was attempted it would have been a significant drain on the Company's resources.

Since the nature of the IR&O Company furnace operations is not described in specific detail by any known source, there is no direct historical evidence for the presence of either a cupola or a reverberatory furnace.

Reverberatory furnace melting at Daisy Farm lacks the overwhelming archaeological evidence that blast furnace possesses. Still, an argument can be made for its presence. The dimensions of the foundation are reasonable for one. The presence of melted copper, a crucible, and what appears to be chisels (see Chapter 3) in and around the area where workmen would have been skimming, tapping and otherwise accessing the interior of the furnace also provides a degree of evidence. Also, the historical record indicates that "loads" of bricks were pilfered from the furnace in 1871 (see Chapter 2).

The extent of brickwork at Daisy Farm remains enigmatic. The lack of brick buildings in Ruth's description of Ransom could be explained by the likelihood that the furnace operations were housed under the same roof as the engine, boiler, and cupola. It is also quite likely that only small portions, such as chimneys of specific buildings, were composed of brick. It is also possible that she may not have considered the reverberatory furnace as a separate entity. This hypothesis is challenged by her entry in which she describes the laying of a corner stone for a "furnace house". Given the nine day window between the laying of the stone and the first run of the furnace, it is unlikely that an entire stone furnace was constructed.

The stone was most likely laid for either a larger casting shed or other structure to protect the cupola furnace, or as part of the foundation for the reverberatory furnace. Structure 1, given the artifacts present, its close proximity to the furnace, and the historical record may have been for the laboratory of the IR&O Company. The establishment of a reverberatory furnace after the arrival of Douglass would lay to rest a significant inconsistency in the historical record. It would explain why Douglass was sent to Isle Royale to establish a furnace, despite multiple accounts indicating that the smelter was mostly completed by the time of his arrival.

A Direct Comparison of Blast and Reverberatory Smelting

In 1885 Henry M. Howe authored a text solely dedicated to a discussion of copper smelting (Howe 1885). In it Howe listed the different advantages that both reverberatory and cupola furnaces conferred to a smelting operation. The knowledge that Howe possessed in the 1880s was part of an intellectual legacy which had been building in the United States for some time. The table below presents an itemized list of these advantages and indicates which would have been applicable for the melting of copper lodes from Isle Royale.

Table 5.1 Advantages of each furnace. From Howe 1885

Cupola Furnace		Reverberatory	
Highly ferruginous ores.	X	Highly Siliceous ores.	X
Anthracite or charcoal is readily available.	X	Bituminous coal or wood is readily available.	X
Oxidized ores.		Unpredictable ore composition.	
Low grade native copper.		Refining rich native copper.	X
Where clean slags are a necessity.	X	When copper rich slags can be offset by with richer ore bodies.	

It is possible, and was the case on Isle Royale, for the mineral body to be both ferruginous and siliceous. Also, Isle Royale would have provided ready access to both wood and charcoal, but these two fuel sources are set apart by Howe for a very good reason. In the case of the reverberatory furnace, the fuel source is virtually non-consequential, as there is little contact between the fuel and the mineral body, greatly reducing any contamination. Further, the molten copper, on account of its weight, is protected by a layer of molten slag, further insulating it from contamination. With the cupola furnace the fuel is mixed in directly with the mineral body as a part of creating the charge. Coke and charcoal are fuel sources that have been specifically refined to

remove impurities that taint the copper. As a rule, cupolas need a cleaner fuel source, while reverberatory furnaces can use almost anything for fuel (Howe 1885:103).

The Fuels Employed

Evidence was recovered indicating the presence of both charcoal and anthracite. The anthracite was discovered only on the surface of the site, indicating that it was most likely from the Civillian Conservation Corp era blacksmithing or camp heating. The strong historical and archaeological evidence for the use of charcoal at the site, and the ample stands of trees provide a very clear image of the fuel sources employed at the furnace. Charcoal production would have been of central importance to running the copper furnace and is suitable for both reverberatory and blast furnace copper production. Wood works as an acceptable fuel for reverberatory furnaces, but not for blast furnace smelting. The boiler for the steam engine would have been heated by burning wood, as this would have been the cheapest suitable source of fuel.

The Engine

Ruth Douglass clearly indicates that an engine house was present, and the 1847 edition of the *American Railroad Gazette* informs us that the agent of the Isle Royale and Ohio Mining Company, most likely Leander Ransom, was sent to the Island with a steam engine (*American Railroad Journal* 1847:488). Since American manufacturers of steam engines had, by the 1830s, already developed to the point where they were able to offer exports of stationary steam engines for foreign markets (Pursell 1969:105) it is not unlikely that the IR&O Company could have purchased a small stationary steam engine at an American center of industry and brought it to the Island.

Where this apparatus would have been located on the site is enigmatic. Since the type of steam engine employed by the IR&O Company is unknown, making it difficult to tell how it would have articulated with the rest of the structures. However, given contemporary trends in American stationary steam engines at this time, it is probable

that this was a horizontal expansive engine, demonstrated in Figure 5.3 (Pursell 1969:117).

Such an engine would have required a long, narrow foundation for mounting, as well as a pit to allowing a sufficiently large enough wheel pit for the flywheel to move freely. A second narrow, but not as long foundation would be needed to support the flywheel on the opposite side of the wheel pit.

It is possible that this was the function of Structures 2 and 3. The main portion of the engine could have sat on Structure 2 or 3. The deep pit between the two would have facilitated room for the motion of a flywheel. The other side that did not serve as the primary mount may have functioned as a support for that flywheel. The length to width ratio of the foundation walls represented by Structures 2 and 3 shows they are much longer than they are wide, as is typical for the mounts of horizontal engines. Such an example is illustrated in Figure 5.4. The largest portion of the engine system would have been the boiler. This boiler may have stood on top of Structure 1, as the large foundation would have easily supported one. From there steam would have been directed to the engine atop Structures 2 and 3. With such a large amount of water so close by, this boiler would not have needed to recycle the steam.

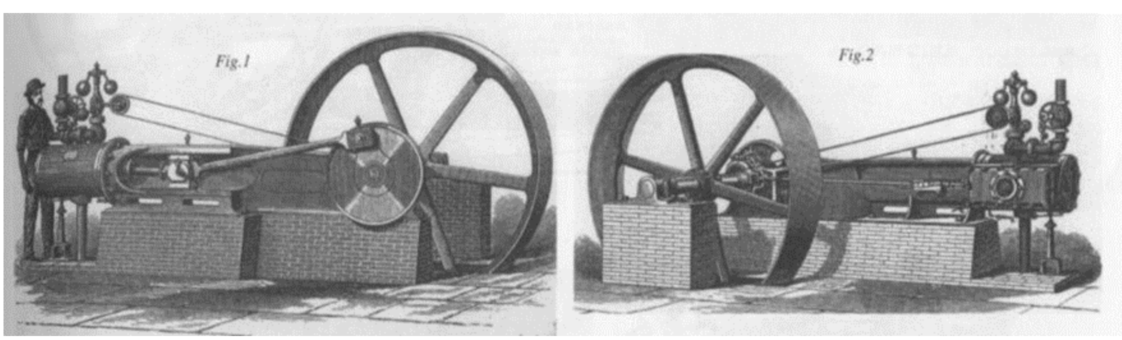


Figure 5.3 Two examples of a horizontally mounted steam engine. Note the two walls needed to support the flywheel and engine, and the person for scale. From Cope 2006:84.

Construction

In his 1907 treatise on copper smelting, Dr. Edward Dyer Peters includes an entire chapter of the principles of furnace buildings, which contains many core elements that would have been applicable in 1848. Assessing Peters' description of the foundations needed for both reverberatory and blast furnaces and making connections to the archaeological data collected will help increase our understanding of the way in which the smelter operated.

Peters lists five essential items required for the construction of furnaces, both blast and reverberatory: mortar, stone, fire-brick, redbrick and ironwork (Peters 1907:499). All five of these materials were recovered during the excavations. Essential to proper construction of a furnace is the foundations that they sit upon. The critical importance of the foundation is in part due to the fact that they have to be constructed onsite, and cannot be mass manufactured to specific measure as the other parts of a furnace can (Peters 1907:495). Fortunately, among the most significant remains of the IR&O Company's furnace were the foundations.

Peters indicated that furnace foundations should rest on a "uniform, compact, solid material that will not yield to the weight" (Peters 1907:497). Structures 1, 2 and 3 all rested on a natural layer of hardpan which clearly met this description. In fact Peters lists hardpan as the ideal surface upon which to construct a furnace (Peters 1907:497). Structure 5, the cupola foundation, could not be excavated to natural hardpan because of ground water penetration, but it seems probable that it would have been laid down to the same depth as the other structures present. A major difference between the foundation construction listed by Peters and the structures observed through archaeological excavation was that if Structure 1 was the foundation for a reverberatory furnace, it is exceedingly large (Peters 1907:495). Reverberatory furnaces are flat, wide structures and as such would have had their mass spread out over a much wider area. A conservative estimate of the Structure 1's volume was calculated at 22.5 cubic meters. It is possible that the great height of the foundation was a result of it needing to both rest on hardpan and be sufficiently raised as to have

the rabbling windows at level with the rest of the work environment. It may also have been desirable to elevate the furnace to a significant height as to accommodate the fire-box and ash-pit.

Structure 2 possesses a well-defined corner and continues north a ways after turning, which if extrapolated on, could be drawn to look like a foundation wall that would have enclosed both the cupola and the bed of casting sand. Structure 2 can be seen as the foundation for a casting shed. Casting sheds are required to protect the molten charge of a blast furnace from the elements, particularly water (Council, Honkerkamp, and Will 1992:20-21). Buried stone was not revealed during probing of the soil in the areas where the wall should have continued. Thus, further trench excavations will be the primary way to confirm the existence of more wall. It is also possible that the event which created Structure 4 may have obliterated the eastern portion of the wall which would have given Structure 2 a "U" shape. If Structure 2 was the foundation of a casting shed, the role of Structure 3 becomes much less apparent. Having another wall immediately one meter inside the foundation wall of the casting shed seems odd because there is little that this space could be used for, other than the previously described arrangement of a horizontal engine. It is possible that this space was used for storage, and supplies were moved from this area up to the feed floor. A wooden floor and stone walls may have been used to keep moisture away from the charge components, which all appear present in the archaeological record. Structure 2 being an outer wall does not eliminate the possibility that the space between them was a wheel pit (Figure 5.4).

<u>Why was the Furnace Operation Unsuccessful?</u>

The construction design of a brick lining, and an iron rich mineral body seems to have set the stage for failure at the IR&O Company furnace as the slag produced would have had a highly corrosive effect on the firebrick. Howe recommends that brick-lined blast furnaces not be used in remote places. When operated in established centers of industry, the fire bricks can be replaced cheaply and the fuel savings generally offset the need to replace the lining more frequently. However, the fuel

savings a brick-lined cupola confers is greatly off set by the high costs of shipping firebrick to remote locations (Howe 1885:88-89) such as the entirety of the Lake Superior after its opening to mining.

Figure 5.4 A view showing the way in which Structures 2 and 3 relate to each other spatially.

It becomes quite clear, when assessing the disadvantages of a brick lined cupola for working copper, that erecting one in a location as remote as Isle Royale was not something which should have been attempted. It seems probable that when shipping opened across the lake in the spring of 1849, the several blasts which had been run damaged the furnace to the point where it needed to be relined, a significant investment of capital considering the poor quality of copper produced, and the unfavorable prospects of the IR&O Company mines. It was most likely then that the Company ceased operations at their furnace.

Chapter 6 - Conclusions

This thesis was an attempt to blend archaeological evidence, historical research and data from hard science to produce a plausible narrative of the Isle Royale and Ohio Mining Company Copper furnace. Many other aspects of the Company were touched on, including its key figures, the nature of its mines, its founding, and ultimately its demise. The nature of life and labor was also touched upon, and the remote setting in which these events took place was unusual, even when compared to other American frontier stories.

This thesis began with an introduction in which three questions were asked. While the answers to all of them can be found throughout the body of the text, it is worth revisiting each to discuss what was learned during the course of this research program.

What was the layout, design and technological operation of the IR&O furnace?

The operation was a combination of at least three different machines, and possibly a reverberatory furnace. Historical evidence clearly indicates that a steam engine was present, which given contemporary trends in stationary engine construction at the time was small and either a horizontal expansion engine or a vertical expansion engine (Pursell 1969:117). The most likely mounting spot for a horizontal engine would have been on Structures 2 and 3, given that the gap between the two would have provided significant space for the free movement of a fly wheel.

The remains of the cupola furnace at Daisy Farm represent a somewhat enigmatic technological system. Neither Peters, Howe nor Hofman ever discuss the use of cylindrical, brick lined, iron plated furnaces for the smelting of copper. The way these authors present it, the leap is made from large pyramidal blast furnaces constructed of stone, brick, and minimal iron fittings directly to brick-less water jacketed blast

furnaces. Considering that water-jacketed blast furnaces were not invented until the mid-1860s and that the cupola found at Daisy Farm so closely resembles an iron-shell furnace for iron smelting, that it is possible that the IR&O Company purchased a mostly pre-fabricated iron furnace and attempted to employ it for melting copper.

Given that copper melts at a significantly lower temperature than iron, quartz and most pyroxenes, employing an iron smelter to melt copper may have seemed logical. However, in iron smelting the oxygen of the charge is diminished by converting it into carbon dioxide (Council, Honerkamp, and Will 1992:36). Preventing and breaking down iron-oxides is an integral process of iron smelting, which also eases the burden on the fire-bricks. A lack of knowledge of the chemistry of the Isle Royale mineral lodes, and the actual chemistry involved in smelting copper and iron may have hindered the ability of the IR&O Company to choose a proper type of furnace. The furnace most likely failed due to the corrosive effects of the iron-oxide (specifically magnetite) present mineral being used (Huber 1975:10). The unreliability of shipping on the Lake would have made relining the cupola prohibitively expensive, and given the short window of operation, it may never have been relined, and was simply abandoned when the company determined they could not work the copper profitably.

Given the clustered nature of the architecture that remained on site, and Ruth's description of the engine house, with its multiple chimneys, the entire operation was most likely housed within a single contiguous structure, as opposed to separate buildings. The engine could have been powered by any of the three types of fuel found on site during the excavations: wood, charcoal or anthracite. Wood and charcoal could be readily obtained on the Island and are the most logical options for the fuel used here. This engine would have provided the power to run a mechanically driven blower, located not far from the furnace. Being the mid-1840s, this device was most likely a positive pressure blower, often called a fan blower. If the tuyeres became too clogged due to the buildup of hardened slag, the significant backup of air pressure could cause these blowers to explode (Peters 1887:256). These types of

cupola furnaces could be run in a continual blast for weeks at a time, and longer blast durations were preferred since routine expansion and retraction of the furnace was a major cause of furnace collapse. Peters claimed that brick lined blast furnaces could produce a continuous stream of molten copper given a sufficient presence of copper in the charge (Peters 1887: 217).

Charcoal was manufactured close by, and could be reliably produced by the Isle Royale and Ohio Mining Company, who probably employed numerous men for timber cutting, transport and charcoaling. While anthracite may have been used at the IR&O Company furnace, the cost and unreliability of shipping across the Lake during the 1840s means it would have been used sparingly. The Company may have shipped a quantity up with them, to have an adequate fuel source on hand until they built up their charcoal reserves. Anthracite found here was likely used by the blacksmiths of the Civilian Conservation Corps.

As the furnace lining began to breakdown, the ability of the furnace to hold heat would have been negatively impacted. As this occurred, the copper matte produced in the furnace would have had increasingly greater volumes of non-copper minerals being incorporated into it. That, coupled with the increasingly lower grades of mineral in the charge would have significantly impacted the copper content of the final product, and may have produced the "badly smelted" copper of which the Siskowit Mining Company complained about.

How does this site fit into the historical narrative of America's first copper region and American copper smelting?

In the early years of Lake Superior copper mining, Isle Royale clearly captured the interests of men of business and industry, and significant work was undertaken on the Island. Companies such as the Isle Royale and Ohio, the Siskowit Mining Company, and the Isle Royale Union Company sank significant amounts of capital into their ventures in their attempts to turn a profit. The role of the Isle Royale and Ohio Mining Company is one of central importance to this story, as it represents an early

attempt to bring all the technological operation needed to produce market grade copper to the Lake Superior region.

The early mining on the Island is similar to that elsewhere in this region and despite producing no firms with staying power, Isle Royale should be placed alongside the mainland in the historical narrative of the region. Isolation, experimentation, uncertainty were the hallmarks of Michigan copper mining in this era. Successfully adapting existing knowledge and skills to the new lodes of copper in Michigan copper would make this region a proving ground for American ingenuity. The Island's mines were a first step forward in this adaptation, and men like Douglass and Matthews took with them what they learned back to the mainland.

Perhaps the largest difference between the historical narrative of the Island and the mainland comes from the slight delay in the official opening of exploration on Isle Royale. The confusion, miscommunication, and deceit surrounding the country's acquisition of Isle Royale is informative of the ways in which America advanced its border westward. Copper mining on Isle Royale has come and gone, but the Ojibwe retain a close bond with the Island and act as strong advocates for its preservation and study.

The agents sent to oversee the Company's operations were selected because they were men of scientific merit, or directly involved with the financing of the Company. Being the largest Island in the largest of the Great Lakes, Isle Royale attracted the attention of many scientific men, who came looking for knowledge or wealth. It also appears that the later opening up of the Island may have prevented significant dishonest speculation on the Island, as many of the firms established on the Island worked after the royalty system had been abandoned. This change would have hit companies with numerous claims, like the IR&O Company, harder than smaller firms as the royalty system allowed for lots of land to be held cheaply as long as mining remained minimal. Regardless, history shows the continued commitment to the Island, and nine three mile square claims that the Company held.

The Ransom location represented a different approach by the IR&O Company. This place was a small hub, dedicated to the essentials of a successful mining operation. The IR&O Company never got far past the prospecting phase. Having Ransom as a hub for mining activities would have provided a degree of stability for the Company as they moved around the Island, looking for a lode that could turn a profit. Ransom also acted as a small port-of-call and the primary reason for its location was the natural harbor it sat on. Larger firms like the IR&O and SMC had their own docks. Smaller ventures were using the infrastructure of these bigger firms for their coming and going and as reliable places to pick up supplies that had been dropped off for them.

What can we learn by performing a phase analysis of copper bearing slags from the industrial era?

The slags recovered from Daisy Farm site contained pyroxenes associated with the basalt rock and other silicates associated with the native copper deposits present on the Island, such as datolite and epidote. The slags that were tested showed no strong evidence of trapped copper. This seems to indicate that the smelting was rather successful. However the historical claims made about the operation indicate that the quality of copper which was produced there did not meet expectations. Given the archaeological discovery of clean copper slags and melted copper with significant non-metallic components, it would appear that while the company was able to remove the copper from their charges. However much of the non-metallic portions of the charge could not be removed. It is likely that while the furnace was still able to reach temperatures high enough to liquefy the copper (1048 centigrade) the inability of the furnace to also fully liquefy the remainder of the charge lead to the poor quality of the finished product. The molten copper would have carried semi-liquid portions of the charge with it as it was tapped out of the furnace, producing a product that would have been considered badly smelted.

There are things that an industrial archaeologist needs to be aware of prior to preforming a phase analysis of copper bearing slags. Firstly, a high signal to noise

ration exhibited by the slags at Daisy Farm were possibly due in part to the sand which adhered to the slag as it was tapped from the furnace and onto a sand bed. It is probable that the signal to noise ration can be reduced if the slags that are collected had little or no exposure to the material in which they were cast. The minerals from the sand and earth that adhere to tapped slags may contain numerous crystalline phases that are quite different from those contained in the slag itself. Slags cast into ladles or granulated into water will most likely provide a clear look at the composition of the slag than those cast directly onto sand.

An archaeologist should also compile an extensive list of the probable phases which may be present, using both contemporary geological knowledge and observations made about smelting the various ores of copper. In this research phases of silver and sulphur were tested against the data: sulphur because it would have been present if coal was used in the furnaces, and silver because it was known historically that the Siskowit Mining Company was recovering silver from one of their mines (Whittlesey 1848:2). Neither one of these were detected, but nevertheless they could not have been fully ruled out without the results of the XRD scan. With this largest list in hand, the archaeologist has a better chance of finding the phases which are present in the slag than they otherwise would by comparing their peaks to lengthy libraries of peaks.

Recommendations for further research:

If more excavations were to be carried out in or around the site of the furnace, several areas of interest should be investigated. The parallel arrangement and close proximity of Structures 2 and 3 should be more closely evaluated. In particular the corner of Structure 3 visible to the south-west of the cupola should be excavated. While excavations at Structure 1 yielded many informative artifacts as to what was occurring at the site, it is the way in which the structures present articulate with each other that remains the least understood aspect of the site. Therefore it is recommended that the structures themselves be more thoroughly examined.

Particular attention should be paid to the charcoal kiln and adjacent depressions, as many of the depressions noted during the 1986 and 2015 still have an unknown function. It is also likely that the Company had more than one kiln, as fuel was on hand prior to the construction of this one. Additional kilns should be sought out using pedestrian survey.

Ideally, further investigations should be made in the area to the west of the 2015 excavation site, as additional structures associated with the furnace or engine house maybe present there. However, it should be advised that this area is rather swampy during the late spring and early summer, and it would be more advisable to conduct any archaeological research there during a drier time of year.

In regards to the slag analysis, the samples already collected and powdered should be sufficient for anyone looking to perform anymore XRD testing. It would be advised that long duration scans be made, in the order of 16 hours or longer. Scans of this length should provide sufficiently clean data for a better look at phases suspected to be present, such as copper or cuprite, which are masked by the high signal to noise ratio.

Myer and Betancourt looked at both slags and furnace chimneys. This report only looked at slags, but it is highly recommended that future work also include a XRD study of the recovered furnace lining. This lining would not have been contaminated by foreign mineral particles such as casting sands that may have had influence on some of the currently powdered samples. Identifying the materials which adhered to the firebrick would also help flesh out how the furnace damage observed reflected on the overall state of its use-life. Based on geological knowledge and contemporary writing about copper smelting, this work was done under the impression that the iron content of the mineral body would have damaged the furnace lining, leading to accelerated damage. Testing the lining using XRD will provided a direct line of evidence for the presence of iron in the mineral worked.

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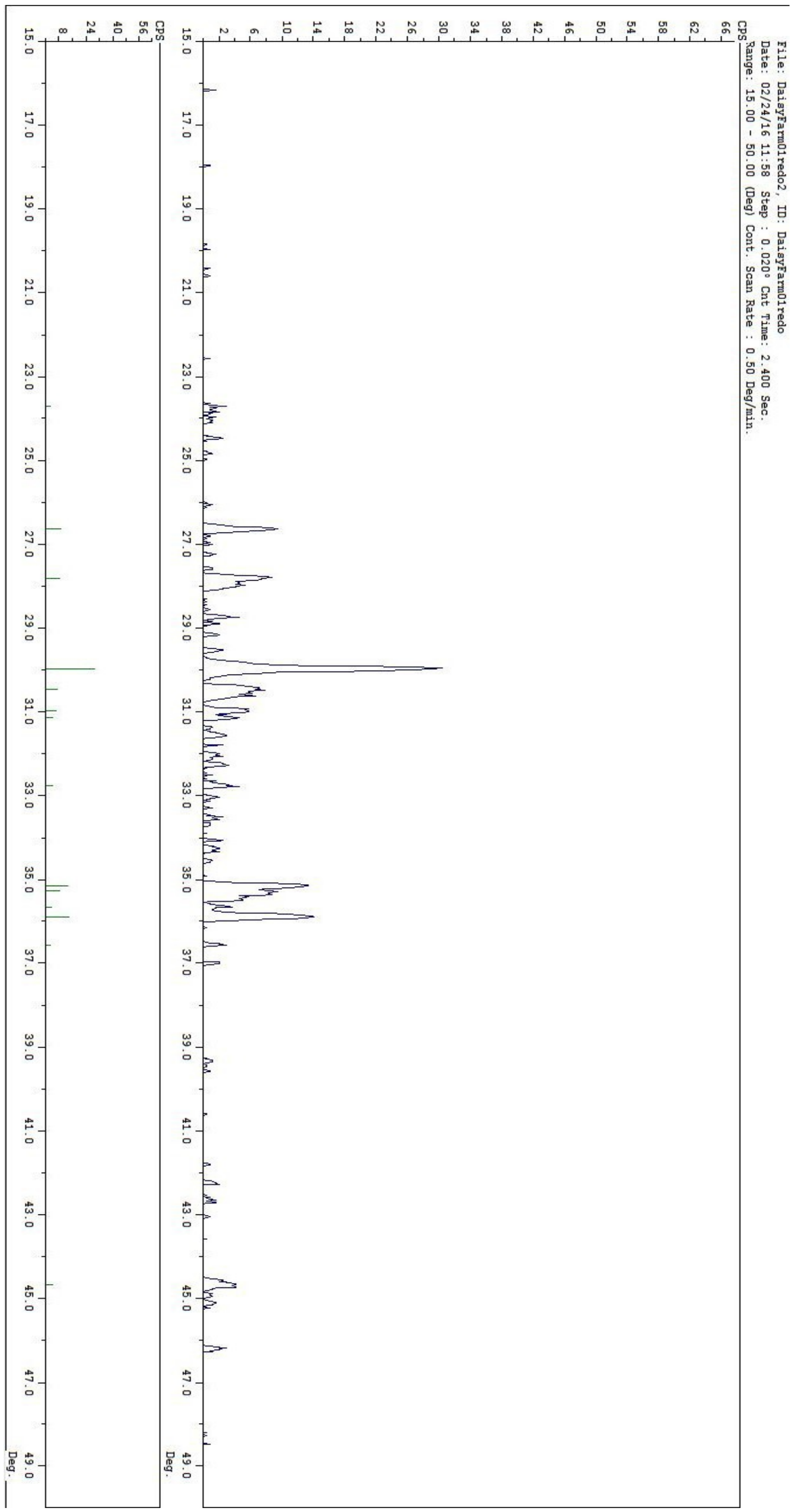
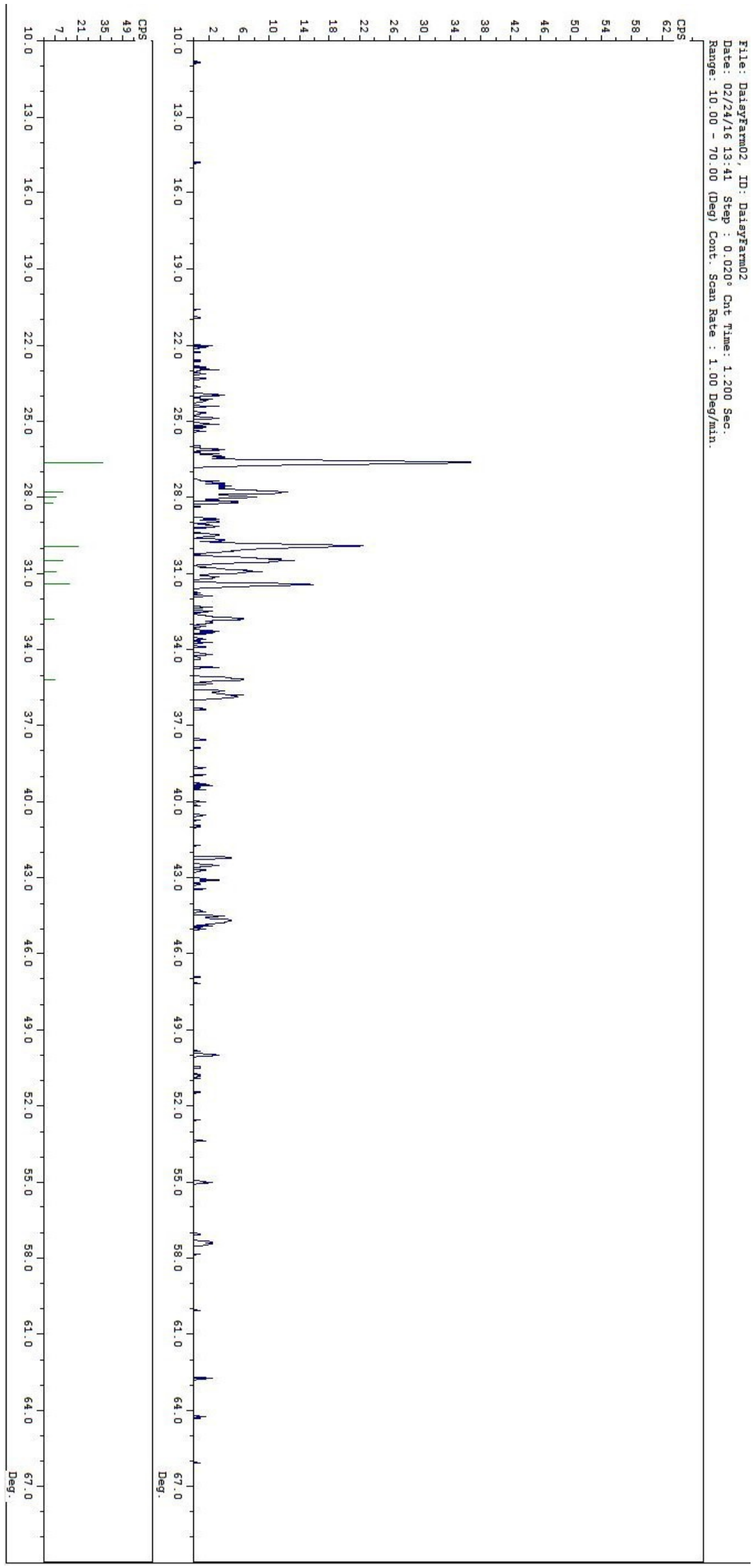
Appendix II: Slag Samples

Sample #	Mass (g)	Volume (ml)	Color (wet)	Density (g/ml)	Provenience
Sample #01	28.3	10	5GY 3/2 "very dark grayish green"	2.83	Surface
Sample #02	27.6	12.5	5GY 3/2 "very dark grayish green"	2.2	Surface
Sample #03	36.1	19	10R 3/3 "dusky red"	1.9	499N/256E L2 ZA
Sample #04	23.1	8	10R2.5/2 "very dusky red"	2.88	499N/256E L2 ZA
Sample #05	27.5	5	10R 3/3 "dusky red"	5.5	499N/256E L2 ZA
Sample #06	28.2	6	10R 2.5/1 "reddish black"	4.7	Trench 2 L2
Sample #07	23	6	10Y 4/4 "dark olive"	3.8	502N/247E L2
Sample #08	24.6	10	10R 2.5/1 "reddish black"	2.46	499N/256E L2 ZA
Sample #09	22.1	8	7.5R 3/6 "dark red"	2.7	499N/256E L2 ZA
Sample #10	21.8	8	5GY 3/2 "very dark grayish green"	2.7	Surface
Sample #11	20.2	9	10R 3/1 "dark reddish gray"	2.24	Surface
Sample #12	15.5	10	10R 3/1 "dark reddish gray"	1.55	501N/256E L3 ZB
Sample #13	14.1	4	5Y 3/2 "dark olive gray"	3.25	501N/256E L3 ZB
Sample #14	19.7	5	10R 3/6 "dark red"	3.94	499N/256E L2 ZA
Sample #15	21	8	10R 3/3 "dusky red"	2.6	499N/256E L2 ZA
Sample #16	33.1	11	5R 3/4 "dusky red"	3	499N/256E L3 ZA
Sample #17	16.4	6	7.5YR 2.5/1 "reddish black"	2.73	499N/256E L3 ZA
Sample #18	7.5	3	5Y 6/4 "pale olive"	2.5	499N/256E L3 ZA
Sample #19	7.1	2.5	10Y 5/4 "light olive green"	2.84	502N/247E L2
Sample #20	11	3	10Y 5/4 "light olive green"	3.67	502N/247E L2

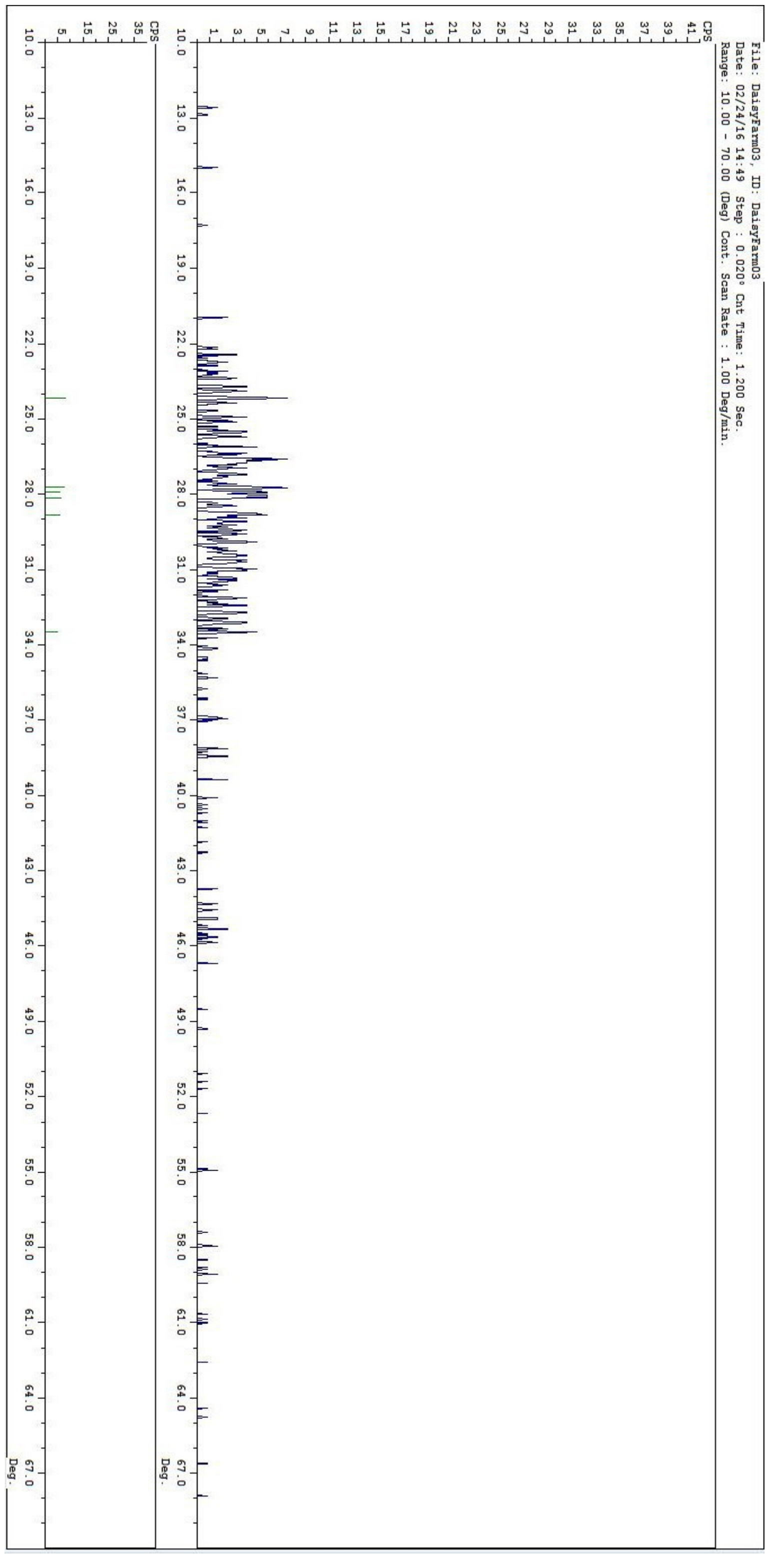
Appendix III X-Ray Diffraction Analysis.



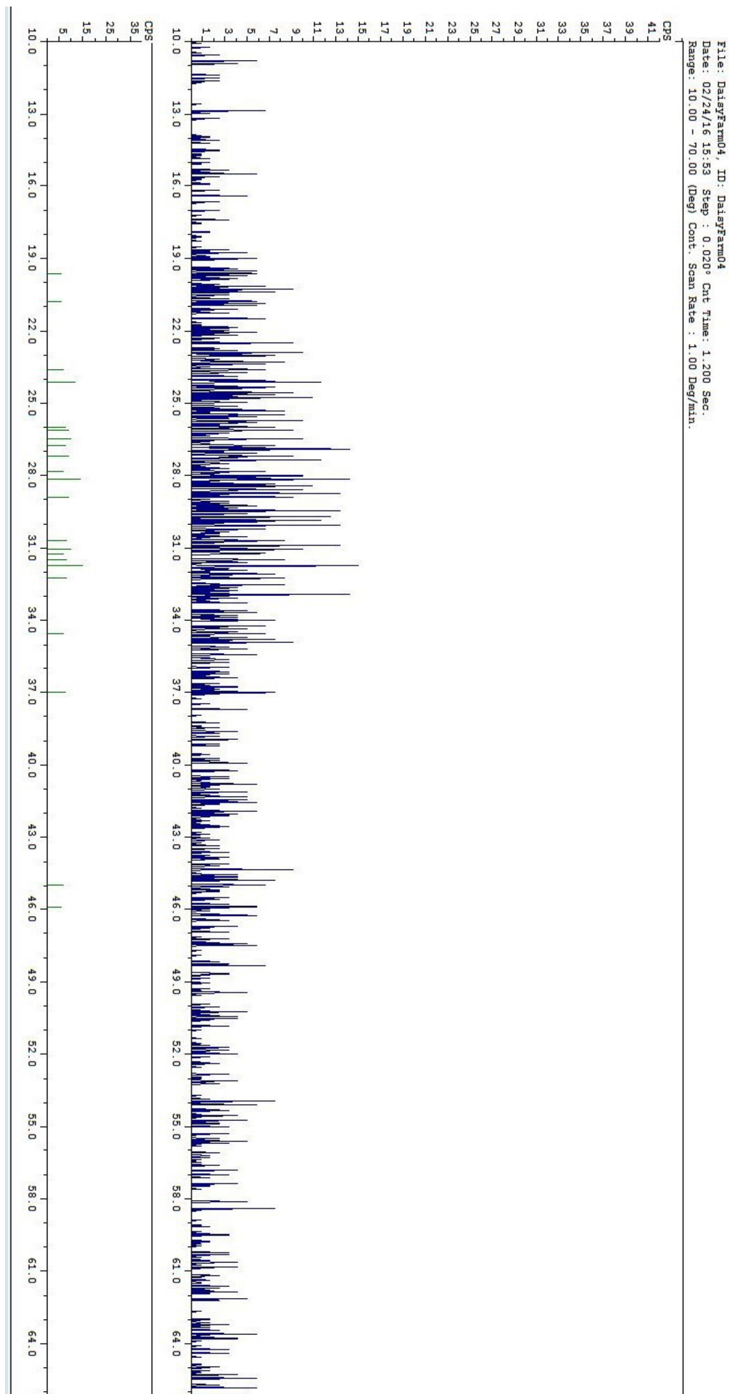
Sample 1.Smoothed with found peaks shown below.



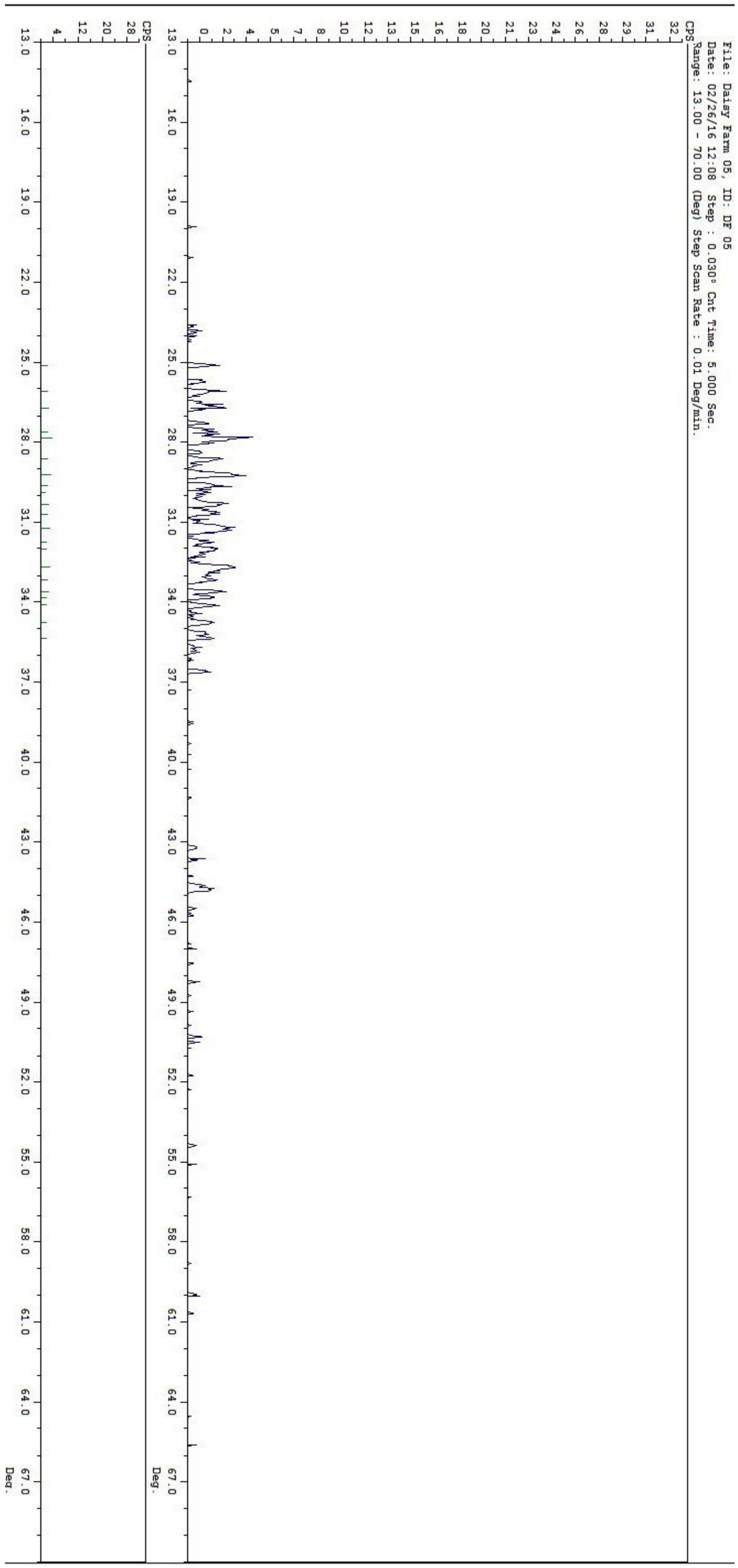
Sample 2. Smoothed with found peaks shown below.



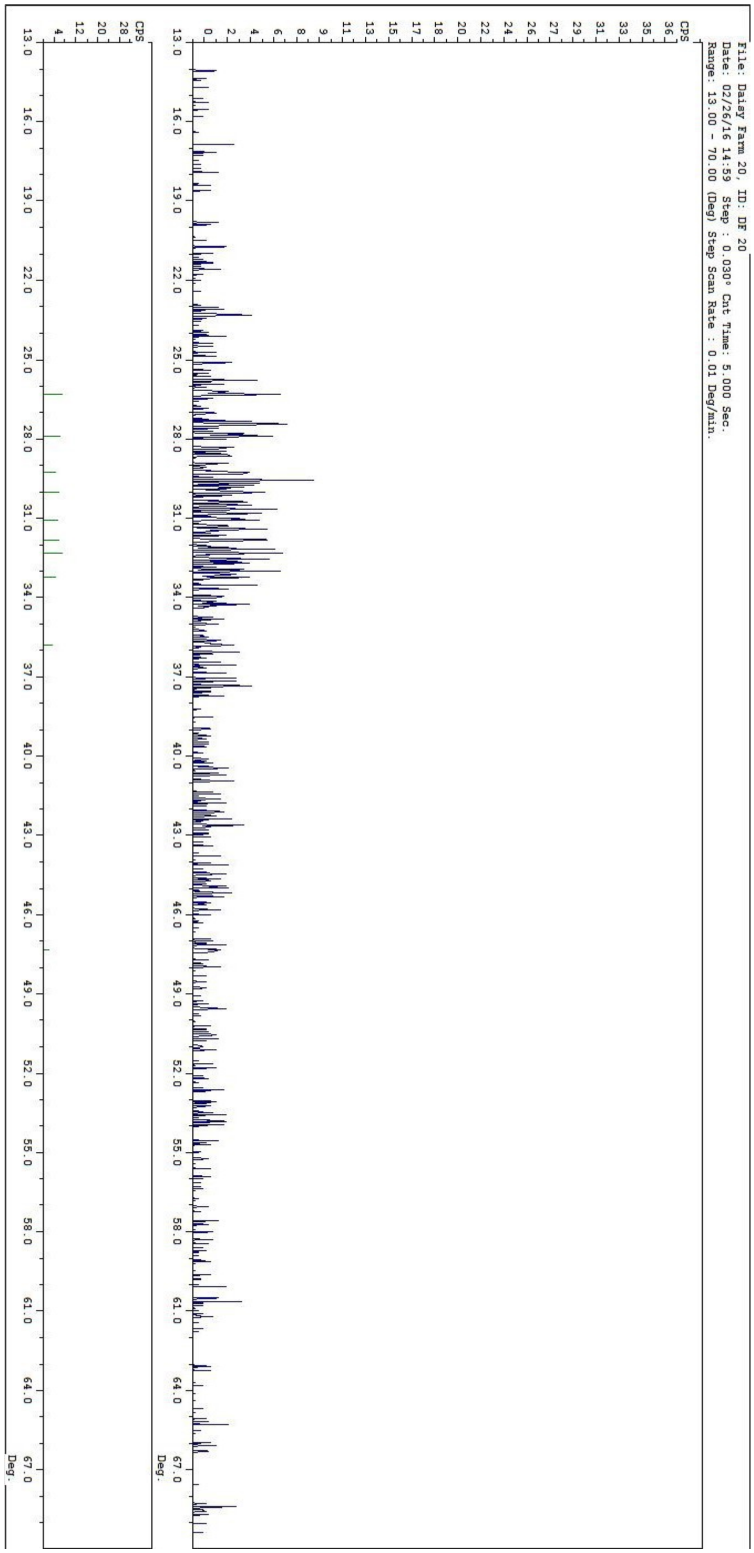
Sample 3. Smoothed with found peaks shown below.



Sample 4. Smoothed with found peaks shown below.



Sample 5. Smoothed with found peaks shown below.



Sample 20. Smoothed with found peaks shown below.