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Winning Coal at 78° North: Mining, Contingency and the *Chaîne Opératoire*
in Old Longyear City

By

Seth C. DePasqual

A THESIS

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN INDUSTRIAL ARCHAEOLOGY

MICHIGAN TECHNOLOGICAL UNIVERSITY

2009

This thesis, “Winning Coal at 78° North: Mining, Contingency and the *Chaîne Opératoire* in Old Longyear City” is hereby approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE IN INDUSTRIAL ARCHAEOLOGY.

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Abstract

The purpose of this thesis is to analyze the evolution of an early 20th century mining system in Spitsbergen as applied by Boston-based Arctic Coal Company (ACC). This analysis will address the following questions: Did the system evolve in a linear, technological-based fashion? Or was the progression more a product of interactions and negotiations with the natural and human landscapes present during the time of occupation? Answers to these questions will be sought through review of historical records and material residues identified during the 2008 field examination on Spitsbergen. The Arctic Coal Company's flagship mine, ACC Mine No. 1, will serve as the focus for this analysis. The mine was the company's largest undertaking during its occupation of Longyear Valley and today exhibits a large collection of related features and artifacts. The study will emphasize on the material record within an analysis of technical, environmental and social influences that guided the course of the mining system. The intent of this thesis is a better understanding of how a particular resource extraction industry took root in the Arctic.

Chapter 1: Introduction

Between 1905 and 1916, the American-owned Arctic Coal Company labored intensively to develop its mining claims on Spitsbergen (today known as Svalbard), an arctic archipelago situated roughly midway between Norway and the North Pole. Within this decade, the company attempted to establish a reliable and effective mining system at its Advent Bay mining property. The enterprise developed strategically but struggled constantly with various deficiencies and uneven growth. Many of the improvements followed a general development plan. Others were spontaneous adaptations to deal with imposing situations. While some of these difficulties related to environmental and technical conditions experienced at the property, socialized aspects of the mining systems played their own role. Taken together, the problems experienced at Mine No. 1 forced the company to continuously evaluate the efficiency of their mining system.

At the Advent Bay location, the Arctic Coal Company developed a large mine ultimately featuring a mechanized mining operation, extensive shipping facilities, aerial ropeways, a power station, and an expansive mining camp. In its heyday, Longyear City accommodated upwards of 400 miners and laborers from varied ethnic backgrounds including Norway, Finland, England, Russia, and America. Despite its arctic setting, the operation ran year round with much of the mining performed during the long winters. There were two seasons on Spitsbergen, summer and winter. Perhaps a more appropriate description would be “open” and “closed.” Spitsbergen’s geographic location was such that its waterways remained frozen with ice for most of the year. This condition could last as long as eight months, compelling companies to invest in extensive supplies and infrastructures that could withstand the harsh environment. Summers on Spitsbergen were largely devoted to construction work around the Longyear Valley property and to the shipment of coal and supplies. Winters were focused on underground works.

Physical manifestations of these activities and difficulties are still existent throughout the Longyear Valley landscape. Their presence is a product of the relative isolation of Svalbard, the arid preservation qualities associated with the Arctic, and a proactive body of laws that govern the archipelago’s heritage. The Arctic Coal Company’s primary asset, Mine No. 1, retains a great deal of integrity considering that it

rests on a steep, rugged mountainside beneath a blanket of snow for most of the year. Many of the mine's features have withstood the effects of time and weather. Others however, have succumbed to these same elements, some now completely indiscernible from the surrounding landscape. Still, the site stands as a significant example of an early 20th century coal mining system that was seminal to Svalbard's extractive mining industry.

At least three separate archaeological documentation projects have recorded features related to the Arctic Coal Company site complex in the community of Longyearbyen. These examinations occurred during the summers of 2004, 2007 and 2008, the product of which has since been used for a variety of academic purposes including both public and private reports, a graduate student thesis, and a project-specific website.¹ Moreover, the research reports have been forwarded to the Svalbard Governor, or Sysselmannen, for use within the government's heritage management program.

Beginning in the summer of 2007, the author took part in a collaborative research endeavor involving Michigan Technological University (MTU) and a host of international colleagues from Europe and Russia. Collectively, the group is known as LASHIPA, which stands for Large Scale Historical Exploitation of Polar Areas. The LASHIPA project is an endorsed and financed research project within the International Polar Year 2007-2008, with participants from the Netherlands, Sweden, America, Great Britain, Norway, and Russia. The purpose of the project is to explain the development of natural resource exploitation in the polar areas from the 17th century to the present, and the ensuing consequences for the geopolitical situation and the local environment.² Research topics vary according to the individual; however, field efforts are often conjoined for comparative advantage and logistical realities. As a founding member of LASHIPA, MTU has been sending professors and graduate students each field season since 2004 to perform research related to the Arctic Coal Company.

¹ Thesis: Tennant, Edward. *Using ArcGIS to Create 'Living Documents' with Archaeological Data: A Case Study from Svalbard, Norway*. MS Thesis, Michigan Technological University, 2005. Website: <http://www.svalbardarchaeology.org/>

² Avango, Dag. *LASHIPA 4 – Natural resources and geo-politics from 1600 to the present, cases from Grønfjorden, Svalbard*. Swedish Polar Research Secretariat, Yearbook 2007. Stockholm: Polarforskningssekretariatet, 2007.

In 2007, MTU researchers focused initially on Arctic Coal Company history in the Green Harbor region. This is where the company maintained a small-scale mine for commercial and political reasons. Researchers documented two mining sites, the remains of the company bunkhouse and a collection of prospect pits tracing along the coal outcrop. Investigations continued in Longyearbyen, where the author and MTU graduate student Cameron Hartnell documented the remains of a company warehouse, various features associated with old Longyear City, and a peripheral hunting hut. Furthermore, the team performed an extensive survey of prospect pits spreading throughout Longyear Valley and those valleys adjacent.³

MTU researchers returned to Svalbard in 2008 with a wide range of goals. One of these aims was to continue collecting information on Arctic Coal Company history in regions separate from Longyear Valley. Hartnell and the author traveled to Coles and Sassen Bays and recorded features related to mining claims made by the company. Back in Longyearbyen, they performed a substantial investigation of the company's flagship mine, Mine No. 1. The purpose of this effort was to enhance the level of information gathered during LASHIPA's 2004 survey of the site.⁴ The 2004 survey documented only portions of the mine complex; the 2008 examination of the mine is the subject of this thesis.

This thesis project is the product of archival and archaeological research performed by the author and Cameron Hartnell between 2007 and 2009. First and foremost, this is an examination of an early 19th century coal-mining endeavor carried out on Spitsbergen. The initial drive behind this research was to locate and document the physical remains of the Mine No. 1 site complex. Despite a rich collection of archival material including letters, reports, maps, and photographs, researchers could not locate a single detailed plan view of the mine's exterior infrastructure. The maps that do exist present the site on a large-scale, with little attention to the technical aspects of the mining system. Compared with the physical remains present at the mine location, there appeared to be a significant level of features and artifacts that remained unexplained.

³ LASHIPA 3, Final Report. *Archaeological Expedition on Spitsbergen, August, 2007*. 2007.

⁴ LASHIPA 1, Final Report. *Industrial Heritage in the Arctic: Research and Training in Svalbard, August 2004*. 2006.

The author viewed this deficiency as an opportunity to investigate the finer contexts associated with the Mine No. 1 site complex. The arrangements of particular mining systems were of special interest, including those associated with production, transportation and storage. These subsystems took many forms through the course of the company's history, from simple narrow-gauge railways and coal piles to elaborate tramways and storage bins. As the operation grew in scale, numerous modifications were made to meet new perspectives on efficiency. The 2008 documentation project sought evidence related to these improvements in an effort to refine our understanding of the company's development over time.

Initial consideration was focused on the technological systems employed at the mine. Since the mine was the first of its size to successfully mine coal on the archipelago, these systems are significant to the history of industry on Svalbard. Questions related to the evolution of the site guided the research. Did the system evolve in a linear, technical-based fashion? Or did the mine develop in a less rigid manner, perhaps influenced by forces other than those technologically oriented? These questions served as meaningful foundations for further lines of inquiry.

Analytical Framework

After the 2008 field data was collected, new queries arose about how to interpret the history and archaeology of the Mine No. 1 site complex. Although technical and environmental aspects of the mining system were accounted for in many respects, little consideration was given to the socialized elements that may have played a role in the development of the mine. Among other aims, this thesis attempts to identify social involvement within a "hard" technological system. To do so, I have employed an analytical tool known as the *chaîne opératoire* (chain of operation).

Defined as a "conventionalized, learned sequence of technical operations, tightly imbricated with patterned social relations, that must be carefully and empirically described as an initial step in grasping the nature and implications of technological activities," the *chaîne opératoire* highlights a technical sequence guided not by a specific

order of things, but rather the internal and external forces that act upon it.⁵ These forces, which might include pressures from the labor force or environment or both, are in continuous flux, amounting to what might be understood as a “dialogue” between the material and the agents with which it engages. Detailing the *chaîne opératoire* for a particular technological system, like mining, stresses the importance of seeing how sequences of activity are parsed and orchestrated.

The examination of *chaîne opératoires* has seen particular development among French anthropologists, being first introduced in the 1940’s by archaeologist and ethnographer André Leroi-Gourhan. Leroi-Gourhan became interested in material culture and how particular techniques came to be used. While studying prehistoric lithic technologies, he noted that *technique* was often the product of an ongoing dialogue between the creator and the material being worked. He stated, ‘Techniques are at the same time gestures and tools, organized in a veritable syntax, one which simultaneously grants to operational series their fixity and their flexibility.’⁶ This notion of the *fixed* and the *flexible* is the essential concept for analyzing operative chains.

As developed further by Pierre Lemonnier, fixed components are best characterized as immutable; ones that cannot be significantly altered without seriously compromising the success of the system. Flexible components are less rigid and can be modified to some degree without jeopardizing the final output. Taken together, the two variables “give the *chaîne opératoire* its rigid frame, and highlight the states and processes through which matter and action pass.”⁷

Lemonnier’s own research among the Anga tribes of New Guinea revealed the importance of seeing social factors in the selection and arrangement of technological

⁵ Pfaffenberger, Bryan. Mining Communities, chaînes opératoires and sociotechnical systems. Social Approaches to an Industrial Past: The Archaeology and Anthropology of Mining. Edited by A. Bernard Knapp, Vincent C. Pigott and Eugenia W. Herbert. New York, Routledge Press. 1998.

⁶ Leroi-Gourhan, Andre. *Le Geste et la parole I – technique et langage*. Paris, Albin Michel. 1964. Quoted in Schlanger, Nathan. *Mindful Technology: unleashing the chaîne opératoire for an archaeology of mind*. The Ancient Mind: Elements of cognitive archaeology. Edited by Colin Renfrew and Ezra B. W. Zubrow. Cambridge, University Press. 1994.

⁷ Schlanger, Nathan. *Mindful Technology: unleashing the chaîne opératoire for an archaeology of mind*. The Ancient Mind: Elements of cognitive archaeology. Edited by Colin Renfrew and Ezra B. W. Zubrow. Cambridge, University Press. 1994.

practice. An examination of usage patterns between three types of wild pig traps, for instance, revealed that some tribes selected traps not due to technical “efficiency,” but for its apparent disuse by a neighboring tribe. Lemonnier concluded, “The ordering and classifications of the technical domains were expressed by choices, ultimately unrelated to what the natural environment or a strictly technical (material) logic would lead us to expect.”⁸ In essence, he was arguing that the “social” - in this case *culture* - had some significant weight in the process of technological choice.

In a separate study, Nathan Schlanger examined lithic technologies using the *chaîne opératoire* approach. Reconstructing the process of flintknapping, Schlanger isolated crucial stages where choices and technique came into play.⁹ He recognized a dialogue between the raw material and the actor, one in which constant adjustments were made within the process of creation.

As seen in the previous examples, the *chaîne opératoire* concept has been applied mostly to non-industrial settings. Nevertheless, the essence of this approach is theoretically applicable with any culture and any time period. Although the *chaîne opératoire* has yet to be fully adopted as an archaeological approach, recent examinations of mining history suggest potential contributions. John Rule’s examination of labor systems in Cornish tin mines, for example, details various components of the contract system. Rule aptly presents how mining companies effectively used the tribute system to take advantage of the people they employed.¹⁰ The miners competed with one another over favorable mine contracts. This “inside” contention prevented them from organizing into larger groups, which benefited the company in that there were fewer strikes. The connections that Rule made between a mining system and labor are useful in that they

⁸ Lemonnier, Pierre. *The Study of Material Culture Today: Toward an Anthropology of Technical Systems*. Journal of Anthropological Archaeology, Volume 5. 1986.

⁹ Schlanger, Nathan. *Mindful Technology: unleashing the chaîne opératoire for an archaeology of mind*. The Ancient Mind: Elements of cognitive archaeology. Edited by Colin Renfrew and Ezra B. W. Zubrow. Cambridge, University Press. 1994.

¹⁰ Rule, John. *A Risky Business: Death, Injury and Religion in Cornish Mining c. 1780-1870*. Social Approaches to an Industrial Past: The Archaeology and Anthropology of Mining. Edited by A. Bernard Knapp, Vincent C. Pigott and Eugenia W. Herbert. New York, Routledge Press. 1998.

describe socialized aspects of the mining process. Such insight can lend itself to better interpretations of archaeological evidence.

Andrew Johnston's examination of California's mercury mining industry provides one such example.¹¹ In his chapter on labor, Johnston describes how the industry organized its body of employees and managers in accordance with race and ethnicity. He then reviews the organization of work at the mine, which is directly associated with the racial hierarchy established by the mine owners. After detailing the type of workers hired in the California mines and where they fit within the industrial chain of production, Johnston shows how the mine owners effectively constructed and controlled a mining system that catered specifically to their needs.

Of special note is Johnston's identification of how underground labor systems had material expressions above ground. In his description of the ore sorting house, or "planilla," Johnston reviews the separating process where different sections of the building's floor were allotted to individual teams of miners. On examination of this system, the organization of work into contract teams necessitated the creation of a sorting house capable of separating out the ore mined by each contract team. Although no excavations or detailed documentation efforts were performed during Johnston's research, the utility of his investigation might prove beneficial when extended into the realm of archaeological analysis.

I use the *chaîne opératoire* approach to compare particular orders of work that occurred throughout the mining system with material evidence identified at the site in 2004 and 2008. How is the *chaîne opératoire* evidenced in the material record present at the Mine No. 1 site complex? Does this approach help us understand social involvement within industrial contexts? And, ultimately, what new perspectives does this provide about how coal mining at Mine No. 1 proceeded between 1905 and 1915 under American management?

What follows is a multi-part examination of Arctic Coal Company history that integrates a rich body of archival records with the physical remains of the technologies

¹¹ Johnston, Andrew Scott. *Quicksilver Landscapes: Space, Power, and Ethnicity in the Mercury Mining Industry in California and the West, 1845-1900*. Doctor of Philosophy in Architecture, University of California, Berkeley, 2004.

and systems involved. Chapter 2 focuses on the geography and history of Svalbard. Attention here is given to environmental conditions and the human history of the archipelago. Chapter 3 delves into four separate archival collections to produce a detailed history of the company, Mine No. 1 and the individuals associated with its operation. The information gleaned from this research was gathered from abundant collections of company records including annual reports, company correspondence, maps, and photographs. Additional primary resources such as trade journals, equipment catalogues and international reports and publications complemented the archival material. In many respects, the sheer volume of information was overwhelming.

Chapter 4 introduces the reader to the archaeology of Mine No. 1 and describes previous work performed at the site by MTU/LASHIPA. Discussion is then given to the 2008 project and the methodologies utilized during the field examination. The final section of this chapter is devoted to an overview of Mine No. 1 with examination of ancillary features located downslope from the mine. Chapter 5 explores the mine complex in greater detail, covering all principal features that were identified during the 2004 and 2008 surveys. Careful descriptions are made of each feature with attention to their functions and larger purpose within the overall mining system. Historic photographs are used for comparative study.

The first section of Chapter 6 contextualizes the *chaîne opératoire* in respect to other ways of looking at social elements within technological systems. Mine No. 1 is then revisited using the approach as a lens for analysis. Related discussion is broken into two sections; one devoted to a review of production methods, the other to transportation and storage systems. Material evidence is brought in where applicable. Chapter 7 examines the merits of the analytical approach and then offers concluding remarks about the project. Suggestions for further research are made at the end of the chapter.

Chapter 2: Review of Svalbard Environment and Early History

Environment

Svalbard, or “Spitsbergen” as it was more commonly known before the ratification of the Spitsbergen treaty in 1925, is an arctic archipelago located between Latitude 76° and 81° North and Longitude 10° and 35° East in the Arctic Ocean north of mainland Europe (Figure 2.01). The archipelago consists of approximately 61,022 square kilometers of landmass; the most extensive section is an island now designated as Spitsbergen. A distance of roughly 800 kilometers separates Svalbard from the northernmost tip of Norway’s mainland. The largest community is that of Longyearbyen, a Norwegian town populated by slightly more than 2,000 year round residents. Barentsburg, a Russian community, is the second-most populated town in the region. All other communities are significantly smaller and operate as either mining or research endeavors.

The archipelago’s western shores are kept relatively warm by the northern reaches of the Gulf Stream. The current melts sea ice and permits sea travel for a few months each year and is largely credited for early penetration of the Russian and West-European seafarers into Svalbard regions.¹ Another related effect is that the warm waters create a temperate climate on the western side of the archipelago. Mean monthly temperatures range from -15° C in January to 6° C in July. The islands experience 24 hours of daylight from mid-April to mid-August, the converse occurring between mid-November and mid-February. Svalbard sees between 20 and 30cm of precipitation every year.

Politically, Svalbard remained a no-man’s-land, or *terra nullius*, until the Paris treaty of 1920. The signers of this treaty agreed that the territory should be governed by Norway. A small number of other nations however, retained rights to settlement and mineral extraction.² Today only Russia exercises their right to operate on Svalbard. A Longyearbyen-based Governor, or Sysselmannen, administers the island.

¹ Starkov, Vadim F. Review of the Arctic Pioneering, Vol. I: Spitsbergen. Moscow, Scientific World. 2007.

² Arlov, Thor B. *A Short History of Svalbard*. Oslo, Norsk Polarinstitut, 2nd edn, 1994.

Svalbard

except Bjørnøya and Hopen

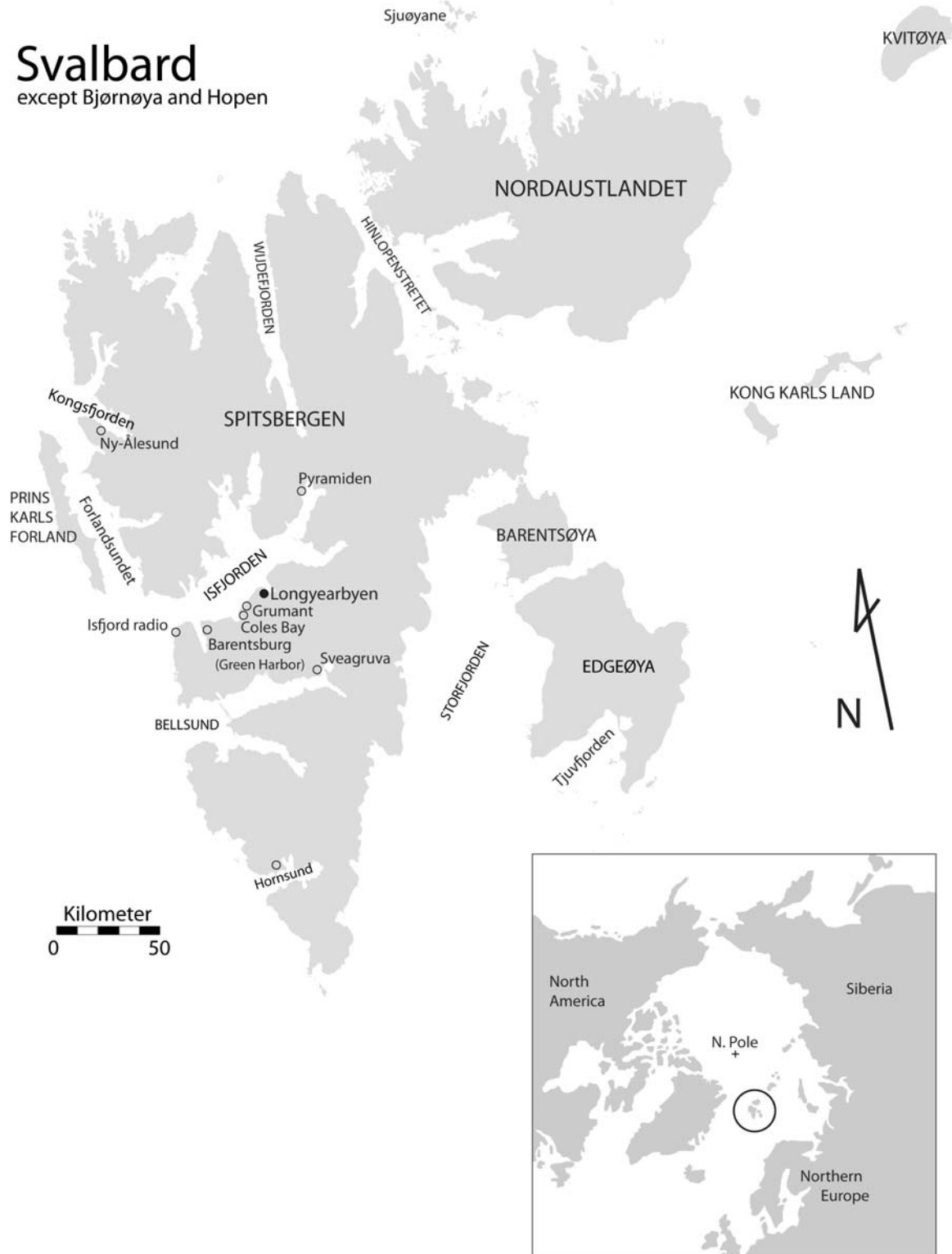


Figure 2.01: Svalbard Archipelago. Base map used with permission from Thor B. Arlov.

Svalbard is devoid of any vegetation larger than stunted shrubs and mosses. Much of the landmass can be described as an 'Arctic Desert.' This is because very little precipitation falls throughout the archipelago. The arid condition lends itself to excellent artifact and feature preservation across Svalbard's rich inventory of archaeological sites. Steep, rugged mountains rise from a large portion of the archipelago. Permanent snowfields and glaciers blanket a significant measure of the interior. The presence of coal on Svalbard suggests that the region once experienced a period of relative warmth. The deposits hint of a time when the climate was significantly warmer, one that supported marshes and swamps throughout the landscape.

Geologically, Svalbard is comprised of rocks that span from Pre-Cambrian to Tertiary epochs. These layers are exposed throughout the archipelago with little topsoil or vegetation to conceal them. Coal seams are found in Devonian, Carboniferous, Permian, Cretaceous, and Tertiary rocks. The coal is derived from peat that originally formed in bogs situated between river channels on the vast Paleocene coastal plains, and later transformed into coal during burial.³

In the Advent Bay region of Svalbard, where the content of this thesis is based, at least four bituminous seams have been identified and studied (Figure 2.02). The lowest seam is Carboniferous in age and is located on the northeast side of the bay. This seam was exploited intermittently during the first half of the 20th century with mostly unfavorable results. The three remaining seams are Tertiary and are situated on the southwest side of the bay. Among these, only one was deemed commercially viable, the No. 2 seam, which today is identified as the Longyear Seam.

The lowest seam (No. 1) is located at elevations between 465 and 600 feet above sea level. Where exposed, the seam featured clean coal that varied in thickness from 2½ feet to 4 feet.⁴ Although this coal was deemed to be of good quality, it remained undeveloped in favor of a second, more promising seam located further up the geological stratum. The second seam (No. 2), or Longyear Seam, lay from 50 to 100 feet above the

³ Ramburg, Ivar B., Inge Bryhni, Arvid Nøttvedt, and Kristen Rangnes. *The Making of a Land: Geology of Norway*. London, The Geological Society. 2008.

⁴ Turner, Scott. *Mining in Spitsbergen, 1949*. Scott Turner Collection, Box Z, Folder 30.

No. 1 seam on an outcrop that varied from 750 to 1000 feet above sea level.⁵ This seam features a high-quality, low-sulphur coal that ranges between 3 ½ to 4 ½ feet in thickness. Due to its relative consistency, the No. 2 seam became the horizon of choice among varied interests that operated in the Isefjord and Advent Bay areas. A third seam (No. 3) is located approximately 45 feet vertically above the No. 2 seam and features a wide range of thicknesses. This is because the seam is split with multiple layers of slate, which introduces a number of production and handling difficulties. For this and other reasons, the No. 3 seam was never developed in the Advent Bay region.



Figure 2.02:
Isfjorden and its
primary bays. Base
map used with
permission from
Thor B. Arlov.

Where mined, the No. 2 seam featured clean coal with no included rock or extraneous matter. Historic records associated with an early 20th century mining endeavor reveal that the coal was “so clean that it required no picking or sorting after being mined” and that “none of the coal was screen or washed.”⁶ This meant that the coal was shipped and burned for steam and domestic uses just as it came from the mine.

⁵ Ibid.

⁶ Ibid.

Sampling data from 1913 indicates that the No. 2 coal averaged 0.71% total sulphur with a calorific value of 14,403 British Thermal Units (BTU).⁷ Although the coal quality was below that necessary for coking purposes, the No. 2 seam proved worthy for steam and domestic uses during the early 20th century.

The Longyear Seam dipped on a 3% grade through a tall sandstone formation. The rock temperatures were the same for summer and winter seasons, “increasing from -5.5° C near the outcrop to -3° C at the 2,200-foot slope distance, indicating that the surface zone of perpetual frost extended to a vertical depth of about 2,200 feet.”⁸ These temperatures evidence that there was little to no water in mine works situated on the No. 2 seam. Moreover, the frozen nature of the coal meant that dangerous coal gasses were almost non-existent. However, the arid conditions found on Svalbard are favorable to coal dust explosions, a situation that has resulted in the death of numerous miners and one that still causes problems today.

Early Resource Extraction

Much of Svalbard’s history is related to some form of resource extraction. Coal mining is hardly the first of these endeavors. The story begins, depending on the literature one reads, with the discovery of the Spitsbergen* archipelago in 1596 by the Dutch explorer Willem Barents. News of the discovery sparked an intense period of commercial whaling largely developed by English and Dutch enterprises. Other nations also took part, albeit in smaller numbers. Shore-based rendering stations were lively establishments during the summer months, the most notable being Smeerenburg, a semi-permanent Dutch facility at the archipelago’s northwest corner. Eventually, intense competition and unregulated exploitation contributed to the collapse of the whale population, so much so that the industry had been largely abandoned by the turn of the 18th century.

⁷ Ibid.

⁸ Ibid.

* Since the history discussed hereafter falls within the historic use of the term “Spitsbergen,” the writer has chosen to refer to the archipelago as such.

While English and Dutch whalers plied their trade along the western shores of Spitsbergen, separate, land-based hunting activities took place throughout the archipelago. Contingents of Russian hunters known as the Pomors initiated these excursions into the uncharted regions of Spitsbergen. Based out of northwestern Russia, from numerous communities surrounding Arkhangelsk, the Pomor sailed seasonally to Spitsbergen to hunt walrus, reindeer, fox, and polar bear. There is some speculation that the Pomor arrived on Spitsbergen during the 16th century (prior to Barents' discovery); however, most researchers believe that the Pomors came after Barents, their activity peaking within the 18th century.⁹ By the early 19th century many of the Pomor had left the archipelago. Although the Pomor used a wide-ranging system of base stations and peripheral hunting camps, their activity on Spitsbergen is not usually regarded as an industry.

Norwegian hunting endeavors and intermittent whaling dominated much of the 19th century. European scientists had taken interest in the arctic regions and began inventorying the natural resources for their scientific and economic values. As these research activities increased, so too did the knowledge of Spitsbergen's geologic properties, especially information concerning its coal resources. Coal seams could typically be viewed on mountainsides and near sea-level exposures at various points on the archipelago. The Isfjorden (Ice Fjord), a mid-island fjord on the western side of Spitsbergen island, gained recognition for its particular abundance of coal seams.

Coal Mining on Spitsbergen

Coal mining on Spitsbergen did not fully develop until the early 20th century. This is not to say that previous visitors ignored the fossil fuel. Seventeenth-century whalers used the resource on their ships and for domestic use at land-based rendering stations. As early as 1610 a walrus hunter named Jonas Poole discovered in King's Bay "sea coales (*sic*), which burnt very well."¹⁰ As the years progressed, research vessels and

⁹ LASHIPA 1, Final Report. Industrial Heritage in the Arctic: Research and Training in Svalbard, August 2004. 2006.

¹⁰ Brown, R.N. *The Commercial Development of Spitsbergen*. Scottish Geographical Magazine, Vol. 28. 1912.

tourist ships took advantage of many outcrops found within short distance from the shore. Numerous participants mined coal in small quantities to replenish dwindling stock on their vessels. As the coastal sources grew scarcer, the part-time miners moved uphill towards less convenient coal seams. James Lamont, a late-19th century sport hunter, noted this condition on one of his many trips to the archipelago. After having exploited some of the easier pickings in the Advent Bay region, he had his crew blast coal from a mountain-based seam. Lamont grew somewhat annoyed with the endeavor as it consumed a great deal of time. He stated, “There was not much difficulty in picking out the coal, but the carrying down of the sack to the water’s edge was serious work, and by no means so popular an amusement as the transport of stags.”¹¹ Lamont knew his coal source as the “Diana Mine”, which he apparently located in the foothills above Advent Point. Although its present whereabouts remain unknown, the small mine is regarded as one of the earliest mining exploits in the Advent Bay region.

Commercialized attempts to mine coal made their first appearance in the late 1890’s. A Norwegian skipper named Sören Sachariassen opened a mine at Bohemanflya in north-central Isfjorden (see Figure 2.02). Sachariassen apparently generated enough interest that other Norwegian skippers soon followed his example. These outfits took possession of coal properties conveniently located near coastlines of the primary fjords on western Spitsbergen.¹² Prior to Norwegian sovereignty, claim signs were used to delineate claim boundaries on the archipelago. This practice instigated many disputes as rival interests sought to maintain rights to common areas. The most effective way to retain ownership under such conditions was by constant presence, although this did not always guarantee a favorable outcome.

Many of the early Norwegian mining companies were low-budget, small-scale operations comprised of simple camps with one or two permanent buildings. Due to low production volumes, the mined coal was likely sold on the local market, to passing whalers and tourist ships. Mine work usually took place within an open pit or adit and was limited to what could be mined during the summer, or ‘open’ season. Since over-

¹¹ Lamont, James. *Yachting in the Arctic Seas*. London, Chatto and Windus. 1876.

¹² LASHIPA 1, Final Report. Industrial Heritage in the Arctic: Research and Training in Svalbard, August 2004. 2006.

wintering required heavier investments of capital for related supplies and infrastructure, no winter mining took place at this time.

Although small in scale, the initial coal mining endeavors on Spitsbergen fostered increasing levels of interest from outside parties. Outfits from Norway, Sweden, Russia, and America are but a few that took notice of the existence of commercially viable coal deposits and their value within world markets. Norway and Sweden both had limited supplies of local coal; however, their qualities were well below international standards for coking and steam use. Northern Russia relied on coal from the interior, which could be expensive to transport. American interest was based less on its own needs than its desire to meet those mentioned above. Many of the nations involved looked at Spitsbergen coal as a viable alternative to British sources. The British markets had become increasingly prone to international complications or coal strikes, which threatened their overall reliability.¹³ As news from the Arctic sailed south, Spitsbergen coal grew more and more attractive to commercial and speculative interests.

The flurry of activity between the late 19th century and mid 1920's has often been regarded as the Spitsbergen coal rush. The archipelago's status as a no-man's-land accounted for varied participants and related conflicts. Aside from seeking an alternative coal resource, many of the nations involved sought access to a natural resource free of government restrictions and taxation. Should a mine prove successful, the potential for turning a large profit was quite conceivable. Political tact had a heavy role in the coal rush. Certain nations preferred that Spitsbergen remain a free-for-all, while others sought complete annexation. Such interests provoked responses in the form of numerous mining claims. Both Russia and Sweden took similar measures in opposition to Norway's push for sovereignty over the archipelago.

These events tied in with other regional affairs below the Arctic Circle. Northern Europe was industrializing at a rapid pace, a phenomenon that raised speculative interest in Scandinavian iron properties. For a time, an American group of investors (later becoming the Arctic Coal Company) considered the formation a large syndicate that

¹³ Atkinson, J.B. *Spitsbergen Coal, 1913*. Spetsbergenarkivet, Vol. 4. Riksarkivet, Stockholm, Sweden.

would develop large tracts of iron-rich land resources in Norway. The proposed industry was to be fueled by Spitsbergen coal. The endeavor might have taken root had the iron and coal proved to be of sufficient quality for iron production. Nonetheless, Spitsbergen coal was valued for steam and domestic purposes in regions that traditionally imported English coal.

As interest in Spitsbergen coal resources grew, some of the smaller companies sold off their properties to larger entities. In Advent Bay, a Norwegian outfit known as the A/S Bergen-Spitsbergen Kulgrubekompani (Coal Mine Company) sold out to the British interest Spitsbergen Coal & Trading Company (SCTC) in 1904. The latter thereafter opened a relatively large settlement named “Advent City” and became the first to invest in a year-round production operation. Dilemmas related to poor coal qualities, inadequate loading facilities and gross mismanagement limited the capabilities of the SCTC. Furthermore, the little coal that the company shipped to Norway was found to be of such poor quality, and the deliveries so irregular and small, that a prejudice had developed against Spitsbergen coal.¹⁴ The company ceased operations in 1908 and eventually sold its properties to a Norwegian named Fredrik Hiorth. Hiorth abandoned the Advent City development and opened a separate mine on a coal seam that outcropped at a higher elevation. This operation was known as Hiorthhamn, a small-scale affair that ran intermittently until 1940.

In 1905 a separate Norwegian mining company known as the Trondhjem-Spitsbergen Kulkompagnie (Coal Company) sold their Advent Bay-based property to an American outfit. The purchaser was the Arctic Coal Company, a Boston-based interest financed by two wealthy industrialist/financiers named Frederick Ayer and John Munro Longyear. The company operated in Advent Bay between 1905 and 1915. During this time they aggressively developed their Advent Bay properties, proving to others that mining on Spitsbergen could be regular and done on a large-scale while maintaining some degree of return. Methods and practices utilized by the Arctic Coal Company were adopted by other mining interests, which is testament to the impact that the former had on Spitsbergen’s burgeoning coal industry. Increasing costs and adverse economic

¹⁴ Turner, Scott. *Mining in Spitsbergen, 1949*. Scott Turner Collection, Box Z, Folder 30.

conditions brought on by WWI eventually forced the Americans to close their operations. The company sold its properties to a Norwegian outfit known as the Store Norske Spitsbergen Kulkompani (SNSK). This company remains in operation, and is now controlled almost entirely by the Norwegian state.

Other players took part in Svalbard's coal mining industry. The Dutch claimed rights to a property in Green Harbor, a large, southern bay in the Isfjorden. This became a hotly contested area through portions of the early 20th century, the Arctic Coal Company one of many exercising a claim to the region. The Dutch eventually sold out to the Russian company Trust Arktikugol, which still functions today in Barentsburg at a relatively modest capacity. Swedish interests opened mines at Svea and Pyramiden. Svea has since been purchased by SNSK and is now the largest producer on the archipelago. Pyramiden was later sold to Trust Arktikugol who then operated the mine until the late 1990's.

The Spitsbergen coal rush ended before the 1930's. The two primary reasons for the demise are falling coal prices on the world market and Norway's granted sovereignty over the archipelago in 1925.¹⁵ The latter made it more difficult for outside nations to develop mining interests on Spitsbergen. Today only Norway and Russia continue to mine coal on Svalbard.

¹⁵ LASHIPA 1, Final Report. Industrial Heritage in the Arctic: Research and Training in Svalbard, August 2004. 2006.

Chapter 3: The Arctic Coal Company

Although the history of coal mining on Spitsbergen is rife with actors large and small, no reflection would be complete without discussion of the Arctic Coal Company. The American enterprise is largely credited for having nurtured Spitsbergen coal mining from its small-scale beginnings into full-bodied enterprises akin to those in operation today. Prior to their arrival in 1905, only one other coal interest had managed to push towards large-scale production. This was the English group known as the Spitsbergen Coal & Trading Company, which began operations at Advent City in 1903. Despite their best intentions, the company failed to grow and adapt due to unfavorable dock facilities and poor management, and ceased mining operations in 1908.

At the same time the Spitsbergen Coal & Trading Company began their operations in Advent Bay, a separate interest had ventured into the region for the purpose of examination. The small group was comprised of John M. Longyear, William D. Munroe and Olaus Jeldness. They had secured passage on a Spitsbergen-bound tourist ship with the intention of visiting the coal seams of Advent Bay. After a short stop at Bell Sound, the ship steamed over to Advent Point where the three looked over a number of prospect diggings. The visit lasted 36 hours; just enough time to take some basic notes and to collect a batch of field samples.¹ Satisfied with their short visit, the trio gathered their coal samples and pointed south for the mainland.

John Munro Longyear (1851-1922) was no ordinary American doing prospecting work in the Arctic. He had traveled to the archipelago from Boston, a city from which he managed vast holdings in timber and iron properties. He and his family had recently relocated from Marquette, Michigan, a timber and iron town on the state's Upper Peninsula. Longyear was a self-made millionaire and had amassed much of his wealth during the latter part of the 19th century. Although he invested in numerous enterprises, most of them were based in the northern reaches of Michigan and Minnesota. Since arriving in northern Michigan in 1873, Longyear had developed acumen for identifying and acquiring resource-rich properties. Instead of troubling himself with extensive

¹ Longyear, John M. *Reminiscences by John Munro Longyear*. J. M. Longyear Research Library, Longyear Collection, Box 26. 1912.

development costs, Longyear got in the habit of leasing his holdings to those more familiar with the related businesses. His strategy proved fruitful after the expansions of Michigan's Menominee and Gogebic iron ranges, and later northeastern Minnesota's Mesabi range.

The following narrative is derived from varied archival sources between America and Norway. Both Longyear and his former employee Scott Turner left behind many detailed documents associated with the Spitsbergen endeavor including company reports, company correspondence, personal correspondence, and personal journals. Collectively, this material offers many interesting perspectives on the company and its diverse range of activities.

By the turn of the century, Longyear was leading a comfortable existence and engaged in many opportunities to perpetuate his investments. Furthermore, he held a position on the Board of Directors for the Michigan College of Mines (now Michigan Technological University). This appointment kept him in touch with leading professionals and the latest technologies employed throughout a variety of extraction industries. Longyear's 1903 Spitsbergen trip was not his first visit to the archipelago. In 1901 he came as a tourist with his wife and children. They visited Advent Point and bought some tourist stamps but little mention was made of the region's coal deposits.² Much would eventually transpire between this trip and Longyear's return in 1903.

In 1902 William D. Munroe, a graduate of the Michigan College of Mines and Longyear's younger cousin, was working for a gold mining outfit in Rossland, British Columbia. While in Rossland, Munroe befriended a technical miner named Olaus Jeldness. Jeldness was a Norwegian expatriate who spent time between the mining districts of Rossland and Spokane, Washington. He had recently become aware of a large iron discovery in northern Norway and intimated this news to Munroe. Jeldness believed that a fortune might be made by exploiting these new iron fields and was "casting about

² Longyear, John M. *Personal Diary: Trip to Germany and Norway, 1901*. J.M. Longyear Research Library, Longyear Collection, Box 2, Book 1.

to discover capitalists who might be interested to form a syndicate, either to acquire options on the tract...or to locate other lands in the vicinity.”³

Well aware of his elder cousin’s business strategy, Munroe approached Longyear for his opinion on the matter. After some due consideration, Longyear agreed that there was great potential in the foreign enterprise. He knew that the English were looking for new sources of iron ore and that a good business might be made of it.⁴ He furthered his opinion by financing a reconnaissance trip to Norway to be undertaken by both Munroe and Jeldness. That winter the two investigated a number of iron properties and eventually convinced a Norwegian landowner to permit an option for the American interest. Longyear, Munroe and Jeldness were examining the potential to be part of a burgeoning iron industry, a venture not unlike others carried out by Longyear. Should the iron properties prove to contain high quality ore, the chance for profitable leasing or development was attractive. During this time, Munroe and Jeldness became aware of the Spitsbergen coal deposits. These coals were purported to be superior to those found closer to the iron fields and could potentially be used for coking purposes.

Longyear corresponded with Munroe and Jeldness that winter from his Boston office. He was aware of Spitsbergen’s coal resources from his 1901 visit; however, he remained unfamiliar with its properties. After consulting with his business associate Frederick Ayer, Longyear determined that he would join his two representatives that summer to look over the iron and coalfields. He instructed Munroe and Jeldness to become as intimate with the option property as possible in order to show him the most favorable sections without delay.

Frederick Ayer (1822-1918), Longyear’s associate, was a prominent industrialist from New England. The two met in 1878 and had together financed a number of business engagements, many of them on Michigan’s Upper Peninsula. Ayer had amassed a great fortune in the early pharmaceutical and textile industries and was best known for being one of the principal organizers of the American Woolen Company, a consolidated

³ Dole, Nathan H. *America in Spitsbergen: The Romance of an Arctic Coalmine*. Vol. I, pg. 197. Boston, Marshall Jones Company, 1922.

⁴ Longyear, John M. *Reminiscences by John Munro Longyear*. J. M. Longyear Research Library, Longyear Collection, Box 26. 1912.

batch of successful New England textile mills. Ayer used his wealth to finance separate business opportunities. He invested in the Lake Superior Ship Canal Railway and Iron Company, a group commissioned for the construction of upper Michigan's Portage Canal. His doings in Michigan eventually brought him into contact with Longyear, then an up-and-coming timber agent with an eye for resource-laden properties. Ayer financed a few of Longyear's start-up endeavors and each profited handsomely.

By the turn of the 20th century, Ayer and Longyear were sharing an office in Boston, Massachusetts and consulting one another about various investment opportunities. By the time the Norway opportunity came around, Ayer had grown quite confident in Longyear's eye for detail and so he likely felt comfortable in agreeing to finance at least a portion of the enterprise.

Longyear arrived in Norway in July of 1903. There he met up with Munroe and Jeldness and proceeded immediately to Spitsbergen aboard the tourist ship *Auguste-Victoria*, the same boat he traveled on in 1901. After their short tour of Isfjorden and Advent Bay, the three returned to Norway to look over the iron properties at Varangerfjord. They spent approximately two weeks canvassing the property and concluded that the ore was of low quality and would be difficult to concentrate economically. Longyear later cancelled his arrangement with the property owner and the three returned to America.

Having given up on the Norwegian iron enterprise, Longyear received encouraging news concerning the Spitsbergen coal properties. After their return, Munroe traveled to Houghton, Michigan to have the coal samples analyzed at the Michigan College of Mines. Apparently the "analyses were so excellent that Mr. Ayer and I authorized him [Munroe] to go ahead and see what he could do."⁵ This meant having Olaus Jeldness open negotiations with the Norwegian prospecting company, which claimed the coal seams located south of Advent Point. After some back and forth during the summer of 1904, the directors of the Trondheim-Spitsbergen Kulkompagnie (Coal Company) agreed to release their rights to the property for 10,000 kroner and 1/7 of the

⁵ Longyear, John M. *Reminiscences by John Munro Longyear*. Marquette, J. M. Longyear Research Library, Longyear Collection, Box 26. 1912.

stock in a company of 350,000 kroner, or its equivalent.⁶ These amounts were roughly equal to \$2,681 and \$13,405 respectively.⁷ The first sum was paid out immediately; however, there is no indication that the Americans honored the second portion of the deal.

After securing the Advent Bay property, Longyear and Ayer made plans for the enterprise's first season on Spitsbergen. The general scheme was to thoroughly examine the Advent Point property and to investigate other coal bearing areas in the Isfjord. Munroe and Jeldness would undertake the endeavor with capital provided by the personal accounts of Longyear and Ayer. The organization became known as the Arctic Coal Company, although the designation was not formally registered until 1906. Early that winter, Longyear instructed Munroe to start his research on "coal mining appliances, etc., and that you may begin work at once."⁸ In making this directive, Longyear's Spitsbergen endeavor began to take shape.

What seems almost striking is Longyear's apparent ease towards the notion of opening a coal mine in the Arctic. Indeed, he performed some examinations and did research on the property and its coal seams. The results of this research were no doubt encouraging and weighed heavily in the ultimate decision to go forward with the project. However, these analyses could not completely negate the fact that the property was based in the Arctic, and as such, bound to a number of certain inconveniences. For example, the archipelago and its waterways remained frozen for most of the year. Shipping to and from the island had to be performed with careful attention to both the markets and the men and equipment stationed on the island.

Furthermore, the enterprise was to be run from America, which factored in a range of logistical problems that would have to be negotiated and surmounted. For many businessmen, these factors alone might have persuaded them from making any attempt to mine coal in such an isolated environment. However, Spitsbergen was indeed a no-

⁶ Ibid.

⁷ The amounts are derived from a 1904/1905 exchange rate of 3.73. Rates assembled by Statistics of Norway, Oslo Stock Exchange and Bank of Sweden. http://www.norges-bank.no/templates/article___42331.aspx

⁸ Longyear, J.M. *Letter to William D. Munroe, September 19th, 1904*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder L.

man's-land, and therefore free from prohibitive government taxation. Any profits to be made would be subject to no one other than the owner-operator. Providing that the resource was both plentiful and marketable, the chance for reliable profit seemed worthy of attention. That, and Longyear's history of doing business in Michigan, seemed to counterbalance at least some of the negativities associated with a Spitsbergen-based coal-mining endeavor.

Perhaps the most telling instance of Longyear's position on the issue is found in a letter he addressed to William Ayer in July of 1903. In this missive, he apprised Ayer of the trip to Advent Bay and the prospect of doing "easy" business on the island. "As hunters live there year round, it will, doubtless, be practical to work the mines continuously. The shipping season would probably be from May to November, say, about the same as on Lake Superior."⁹ This statement highlights Longyear's apparent comfort with the proposed business on Spitsbergen. If not for his experience with comparable climates on Michigan's Upper Peninsula, he may have dismissed the Spitsbergen mining endeavor.

Development of the Advent Bay properties

The development of the Advent Bay location under the management of the Arctic Coal Company (1904 – 1915) will be discussed in respect to three separate phases of operation as designated by Michigan Technological University student Cameron Hartnell.¹⁰ The first phase concerns the years 1905-1908, during which the company took the necessary steps to establish a functioning coal mine on an untested landscape. These early years were committed to: the identification of separate coal properties; a thorough examination of all selected properties; and the establishment of the flagship mine property at the mouth of Longyeardalen (Longyear Valley). Phase II covers the years 1909-1911, when the company initiated its move into large-scale production. These years were committed to the improvement of the mining systems utilized on site.

⁹ Longyear, John M. *Letter to Frederick Ayer, July 20th, 1903*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder L.

¹⁰ Hartnell, Cameron. *Unpublished doctoral dissertation*. Michigan Technological University, 2009.

Electrification of the property permitted the use of mechanized apparatus, which enabled the mine to ramp up its production output. The final phase, Phase III, encompasses the years 1912-1915, during which company efforts were focused primarily on increased production and the further adaptation of the mining and operational systems. Despite a number of improvements to both mine and property, the enterprise continued to operate at a loss until its eventual sale in 1915.

Phase I: Startup (1905-1908)

Following the 1904 purchase of the Advent Bay coal properties from the Trondhjem-Spitsbergen Kulcompagnie, the interests of John Longyear and Frederick Ayer immediately set into motion plans for development of the property. William D. Munroe and Olaus Jeldness shipped over to Europe in February of 1905 to prepare for the coming field season. Munroe took on the role of general manager of the interest while Jeldness facilitated the appropriation of men and equipment. A Norwegian skipper working for the Trondhjem company told them of the coal he removed from the Advent Point mine as well as other deposits in King's and Sassen Bays. This skipper, Captain Henrik Naess, would eventually hire on with the American outfit, providing years of service and knowledge related to the archipelago.

As Munroe became more familiar with the seemingly abundant supply of Spitsbergen coal, he made plans to claim additional properties that summer on behalf of Longyear and Ayer. This plan recognized Longyear's earlier advice to Munroe, where he intimated that they should not be tied down to one spot.¹¹ Longyear was applying a proven business strategy that had served him well back in Michigan: identify the choice properties and claim them; sooner or later they may become of use.

After making all the necessary preparations, Munroe steamed north along with approximately 30 people on May 29th, 1905. On board were ten laborers, the pilot Captain Naess, and a band of crewmembers that Munroe had hoped to make use of on land. It appears that Munroe had settled for a collection of unskilled, poverty stricken

¹¹ Munroe, William D. *Letter to Ayer and Longyear, May 20th, 1905*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

laborers.¹² Similar rules would apply for all subsequent hiring initiatives undertaken by the company. Olaus Jeldness decided not to join Munroe, and instead returned to America to catch up with personal business interests in Washington State. Along the way he did a self-appreciating newspaper interview, in which he described his exploits on Spitsbergen and his outlook for the enterprise.¹³ The bombastic piece soon came around to Longyear, which had a damaging effect. Among other things, the action eventually led to Jeldness' dismissal from the group.

On location in Advent Bay, Munroe evaluated the Trondhjem company's mining efforts at Advent Point and prospected a number of coal seams found throughout Advent Valley. Mining was begun at the Trondhjem company's primary prospect, a single drift that had only penetrated 60' into the mountain. Plans were made to erect a tramway up to the mine. Munroe took orders from passing whalers for at least 200 tons of coal to be delivered by the end of July. By mid-July Munroe was exhibiting some frustration. The sheer immensity of the field became intimidating and he lamented in a letter to Longyear that it was "too large for one man to cover."¹⁴ This was a nod to Longyear that he remained disappointed in Jeldness for not joining him that summer. As the mining progressed, the field manager became more dissatisfied with its location. He stated, "The opening made by the Trondhjem people is entirely in the wrong place, in fact the very worst place that could have been chosen."¹⁵ Apparently the Trondhjem company had situated its coal mine on a narrow ridge of a mountainside, which meant that the formation sagged on both sides. This made development work difficult since the main entry had to proceed through an indefinite length of fragmented coal, a discouraging reality for an operation that had only just started.

Understanding the limits of the Advent Point mine, Munroe put more energy into regional prospecting. By mid-August he had become more positive towards the

¹² Munroe, William D. *Letter to Ayer and Longyear, May 29th, 1905*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

¹³ Longyear, John M. *Reminiscences by John Munro Longyear*. Marquette, J. M. Longyear Research Library, Longyear Collection, Box 26. 1912.

¹⁴ Munroe, William D. *Letter to Ayer and Longyear, July 14th, 1905*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

¹⁵ Ibid.

endeavor. Prospecting efforts in the region had yielded more satisfactory results. The manager was convinced that a number of large mines could be opened within convenient distance of Advent Bay Harbor and that five different openings had been started, three or four of which “could be used as permanent openings.”¹⁶ Munroe was referring to seams located in a glacial valley southeast of Advent Point. He would later name this area Longyear Valley, today known as Longyeardalen.

Having relocated to the new openings in Longyear Valley, Munroe abandoned all mining activities at Advent Point. While performing his work he kept tabs on business across the bay. The English outfit, Spitsbergen Coal & Trading Company, had been working at Advent City since 1903 and was struggling with poor harbor conditions and an intemperate superintendent. The American manager found all of this quite amusing. The one positive aspect, in Munroe’s opinion, was the company’s mine superintendent Arthur Mangham. Mangham was an experienced colliery manager from Rottherham, England and had the misfortune of working beneath an incompetent superior. Sometime that August, Mangham had found the time to visit the American activity on the south side of the bay. Munroe toured him around the property and the two became friendly, much so that Mangham took it upon himself to submit a formal report to the company that outlined some considerations for the development of the Longyear Valley property. Among other things, the report discussed the nature of the seams and how to properly exploit them.¹⁷ Mangham’s brief visit with Munroe would eventually develop into a much larger collaboration, one that would essentially guide the course of the operation.

Satisfied with the summer’s progress, Munroe left Advent Bay on September 1st. In addition to the work in Longyear Valley, Munroe had looked over properties in Coles and Sassen bays as well as Cape Boheman and Safe Harbor. He made claims on portions of each property. On his return to Norway, Munroe looked after some business arrangements including a visit with the chief engineer of the railway department, who said that he was interested in the development of Spitsbergen coals. Thereafter he

¹⁶ Munroe, William D. *Letter to Ayer and Longyear, August 10th, 1905*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

¹⁷ Mangham, Arthur. *Report submitted to William D. Munroe, August 26th, 1905*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

departed for America with a collection of coal samples. While in Houghton, Michigan, Munroe had a Michigan College of Mines chemist perform tests on the coal specimens. The results showed that the coal from the new mine was too high in sulphur and therefore below quality standards for coking purposes. However, the coal proved satisfactory for steaming and domestic use, which boded well for its introduction to European markets.¹⁸

1906 marks the formation of the Arctic Coal Company, a Boston-based entity financed exclusively by Ayer and Longyear. Although the Trondhjem-Spitsbergen Kulkompagnie people remained on board as stockholders, they were not obligated to fund any aspect of the endeavor through its duration. Munroe spent most of that winter making arrangements for the 1906 expedition. Munroe sailed for Europe in May with a newly hired mine engineer named J. Phillip Furbeck. Furbeck had recently graduated from the Michigan College of Mines and would assist Munroe with operations that summer. Along the way they made equipment purchases from supply houses out of Sheffield, England, a region perhaps suggested by Arthur Mangham [who was then working for the Sheffield-based Spitsbergen Coal & Trading Company].

After collecting supplies for mining and construction, and after some delay in locating a ship, Munroe arrived with his crew at Advent Bay on June 15th. Priorities slated for that summer included: the erection of a small collection of bunkhouses and auxiliary buildings on the valley floor (later named Longyear City); construction of a dock for the transfer of coal and supplies; and continued development at the mine including preparation for coal storage and an aerial tramway terminal. Munroe saw the course of these developments as necessary for success of the operation. He stated, “The work to be done this summer and to be done this winter is what must be done before a production can be depended on.”¹⁹

Munroe and Furbeck arrived with four English miners and a band of Norwegian laborers. The English miners were hired from the Sheffield area and included Arthur

¹⁸ Munroe, William D. *Letter to Frederick Ayer, December 27th, 1905*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

¹⁹ Munroe, William D. *Letter to the Arctic Coal Company (ACC), October 13th, 1906*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

Mangham's son Bertrand, or Bert, a mine engineer.²⁰ Arthur likely facilitated the hire and appears to have kept in contact with Munroe on some level since their discussions at Advent Bay. Munroe asked Bert to locate a handful of English workers and to assist with the hire of Norwegian labor. The English miners were necessary as foremen, to instruct the Norwegians in coal mining practice, as the latter had no prior experience.²¹

At the mine site, Munroe had to prepare the surface area to accommodate the mine entries and surface plant. This required a large degree of earthwork and the blasting of a dangerous rock overhang.²² Soon after the 1906 work began, Munroe wrote to Longyear in Boston and commented, "The English miners I have think very highly of our coal seams and say they will be able to get coal fast once opened out."²³ This statement suggests that the English miners held some level of authority over how the mining would progress. Although he had received a Mine Engineering degree from the Michigan College of Mines, Munroe's subsequent experience was steeped in the principles of hard rock mining. The fundamentals associated with coal mining required a different kind of experience, one that Munroe had only recently attempted to acquire. Since Munroe was superintendent of all Spitsbergen-based operations, including all construction and prospect endeavors, it seems likely that he left many of the coal mining decisions to the coal miners themselves. And the only people with any coal mining experience on site that summer were the 4-6 English miners under the direction of Bert Mangham.

Situated on the northwestern slopes of Longyear Valley, ACC Mine No. 1 rested approximately one half mile south from the shores of Advent Bay, at an elevation of approximately 725 feet (Figure 3.01). The target coal seam rested at the intersection of steep rugged cliffs and slide rock. The mine took advantage of Advent Valley Seam No.

²⁰ Although company records fail to clarify the extent of Munroe and Mangham Sr.'s relationship, it apparently grew to a point where the latter managed to land work for his son at the American operation. Additionally, Munroe had engaged the elder Mangham to watch over the American property during the winter of 1905/06. This would only have been possible if Mangham Sr. was working for the Spitsbergen Coal & Trading Company, a connection that remains difficult to define clearly.

²¹ Mangham, Bertrand. *The First Mining in Spitzbergen*. Transcribed by Grant A. Mangham, 1993. Source date unknown.

²² Ibid.

²³ Munroe, William D. *Letter to ACC, June 15th, 1906*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

2 [today identified as the *Longyear Seam*], which hosted a Tertiary coal found to be satisfactory in quality and with a consistent thickness. On average, the seam measured 3' 9" in depth and rested on a fairly level plane with a slight dip towards the west. The roof and floor were comprised primarily of sandstone, a favorable composition that lessened the chance for roof collapse.

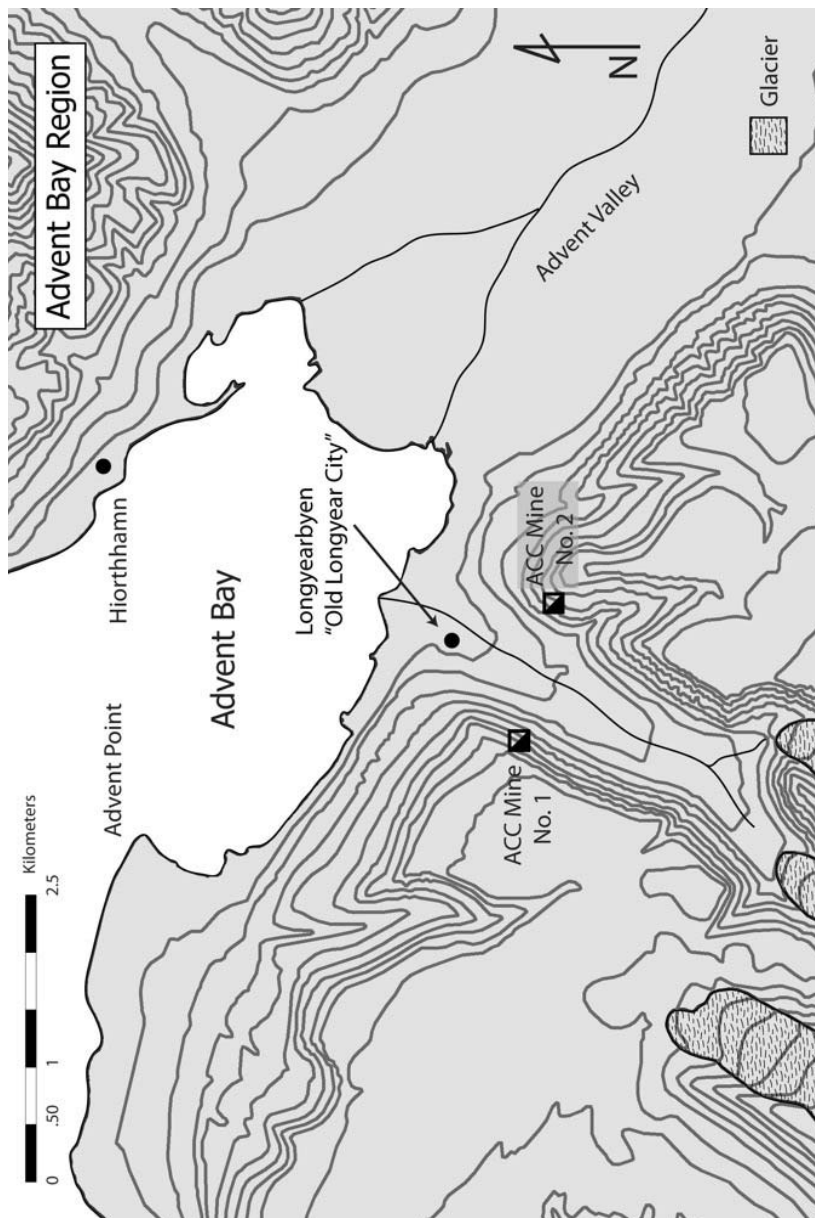


Figure 3.01: Map of Advent Bay Region. Image created by Seth DePasqual.

By mid-July of 1906, the Arctic Coal Company had initiated use of the longwall mining method (Figure 3.02). In a letter to Boston, Munroe wrote of the updates at the mine and stated that the Mine No. 1 seam “is an ideal seam for longwall working....and when we get it opened out we shall be able to work this seam very cheaply.”²⁴ Munroe is possibly referring to the height and horizontal nature of the coal seam, which was an added advantage to commercial longwall mining on Spitsbergen. English coal seams tended to be deeper underground and often required expensive shafts in order to reach them. Since the Longyear Valley seams outcropped on elevations above sea level, mine location became a matter of identifying conditions that would accommodate the transfer of coal to outside storage and sea-going vessels.

Although company records offer no clear reason for the decision to go with the longwall method, one can assume that it was influenced to some degree by British experience and know-how. Many of England’s coal seams were thin, or below 4’ in thickness, and therefore more difficult to mine. This is because cumbersome rock work was necessary to facilitate movement within the mine’s network of gates and passageways. Therefore, in England, “there was a tendency to make full use of the possibility of working optimally long rather than optimally short faces.”²⁵ For these reasons, as well as others not mentioned, the longwall method came to be a particularly useful way to extract coal from thin seams.

In light of such details, it is not surprising that a band of English miners employed by the Arctic Coal Company opted for the longwall system as opposed to others where shorter working faces were developed. Additionally, there is anecdotal evidence that suggests the Spitsbergen Coal & Trading Company employed the method at their mine across the bay.²⁶ The English company hired experienced miners from the Sheffield area

²⁴ Munroe, William D. *Letter to ACC, July 13th, 1906*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

²⁵ Trist, E. L. and K. W. Bamforth. *Some Social and Psychological Consequences of the Longwall Method of Coal-getting*. Human Relations, Vol. 4, No. 3. 1951.

²⁶ Atkinson, J. B. *Spitsbergen Coal, 1913*. Spetsbergenarkivet, Riksarkivet, Vol. 4. Stockholm, Sweden. This is a report related to a 1912 mineral expedition undertaken by Swedish interests. While examining the closed property of Advent City, Atkinson penetrated the mine “as far as a long wall face about 150 yards from the entrance.”



Figure 3.02: 1910 map of Arctic Coal Company Mine No. 1. Mine map presents the longwall mining arrangement after four years of development. Image courtesy of Michigan Tech Archives, Longyear Collection, Box 2, Folder 9.

including Arthur Mangham. It seems likely that Mangham Sr. influenced the choice of the longwall method through either his son or Munroe, or both.

Munroe had an inclined surface tramway constructed to transport coal from the mine to a temporary pile on the Valley floor. A separate tramway system transferred coal to the small wharf on Advent Bay. The single-track incline, or “jinny,” was powered by gravity; the controlled fall of a loaded tramcar would carry up a separate, lighter car. This is how the operation sent mining and construction materials up to the mine. The tramway only delivered coal on a small scale, and therefore was used as a temporary transfer system. Munroe had planned for the installation of a more efficient, high-capacity aerial tramway system that would carry the coal directly from the mine to the dock on Advent Bay. He sought out bids from numerous tramway manufactures in both America and Europe and eventually decided on a German design to be constructed the following year.

At the mine Munroe had a small stable placed inside the main entry to shelter the mine horses. These animals were used to haul tramcars up a slight incline inside the mine. The assistant mine engineer, Furbeck, proved to be a great disappointment over the course of the summer. He apparently wanted to be “pitted, coaxed, and housed like a prince and made boss of everything.”²⁷ Even more frustrating was a mid-July strike initiated by the Norwegian laborers. The strikers demanded increased pay for their services, which Munroe adamantly refused. The miners returned to work after a few days of only hard tack to eat. Munroe learned later that the miners struck in part due to their dissatisfaction with the accommodations in the mining camp.²⁸

At the close of the 1906 summer, Munroe left behind approximately 40 individuals under the direction of winter superintendent Bert Mangham. He instructed Mangham to extend the opened coal bodies of the mine and to prepare the work necessary for the construction of a timber-framed coal hopper below the mine entrance.²⁹

²⁷ Munroe, William D. *Letter to the ACC, August 7th, 1906*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

²⁸ Munroe, William D. *Letter to the ACC, July 28th, 1906*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

²⁹ Arctic Coal Company. *General Manager's Report, December 31st, 1906*. U.S. National Archives.

With attention to the expected installation of the aerial tramway, Munroe remained optimistic that the company would be able to bring coal to European markets by the following fall.

In early October, Munroe returned to the Trondhjem office in Norway and then proceeded to Leipzig, Germany to order the aerial tramway from the Adolph Bleichert & Co. manufacturing facility. He then returned to Boston to produce a company report. On his return to Europe, he traveled to Sheffield, England to place orders for mining equipment. Then on February 21st, 1907, while traveling from England to Holland, general manager William D. Munroe was killed when the steamer *Berlin* wrecked at the Hook of Holland. Stunned by the loss of his younger cousin, John M. Longyear canceled a trip to Egypt and traveled to Norway to command the operation of his enterprise until a new operational manager could take over. Back in Boston, Mr. Ayer hired Kenneth L. Gilson of Pennsylvania, who then steamed for Europe to assist Longyear with field operations.

That spring, Longyear visited the Bleichert plant in Germany and then traveled Norway to make preparations for that summer's work. He supervised the refitting of the company boat that Munroe had purchased earlier that winter. In tribute to his deceased cousin, Longyear renamed the former whaling vessel the *William D. Munroe*. While in Trondhjem he rented an office space and set to hiring men for work at Advent Bay. To assist with this process, Longyear brought on a Norwegian named Carl Saether to act as clerk. Saether had spent seven years in America and was most recently employed as a clerk for a Norwegian bank. He remained with the company until its eventual sale in 1916 and then transferred his services to the Norwegian purchaser.

By early May, Longyear had assembled most of that summer's labor force, which was largely comprised of English and Norwegian workers. They shipped for Spitsbergen on May 16, the day before a weeklong Norwegian holiday celebration. Besides roughly 50 men on board, the first boat of the season carried the first shipment of timber necessary for the erection of the aerial tramway. On arrival they discovered that Mangham and his crew had over-wintered successfully without any serious mishaps. They had enjoyed a prosperous winter and made good progress on the loading dock; the

coal hopper stood framed and ready for finishing work.³⁰ Several thousand feet of driving had been performed within the mine. The coal removed that winter related to development work only. Since the hopper had yet to be completed, all of this coal was brought down the incline and stored at a beach-based storage pile.

Development at Longyear City carried on with diligence that summer despite the initial hindrance caused by persistent sea ice and weather. Of the 50 or so men that shipped up that summer, roughly half were carpenters assigned to the construction of the aerial tramway and coal hopper. The tramway remained unfinished that year on account of the short summer season and the scope of work it entailed. In consequence, the amount of coal produced during the year had to be kept at a minimum. The mine development work that did occur was confined to the driving of headings and the opening of the coalface.³¹ To generate their market, the company sold small tonnages of coal to passing whalers and to research and tourist boats.

By the end of the summer, the main entry and airway return had been driven approximately 250 yards. New English mine cars from Sheffield were received and put to use. Sand and cement was used to prepare foundation work for the coal hopper and tramway loading station. For convenience, the company erected an “eating-house” and smithy shop near the entrance to the mine.³² Prior to his departure at the end of July, Longyear visited a separate claim at Green Harbor. Munroe had placed claim signs on the property in 1906 and now Longyear decided to set up a small seasonal camp above the Norwegian whaling station. The location proved to be of some value to the company during their time on Spitsbergen; however, its development never escalated beyond a simple camp and two low-volume mine workings. Most of the coal produced was sold to the whaling station and related whaling vessels.

That winter Bert Mangham remained on the property to manage the efforts of approximately 40 men. These men were mostly miners and carpenters and would spend the dark season expanding the mine, timbering gates, and improving the dock system.

³⁰ Gilson, Kenneth L. *Letter to the ACC, August 1st, 1907*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 18.

³¹ Arctic Coal Company. *General Manager's Report, November 27th, 1907*. Michigan Tech Archives, Scott Turner Collection, Box Z, Folder 24.

³² Ibid.

Gilson expected that 50 tons of coal would be stocked during the winter.³³ Back in America, Longyear appointed Frederick P. Burrall to act as General Manager of the Spitsbergen endeavor. Burrall was the nephew of Mary Longyear, John's wife, and had graduated from the Michigan College of Mines in 1894. Prior to his appointment with the company, Burrall had been employed as a mine engineer for over 14 years.

Kenneth Gilson remained in Europe that winter to prepare for 1908 field operations. Burrall joined him the following April. Upon arrival to Advent Bay in May of 1908, company managers learned that the main entry had been extended to 900 feet. The return airway remained shorter in length at 750 feet. Burrall reported "On each side [of the main entry] are 450 feet of long wall face, making 900 feet available for mining either by hand or by machine."³⁴ Approximately 2000 tons of coal had been taken to a beach-based storage area near the dock. The coal sold that summer went to passing whalers or was used by the *William D. Munroe*.



Figure 3.03: 1908 image of the Bleichert aerial tramway and coal hopper. Photograph taken by Anders Beer Wilse. Mine No. 1 is barely visible at top-right corner. Image courtesy of Keweenaw Digital Archive, Image#: MS018-007-02-12.

³³ Ibid.

³⁴ Burrall, Frederick P. *Letter to the ACC, June 8th, 1908*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 19.

While the crew labored to erect the 1300-meter aerial tramway that summer, the company kept mining at a minimum. Burrall stated, “We are sacrificing as much of the other work as possible to attain this end.”³⁵ By August the tramway and 1100-ton coal hopper had been completed and put into use (Figure 3.03). The tramway spent the remainder of the season transferring rock from a mountain-based quarry to the dock for use as fill between its pilings. Valley work that summer included the construction of additional bunkhouses, an office and an oil storage house. Additionally, Burrall had the old tourist hotel from Advent Point moved over to Longyear City for use as a storehouse.

Bert Mangham continued operations through the winter along with 45 men. He received orders to push development of the mine and to fill the hopper. Additional coal would be stored inside the mine. Burrall advised Mangham that he should “keep development going all winter, even at the sacrifice of coal tonnage if necessary.”³⁶ He had become concerned with coal storage outside the mine with no protection from the winter elements. Until he could figure the storage problem out, he advised Mangham to proceed with development as opposed to production. Burrall returned to the Boston office to pen his report and Gilson remained with Saether in Trondhjem. Later that winter, Burrall intimated to Longyear that he would resign from his post at the close of 1909. He cited his lack of coal experience and his desire to be closer to family.³⁷

Phase II: Small-scale Operation (1909-1911)

Upon completion of the aerial tramway and coal hopper, the company entered into a new phase of productivity. Coal could now be conveyed more efficiently and in higher volumes. The tramway manufacturer claimed that the system could deliver 100 tons of coal per hour; however, the device never reached this specification. Still, the delivery rate far exceeded that previously experienced through use of the incline tramway. More importantly, the aerial tramway transferred coal product straight to

³⁵ Burrall, Frederick P. *Letter to the ACC, June 26th, 1908*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 19.

³⁶ Burrall, Frederick P. *Letter to Bert Mangham, September 4th, 1908*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

³⁷ Burrall, Frederick P. *Letter to John M. Longyear, March 24, 1909*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 20.

awaiting ships (Figure 3.04). Despite these new installations, little mine work could be performed during the winter of 1908/1909 on account of ice problems at the dock. However, by the time the spring ship arrived, approximately 3,000 tons of coal had been removed from the mine.

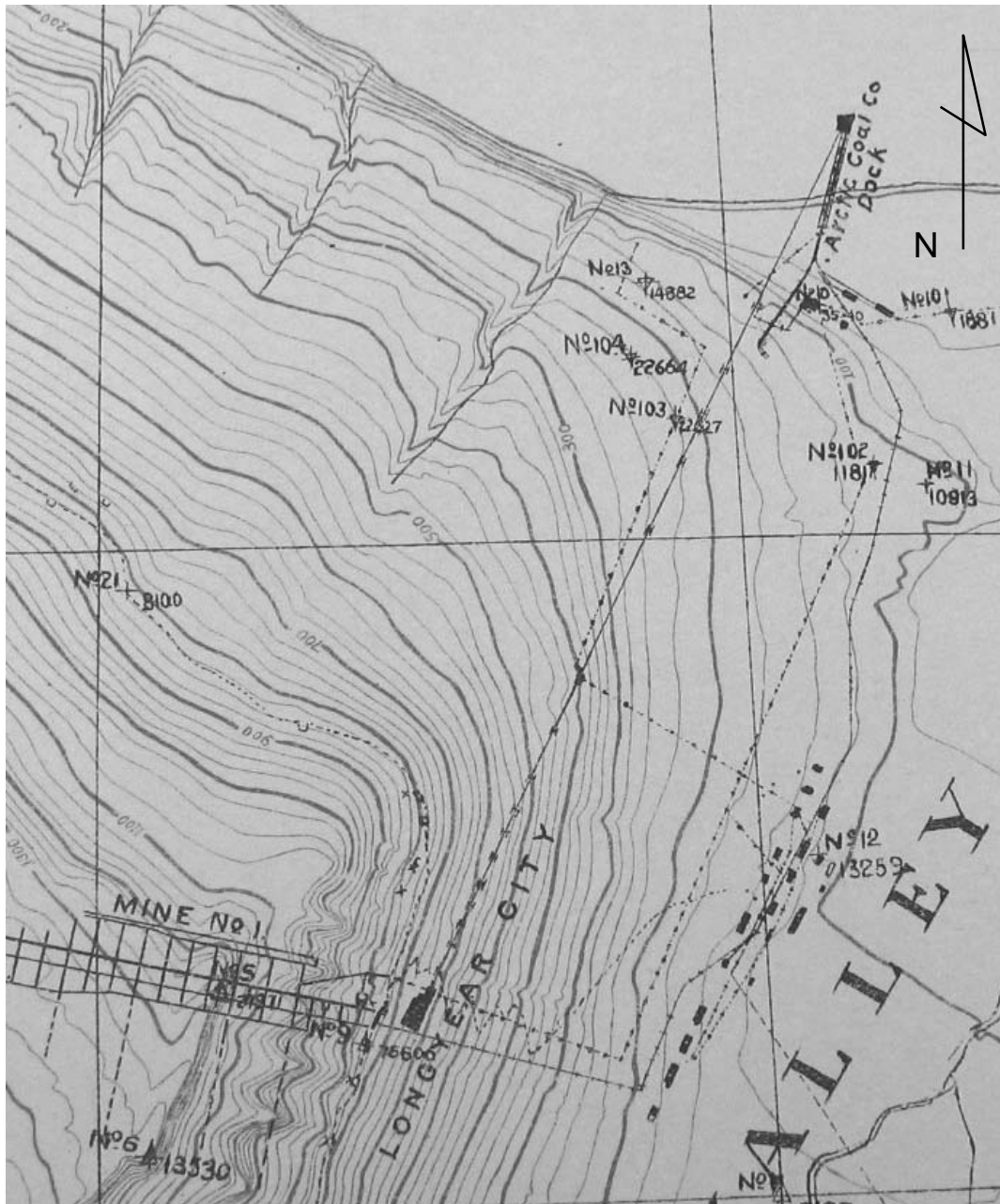


Figure 3.04: 1912 map depicting the locations of Longyear City, Mine #1, the Bleichert aerial tramway, and the lower terminal dock.. Image courtesy of MTU Archives, Scott Turner Collection, Box Z, Folder 27.

Near the close of the previous summer, the Arctic Coal Company received a report from Arthur Mangham. The elder Mangham, who apparently did work for the company that summer at its small Green Harbor mine, reported on inspections he made that June.³⁸ In his report, Mangham comments on the state of operations at the numerous tracts held by the enterprise, which included Advent Bay, Green Harbor, Sassen Bay, Coles Bay, and Cape Boheman. On the topic of mining conditions at Advent Bay, Mangham pushed for the mechanization of coal cutting activities. He viewed the use of electric coal cutters as a way to tackle some of the company's problems with transient labor. He stated, "By the use of machines, the Company would be independent of Norwegian miners, only requiring laborers to fill out the coal at the tonnage rate of 1/3 to 1/4 per ton, which would bring the cost considerably below that of manual labor."³⁹

Arthur Mangham's report apparently generated a heightened interest in the enhancement of the mine property. The company knew that eventually, at the proper time, the mine would reach a point where increased use of machinery would become necessary in order for the mine to prosper. The question was not *if* mechanization would be necessary but rather *when*. In preparation for the coming summer operations, the company contracted with a mining consultant named Walter L. Coulson. Coulson was a mine engineer from Cincinnati, Ohio and had an extensive background in coal mining. Boston officials commissioned him to visit the Spitsbergen property near the close of the 1909 summer, asking that he evaluate the condition of the property and make any necessary recommendations.

On arrival, Burrall noticed that Mangham had created a coal pile near the base of the aerial tramway. Although the two had agreed to store excess coal in the mine, Mangham had apparently located a relatively dry spot behind a ridge where the snows did not greatly accumulate. Burrall feared that coal impregnated with ice would be frozen and harder to handle, forcing one to further fragment the resource in order to free it from the frozen pile. In locating an optimal ground on which to store the excess coal,

³⁸ Dole, Nathan H. *America in Spitsbergen: The Romance of an Arctic Coalmine*. Vol. I, pg. 360. Boston, Marshall Jones Company, 1922.

³⁹ Mangham, Arthur. *Report Submitted to the ACC, September 18th, 1908*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 91, Folder M.

Mangham initiated a long-running question of how to properly store and load coal efficiently.

Approximately 82 men hired on with the company that summer. In the mine, the main entry had reached a length of 1,140', and approximately 1,335' of longwall face had been prepared for mining.⁴⁰ The main entry now featured a double-track, narrow-gauge rail system with single-track branches extending into the drifts. Thirty-five summer laborers worked in the mine and utilized 20 mine cars. By this time, over 10,000 tons of coal had been extracted from the mine. As part of an exploratory effort, Burrall instructed his men to drive a separate entry on a coal seam above Mine No. 1. This became known as the Level 3 seam, which William Munroe first identified in 1905. By the close of the summer, the company had extracted approximately 4,692 tons of coal, which they sold in Norway, to passing whalers, or used for company purposes. The total included the winter output.

In addition to the mine work, Burrall engaged in prospecting endeavors in the West Point region, an area west of Advent Point where the bay meets the Isefjord. He also installed an incline tramway, which ran from the loading dock to the base of Tower 16 (of the aerial tramway). The incline served as a secondary loading system, to be used in conjunction with the aerial tramway. Since Mangham decided to pile excess coal at the tower location, the incline became necessary in order to continue the coal's movement to waiting ships. Burrall saw this system as a way to load ships more expeditiously.

In August, Walter Coulson arrived for his two-week evaluation of the Spitsbergen properties. John Longyear and John Gibson Jr. accompanied him during the visit. Gibson was a mine engineer who would eventually succeed Burrall. Coulson had recommended Gibson to Longyear, citing his experience as a superintendent of a coal mine in Jerome, Pennsylvania. His extensive background would be a first for the organization, which up to this point had relied on American managers with little or no experience in coal mining. Having recognized his own deficiencies on the job, Burrall

⁴⁰ Arctic Coal Company. *General Manager's Report, December 27th, 1909*. Michigan Tech Archives, Longyear Collection, Box 1, Folder 13.

may have fostered this shift towards experienced managers. In his resignation he argued for a replacement with adequate mining experience. He added, “Coal mining is very different than metal mining and your profit margins are not going to be great enough to allow any more experimenting than is absolutely necessary.”⁴¹

Coulson made his detailed examination of the Advent Bay property, duly noting the performance of the mine. He observed that all mining on the property had been performed by hand, which he attributed to the daily output of less than 50 tons.⁴² He recognized the difficulty of maintaining an experienced workforce; many laborers hired for one year’s service failed to renew their contracts or were blacklisted by the company. This forced the company to train a new batch of workers every season, which was costly in time and capital. Following his examination, Coulson recommended a number of improvements to the mine, the most notable being the introduction of electric machinery. Powered by a valley-based power plant, electric machinery would permit an increased volume of coal to be won by a single individual. Coulson’s report estimated that if the company properly executed all of the recommended upgrades, the Arctic Coal Company could experience a handling capacity of 200,000 tons of coal per year.⁴³

At the close of the season, Burrall left behind Mangham along with 44 men. He instructed Mangham to continue with the mine development and to push the main entry as far as possible. Necessary work on the new surface incline near Towers 15 and 16 could be performed in the spring before the first ship arrived. Later that winter Longyear addressed the company’s stockholders (essentially Ayer and the Trondhjem-Spitsbergen Kulkompagni people) with a prospectus on Spitsbergen operations. The letter was brief but concise. He observed that the return on the operation had been low and that they did “not anticipate that the property will yield a sufficient return to pay working expenses until 1912.”⁴⁴ He made further reference to Coulson’s examination and that they felt

⁴¹ Burrall, Frederick P. *Letter to John M. Longyear, May 11th, 1909*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 20.

⁴² Coulson, William L. *Examination Report sent to the ACC, October 6th, 1909*. J.M. Longyear Research Library, Spitsbergen Papers, Box 3.

⁴³ Ibid.

⁴⁴ Longyear, John M. *Letter to Stockholders, January 4th, 1910*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 9, Folder L.

justified in following through with his suggestions. Frederick Burrall resigned at the end of 1909 and was replaced by John L. Gibson as general manager in 1910. Kenneth Gilson stayed on as the superintendent for summer operations.

That winter Mangham and his men extracted 5,601 tons of coal, which he sent to the Tower 15 stockpile via aerial tramway. They also continued work on the connecting bridge to the loading dock. This type of work took place in the late fall and early spring. Additionally, Mangham had a new ventilating fan installed at the mine entrance. Although the mine experienced adequate natural ventilation without the assistance of a fan, the device complemented plans for increased development.

Only small amounts of mining occurred during the summer of 1910. Priority had been given to the installation of machinery and apparatus for the purpose of producing coal in large quantities. Upon completion of the powerhouse at the valley floor, construction crews ran electricity up to the mine to power lights, two coal cutting machines, and a new main-and-tail hoist for use inside the main entry. They also installed a mine-based power transformer to accommodate the mine system's varied machinery.

To allow better communication, the company installed a complete telephone system, which connected all necessary positions including the mine. The incline tramway received an upgrade that elevated its trestles to keep it free from snow during winters. A new electric motor hoist replaced the older one used since 1906. Crews recessed this hoist within a small cavity burrowed out of the mountain. The electric hoist did away with the use of gravity to power the incline system, thereby providing the company with a safer and more effective way to transport men up to the mine. Until this time mine laborers had been hiking up the steep footpath, which often amounted to 45 minutes of lost time each day for each laborer. The company also purchased a steam crane to assist with loading at the Tower 15 stockpile.

At the close of the summer, the length of the main entry measured 2,025'. That season a large fault had been encountered at the tail end of the main entry. This fault severed the coal seam entirely which meant that the tunnel faced rock instead of coal. A small amount of driving was performed to determine the nature of the fault. The effort

proved unsuccessful. John Gibson remained optimistic and stated, “there will be no hindrance to the output from this, as we now have enough coal developed to last at least 10 years, without the Main Entry moving a foot.”⁴⁵

Summer production amounted to 1,243 tons of coal that, when combined with the winters total, amounted to 6,844 tons gathered during the year. A crew of 73 men and three women remained on the island that winter, which amounted to the largest assemblage of people at this time of year. Mangham received instructions to develop the mine and to relocate the coal seam at the back end of the main entry. With attention to the improvements made to the property that year, Gibson declared that the company had a “complete and up-to-date” mining plant on the property and estimated that the mine should produce between 45 and 55 thousand tons of coal during 1911.⁴⁶ He also stressed that the company should attempt to strengthen its market through improvement of its shipping network. English coal could be obtained with relative security, as backup ships were frequently available. Until the company could contract with a reliable fleet of ships, Gibson predicted some level of difficulty in locating a committed group of buyers. For the following season, Gibson had the company’s Norway office relocated from Trondhjem to Tromsø, the latter being 500 miles closer to the operations in Spitsbergen.

Gibson arrived to the Advent Bay property in early June of 1911. There he learned that 24,000 tons of coal had been removed from the mine over the winter, which he noted as a significant increase in comparison to previous winters. Mechanized mining continued throughout the summer, which produced an additional 13,000 tons of coal. Within a month of his arrival, Gibson realized that Mangham’s declared winter output did not match that found in storage. Either through careless optimism or through actual incapacity Mangham had reported that he had placed an additional 8,000 tons of coal in the stockpile.⁴⁷ The overestimate proved to be a serious problem as Gibson had made contracts for the original amount. In consequence his bookkeeping became extremely tight as he struggled to balance his contract obligations with the summer

⁴⁵ Arctic Coal Company. *General Manager’s Report, November 5th, 1910*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 23.

⁴⁶ Ibid.

⁴⁷ Dole, Nathan H. *America in Spitsbergen: The Romance of an Arctic Coalmine*. Vol. II, pg. 109. Boston, Marshall Jones Company, 1922.

output. The oversight proved to be a stain on Bert Mangham's record, which became one of the primary reasons for his eventual dismissal later in 1913.

Excepting 1,500 tons for its own use, the company delivered its product to ports in Russia and Norway. Longyear visited the location again this summer and brought with him a mining engineer named Scott Turner. Turner was the son of Longyear's cousin James Turner, and a 1904 graduate of the Michigan College of Mines. Longyear knew that Turner was entertaining multiple job opportunities within foreign mining activities. With an eye towards the future, he invited Turner to join him for a view of his Arctic endeavor. Earlier that year, Gibson had intimated to Longyear that he might have to resign due to family obligations in Pennsylvania. Although Longyear did not share this knowledge with Turner, he thought that there might be a chance that he could serve as a backup should Gibson choose to resign.⁴⁸

Despite the favorable condition of the mining system, the Arctic Coal Company reported low production that summer, blaming difficulties with the Scandinavian contingent of miners. Gibson stated that the trouble "was greatly owing to the fact that all miners in Norway were on strike all summer and our men had a strong feeling they should join them."⁴⁹ In addition to the labor dilemma, the company experienced problems with its haulage system on the bridge to the dock. Although these difficulties were eventually sorted out, the production loss proved significant to an organization limited by short shipping seasons.

That winter (1911/12) the company left a force of 90 persons on the island with instructions for Mangham to develop a combined working face of 700 yards. The related coal would then be exploited at the arrival of the first spring ship. Gibson estimated that the mine might produce 30,000 tons that winter if things went according to plan. The recent construction of a Norwegian radio facility at Green Harbor enabled the company to communicate with mainland Norway and vice versa. They had planned to secure a facility of their own but political posturing in Norway hampered the effort. The Green

⁴⁸ Longyear, John M. *Reminiscences by John Munro Longyear*. Marquette, J. M. Longyear Research Library, Longyear Collection, Box 26. 1912.

⁴⁹ Arctic Coal Company. *General Managers Report, November 24th, 1911*. Michigan Tech Archives, Longyear Collection, Box 2, Folder 3.

Harbor “wireless station” however, did offer an alternative and so the company enjoyed its first season of winter communications, albeit with necessary ski-trips between Advent Bay and Green Harbor. The construction of a radio tower at Advent Bay the following summer negated this inconvenience.

Gibson did ultimately submit his resignation near the close of the summer operations. Although he had planned on staying on board, a recent death in the family required his return to Pennsylvania. In a letter to the company he remarked, “I take the liberty to most respectfully suggest that in the selection of my successor more attention be paid to experience in the organization and handling of men, selling and shipping by steamer, rather than mining experience, as the actual mining on Spitzbergen is the simplest of all the branches of this business.”⁵⁰ In effect, Gibson’s advice recognized that the Spitsbergen business had grown much larger than a standard mining affair, and that those more intimate with coal mining could handle the production process. He thought that winter and summer superintendents could handle this type of work. What mattered more would be finding a General Manager who was comfortable with handling larger business systems. Longyear apparently took this advice as he offered the position to Scott Turner, a man with no practical coal mining experience but one who had previously administered a number of mining enterprises.

Phase III: Large-scale Operation (1912-1915)

The year 1912 marked a new phase of operations at the Advent Bay property now directed by Scott Turner. As an experienced hard-rock mining engineer, Turner was hired in the hopes that he could put the enterprise on a paying basis. Having gained control of a fully functional mining property, Turner sought to refine the system in an effort to increase its production and overall efficiency.

Upon arrival to Advent Bay, Turner experienced a number of difficulties that required immediate address. A winter fire at the mine entrance had consumed all of the wooden buildings and structures in that area including the smithy shop, eating-house and

⁵⁰ Gibson, John Jr. *Letter to the ACC, August 29th, 1911*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 94, Folder F.

surface plant. A small labor force had also stymied winter development. Turner noted that an average of 55 men worked in the mine over the course of winter and that their output averaged two tons per man per day, which he regarded as disappointing for a mine this size.⁵¹

Production was also hindered by an inadequate dynamite supply and a steep, local dip encountered at the south end of the mine. The dip, or “roll,” exhibited loose forms of rock between the top of the coal seam and the sandstone roof. This condition affected the depth of the coal seam. As the miners performed work in this area, more time had to be committed to the hand removal of the suspect rock. The thinning coal seam and related decrease in tunnel height made it almost impossible for tramcars to enter and assist with the work at hand. This factor, combined with steep tramming conditions, only frustrated the workers therefore contributing to their low production numbers. To make matters worse, inadequate power capabilities and mechanical haulage systems further affected the efficacy of the mining system.⁵²

Complications at the mine were further compounded by misuse of the aerial tramway, which rendered the apparatus idle. Turner blamed incompetent Norwegian mechanics for the dilemma and promptly ordered a complete overhaul of the system.⁵³ Disappointed with the overall condition of the property, the manager devoted most of that summer to bringing the mine back into working order. New coal faces had to be quickly developed in order to fill outstanding sales contracts. To combat problems with thinning coal on the south side, many of the mining cars needed to be cut down so that they could enter the smaller tunnels.⁵⁴ Outside the mine, crews erected concrete and steel buildings to replace those damaged by the fire. Crews enlarged the mine’s surface plant footprint to facilitate better movement and to accommodate the larger concrete constructions. By the close of the season, all surface facilities at the mine entrance were now fireproof and protected from falling rock.

⁵¹ Arctic Coal Company. *General Manager’s Report: Covering the Fiscal Year October 1st, 1911 to October 1st, 1912*. Michigan Tech Archives, Scott Turner Collection, Box Z, Folder Z-13.

⁵² Ibid.

⁵³ Turner, Scott. *Letter to the ACC, June 21, 1912*. Michigan Tech Archives, Scott Turner Collection, Box A, Folder 20.

⁵⁴ Ibid.

That summer, Turner initiated a large-scale geological survey of the Advent Bay property. The examination was “carried on to demonstrate the continuity and extent of the workable area of coal land.”⁵⁵ Although previous managers had conducted similar prospecting surveys in the past, respective records were short on detail with regard to the thickness and character of the coal seams. The information gathered during the 1912 survey provided Turner with data necessary for the proper management of the property. Additionally, the manager hired a cartographic surveyor from the United States Geological Survey (USGS) to produce a series of maps related to the company’s Advent Bay properties.⁵⁶

The operation experienced two labor strikes occurring in June and July. Both concerned the labor force’s desire for increased wages and contract rates. The first resulted in the removal of 75 men. The second was more serious since it lasted a few weeks, during which the Scandinavian workforce pelted the English contingent with stones.⁵⁷ The company sent home 20 individuals on a ship that otherwise would have gone south laden with coal. Turner used such incidences, and other problems previously mentioned, as justification for incorporating new methods of mining on the property. Turner stated, “The excessive amount of rock work, the low roof, the steep grades, and the unskilled labor seem to justify experiments with more mechanical devices underground.”⁵⁸ One of his proposals concerned the introduction of room-and-pillar mining. The method was widely applied in America and Turner felt that a Spitsbergen adaptation might alleviate some of the labor problems, in particular those related to contract work. In preparation for his experiment, Turner laid out a plan for room-and-pillar mining on the north side of the mine.

⁵⁵ MacGavin, Drummond. *Report covering Geological Field Work and Surface Exploration & Development during the Summer Season of 1912*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 12.

⁵⁶ Marshall, Robert M. *Letter to Scott Turner, December 18th, 1911*. Michigan Tech Archives, Scott Turner Collection, Box A, Folder 23. Marshall is then Chief Geographer for the United States Geological Survey (USGS). In this letter Marshall authorizes the company’s use of government surveyor Thomas H. Moncure.

⁵⁷ Turner, Scott. *Letter to the ACC, August 5th, 1912*. Michigan Tech Archives, Longyear Collection, Box 5, Folder 4.

⁵⁸ Turner, Scott. *Letter to the ACC, June 21, 1912*. Michigan Tech Archives, Longyear Collection, Box 5, Folder 4.

Before the close of the summer season, the mine received two 100-yard Blackett underground conveyors, which would be employed at the longwall faces that winter. For the next year's use, Turner requested the following: a man-car for the surface incline; a Sullivan Short-wall coal-cutting machine for driving headings and for use with the room-and-pillar plan; and another mechanical hoist to assist with steep grades at the south end of the mine. Within his annual report, Turner noted that the mine had produced 26,399 tons of coal between the winter and summer. He further calculated that the company had produced approximately 70,000 tons since 1906, 58,905 tons of which had been marketed.⁵⁹ For the coming winter the manager left over 200 people on the property under the charge of Bert Mangham. Turner issued instructions for continued development of the mine with hopes that 35-40,000 tons of coal might be produced by July.

Despite high expectations for development and production during the winter of 1912/1913, Scott Turner returned to the Advent Bay property in June to discover that the work had progressed only slightly. Disappointed he stated, "Our instructions of last fall were not carried out in the mine, with the result that development work, instead of going ahead vigorously, was practically ignored."⁶⁰ Adding to Turner's frustration, the winter manager had installed the two electric coal conveyors in places other than those ordered. As a result, both ran into the migrating fault line before a significant coal tonnage could be extracted. Since much prep work is necessary to put a conveyor into operation, Mangham only had one in use by the time the spring boat arrived. Consequently, Turner had to reprioritize the summer's work in order to catch up with lost mine development.

As the summer progressed, conditions at the tail end of the main entry failed to improve. Due to shifting priorities, the workforce only drifted 50' beyond the fault line. This effort proved disappointing, as the coal body could not be relocated. Additionally, the fault gradually progressed southeast through the southern coal body, thus limiting the available coal in this region. Recognizing this emerging dilemma, Turner shifted focus to

⁵⁹ Arctic Coal Company. *General Manager's Report: Covering the Fiscal Year October 1st, 1911 to October 1st, 1912*. Michigan Tech Archives, Scott Turner Collection, Box Z, Folder Z-13.

⁶⁰ Arctic Coal Company. *General Manager's Report Covering Operations During the Year October 1st, 1912 to August 31st, 1913*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 13.

the north side of the mine, which until this point remained largely undeveloped. The conveyors were moved to this side where they would remain in place for the next few years. In making room for the labor-saving devices, mine managers had to section off a portion of the mine originally slated for room-and-pillar mining. They saw this as necessary since the fault line had rendered their south-side use ineffective.

That summer Turner initiated the room-and-pillar design and made note of its many benefits within the mine (Figure 3.05). The method was viewed as an alternative to longwalling, which had experienced a series of haulage problems on the south side of the mine. Except for the main-and-tail hoist at the top of the main entry, the mine had no additional mechanical haulage to assist any of its side gates. Turner stated, “As the faces of all gates to the south are now over 600’ from this rope, with the grade against the loads, no speed can be made in getting coal to the rope.”⁶¹ One of the benefits of the room-and-pillar design was its independence from mechanical haulage. Mine managers situated the room and-pillar entry on the north side in such a way that it ran at level across the top of the descending grade. This permitted the use of hand and horse tramming without any need for hoist assistance.

Despite the advantages offered by the room-and-pillar design, the company realized that the production of the mine would be limited by an inadequate power supply. Turner expressed that “There has never been power enough to cut and haul coal both at the same time, nor is there power enough to drive all the cutting and boring machines when the hoist is not running.”⁶² As a result, each shift was limited to either cutting or hauling since simultaneous operation could not be achieved. What the mine needed was more power; however, the existing power plant had problems of its own and therefore could not deliver its rated capacity. Turner reasoned that the mine’s haulage system would remain inadequate until the power plant experienced a legitimate upgrade. Until the latter occurred, the mine’s production would remain constrained by a limited mechanical advantage.

⁶¹ Ibid.

⁶² Ibid.

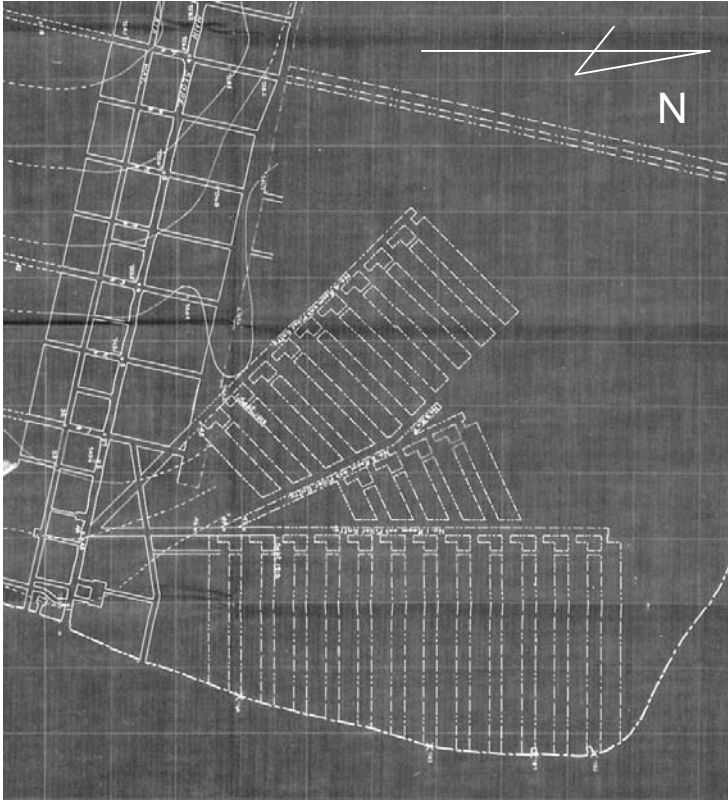


Figure 3.05: Section of a 1913 map of ACC Mine No. 1. Image presents development of new room-and-pillar system. Courtesy of Michigan Tech Archives, Longyear Collection, Box 4, Folder 13.

Regional exploration activities continued that summer, some of which produced unfavorable results. To the south of Mine No. 1, “Parting of rock were found in the coal at all new points...which indicates that the workings to the south of the main slope are soon to be out of the areas of clean coal which has been found thus far.”⁶³ The managers observed similar results to the west towards Flower Valley (Blomsterdalen). This was the same location where the Trondhjem-Spitsbergen Kulkompagni had originally situated and where the Arctic Coal Company had planned to drive a new entry southeast to connect with their primary workings. The only promising coal was found on the east side of Longyear Valley directly opposite Mine No. 1. This is where the company started a second operation known as Mine No. 2. Turner initiated the small-scale endeavor as a backup should the first mine “fill out” or encounter some form of catastrophe.

Summer improvements at the mine’s surface included a new concrete and steel dining room and kitchen. The incline tramway saw a number of modifications and

⁶³ Ibid.

repairs, as did the coal hopper. Within the mine, crews enlarged the underground stable to accommodate six horses. The Sullivan short-wall chain machine ordered the previous year was employed that summer for driving tunnels and cutting coal faces in the rooms. Although the mine enjoyed natural ventilation, the operation ran a small electric fan for a short time each day to assist with the air currents.

By the end of the summer, Turner calculated that the total production for the year amounted to 35,842 tons of coal.⁶⁴ The total failed to meet his expectations made the previous year, which he attributed to the energy diverted to that summer's development of the mine. For the winter of 1913/1914, approximately 240 people remained on the island to continue with the development of the mine. However, this time Turner left his instructions with the new winter superintendent, Frank A. Dalburg. Dalburg, a 1906 graduate of the mining school at Pennsylvania State College, was engaged that summer after having been recommended to Longyear by his former classmate Kenneth Gilson. Dalburg came on to replace Bert Mangham, with whom Turner had grown exceedingly frustrated. Mangham had left on vacation earlier that summer unbeknownst of Turner's intention to replace him. Although he desired to return for another winter season, Turner refused to renew Mangham's contract.

Having rid himself of Mangham, Turner grew more optimistic towards the future of the enterprise. A newly installed boiler provided additional power and served as an improvement over one that had never worked properly. In respect to the winter development work, Turner ordered the driving of new headings, which would make available more coal. If their work went unhampered, there stood a chance that the winter's development might exceed that done in the past four years. Assuming that the necessary upgrades to the mine and power plant occurred the following summer, Turner believed that the mine might be capable of producing 60,000 tons of coal per year.

The winter of 1913/1914 turned out to be more productive than those previous. Much of this can be attributed to a workforce of 225, the largest ever assembled this time of year. The mine produced a total of 30,699 tons of coal by the end of May, which

⁶⁴ Ibid.

amounted to slightly less than the total for all of 1913.⁶⁵ Development work continued into the summer season with focus on the coal bodies found north of the main entry. With a summer crew of approximately 400 individuals, the year proved to be the busiest in the history of the company. Turner noted that “More men were employed, more coal was mined, shipped, and marketed, and more development work was planned and carried out than in any other period of equal length.”⁶⁶

Continued application of and experimentation with the room-and-pillar method proved, at least in Turner’s view, that the technique was the most efficient and cost-effective means of coal production on the property. He stated, “It seems probable that better results and lower costs would have been had throughout your [the company’s] operations on Spitsbergen if room-and-pillar had been adopted from the first, instead of longwall.”⁶⁷ As the development of the mine progressed into the summer, the position of the fault failed to improve. Miners drove approximately 200’ beyond the fault line at the back end of the main entry in the hopes of relocating the fugitive seam. The effort proved futile. The same fault line continued to hamper work on the southern coal bodies, where it gradually penetrated from the western side of the mine. Additionally, the remaining coal in the southeast corner narrowed in thickness, making extraction difficult.

Although the northern coal bodies were generally more promising than those found south of the main entry, development work in the northwest section offered disappointing results. In a side gate, which was 200-300’ to the east of the fault line, the coal had pinched down to two feet in thickness. This finding, compounded by the problems found south of the main entry, brought the viability of Mine No. 1 under question. Turner commented “the only direction in which good coal can be expected is to the north of the main slope and to the east of No. 14 North Gate, which ground is limited

⁶⁵ Arctic Coal Company. *General Manager’s Report Covering Operations During the Fiscal Year, September 1st, 1913 to May 31st, 1914*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15.

⁶⁶ Turner, Scott. *Letter to the ACC, October 1, 1914*. Michigan Tech Archives, Longyear Collection, Box 5, Folder 8.

⁶⁷ Arctic Coal Company. *General Manager’s Report Covering Operations During the Fiscal Year, September 1st, 1913 to May 31st, 1914*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15.

in extent by the outcrop, being nowhere more than 1000' in its North-South dimension."⁶⁸

In total, the company mined 30,699 tons between September 1913 and May 1914. This amounted to the largest production ever accomplished by the company since operations began in 1906. Despite their achievement, the company refrained from any celebratory tone. No matter how successful the mining proved to be, the enterprise continued to operate at a loss. Turner laboriously attempted to resolve this issue and took many measures to control the cost of mining. Only after gaining a few years experience in the endeavor did he finally come to understand the true nature of the problem. He noted his findings in the company's 1913-1914 annual report:⁶⁹

Therefore, due to the peculiar position occupied by Spitsbergen, and its geographical situation, costs other than straight mining costs are what go to swell the production cost to a prohibitive figure. Nowhere else in the world would coal mines show a general expense item of more than 10% of the production cost, generally it should be less than 5%. Here it is 37%. If this mine were better situated geographically so this general expense item could be cut to the normal, or, say 10% of the total, leaving the costs as they are, your operations might result in a small profit.

The general expenses that Turner speaks of are those tied to more administrative activities undertaken by the company. These expenses are associated with, among other things: offices in Boston, Tromsø, and Longyear City; transporting men from America and England; the hiring of men; the selling and shipping of coal; and various legal services related to doing foreign business.

In consequence, Turner ordered the cessation of construction and development at the property and sidelined any significant improvements to the power plant. No additional equipment or machinery would be ordered and all necessary expenditures would be cut to a minimum. All work thenceforth would concern the extraction of coal product. John Longyear fully supported these actions as he had become increasingly

⁶⁸ Arctic Coal Company. *General Manager's Report Covering Operations During the Fiscal Year, September 1st, 1913 to May 31st, 1914*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15.

⁶⁹ Ibid.

wary of the operation's mounting expenditures. The enterprise had become unwieldy for two men to support exclusively. In the summer of 1913 Longyear remarked:⁷⁰

All these matters are getting too big for two individuals, or at least for me, to handle and finance. I think we now have a development and a basis, which will justify us in forming a large company to take over this business. But that is a business I cannot do, not having had the necessary experience.

In addition to the company's general expenses, the outbreak of World War I in August of 1914 promised to have its own influence on business operations in Spitsbergen.

Although not immediate, the effects of the conflict would become more discouraging in the following year.

Having decided against continued development, Turner prepared for reduced activities on the island that winter. Winter superintendent Frank Dalburg would command roughly 127 individuals through the dark season. Their primary task would be the removal of all previously developed faces and coal bodies. In addition to the face mining, instructions were given for the removal of all pillars not vital to the mine's safety including those related to the main entry and airway. Such practice is known as "robbing" and was usually employed near the tail end of a mine's existence. At the conclusion of the annual report for 1913-1914, Turner remarked "From now on, efforts will be entirely directed toward mining this coal, at as low a cost and with as little extra work as possible, with no attempt to farther explore or develop Mine No. 1 or any other mine or the coal tract as a whole."⁷¹

If management had any questions about how the war might affect the operation, Scott Turner became the first to realize its dimension. On May 7th, 1915, while traveling from America to Europe aboard the British passenger liner *Lusitania*, Turner experienced history when a German submarine torpedoed the ship. Although he managed to survive

⁷⁰ Longyear, John M. *Letter to W.F. Bentinck-Smith, August 3rd, 1913*. Michigan Tech Archives, Longyear Collection, Box 5, Folder 6.

⁷¹ Arctic Coal Company. *General Manager's Report Covering Operations During the Fiscal Year, September 1st, 1913 to May 31st, 1914*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15.

the sinking, nearly 1,200 people perished in the disaster. Shortly thereafter he returned to Advent Bay to oversee the summer operations.

On arrival, Turner learned that the mine had produced 44,090 tons of coal since June of the previous year. This number was the largest amount produced over a twelve-month period, a company record. And this occurred in spite of a reduced workforce. Mine work continued as it had that winter, large production with little to no development. Approximately 200 individuals had been brought to extract as much coal as possible. All of this work took place in Mine No. 1; Mine No. 2 saw no activity whatsoever. The outfit was essentially gearing towards closure. Concerning the situation of the enterprise, Turner commented, “The whole position in Europe is so unsettled and problematical, that this factor alone would seem to be decisive in the matter of further large-scale operation on Spitsbergen.”⁷²

As the World War I conflict escalated, the Arctic Coal Company experienced many related difficulties. The outfit could no longer acquire explosives for use at the property and so were forced to make do with supplies on hand. Replacement parts for the English machinery and German tramway became impossible to acquire since both nations had engaged themselves in the war. The availability of transport ships dwindled, which hindered the company’s ability to offload its product. Many of the ship owners grew wary of northern travel or had were repositioned to more pressing national interests. Further complicating matters, the Norwegian government initiated a number of restrictions (often contradictory) on exports to Spitsbergen. As a result, the necessary foodstuffs and supplies for the Spitsbergen operations became exceedingly difficult to acquire. The same government began censoring telegraphic and postal communications to and from the island. At one point a German submarine confiscated a sack of company correspondence, which they then forwarded to Berlin for review.⁷³

⁷² Arctic Coal Company. *General Manager’s Report Covering Operations During the Fiscal Year June 1st, 1914 to May 31st, 1915*. Michigan Tech Archives, Scott Turner Collection, Box Z, Folder Z-03.

⁷³ Turner, Scott. *Letter to ACC, February 16, 1916*. Michigan Tech Archives, Scott Turner Collection, Box AA, Folder AA-03.

Despite the war's positive effect on coal prices, the Arctic Coal Company understood that their shipping and supply capabilities would likely degrade more than they already had. In the face of such imposing realities, and combined with continuing operational losses, the company decided to close the property at the end of the summer season. The mine would remain closed until business conditions improved or a purchaser could be located. Thus on September 23rd, 1915, the Arctic Coal Company ceased operations at all of its Spitsbergen properties (Figure 3.06). Turner left behind only three Norwegians that winter to keep watch over the Longyear Valley installations. He noted, "The mine has been closed and boarded up, after putting all machines and tools in order and in place; the mine is clean and in excellent condition, and operation could be resumed there at a day's notice."⁷⁴ After a decade of operations, the Arctic Coal Company had decided to exit the Spitsbergen coal theatre.

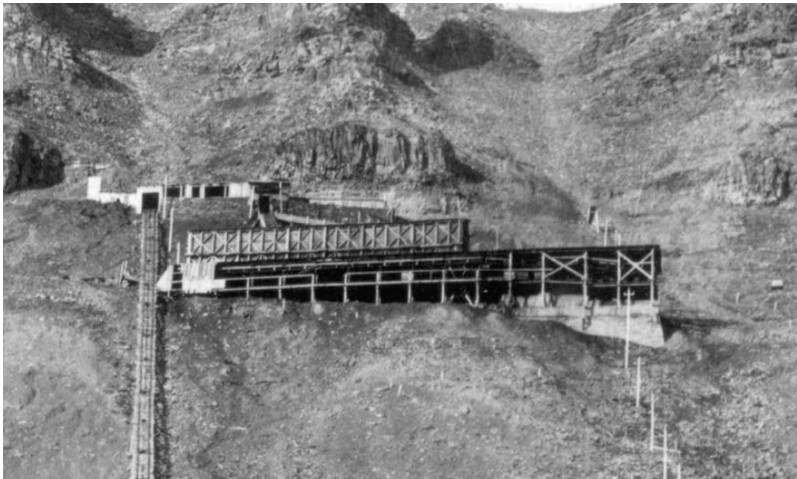


Figure 3.06: 1915 photograph of Mine No. 1. Image presents mine during last year of American ownership. Courtesy of Keweenaw Digital Archive: Image# MS018-005-01.

After all the investment, the interests of John Munro Longyear and Frederick Ayer accepted their defeat, realizing that a "small profit" would not likely be worth any additional expense. And most definitely not within the vicinity of an escalating European war. All told, the Arctic Coal Company produced over 217,000 tons of coal during its occupation of the Advent Bay properties. Although it was a financial failure, the Spitsbergen enterprise validated the opinion that a large-scale mining endeavor could

⁷⁴ Arctic Coal Company. *Annual Report Covering Year June 1, 1915 – October 31st, 1915*. Michigan Tech Archives, Scott Turner Collection, Box 26, Folder Z-02.

be possible within a remote arctic setting. The mining systems employed at the Advent Bay properties were tested and evaluated to a degree where a determination could be made as to their effectiveness. Such information would prove useful to subsequent mining efforts that took place on the Advent Bay property as well as to others that occurred elsewhere on the island.

Chapter 4:

Archaeological Investigations of Arctic Coal Company Mine No. 1

Michigan Technological University has performed two separate field examinations of Arctic Coal Company Mine No. 1. The first was conducted in August of 2004 as part of LASHIPA's inaugural field season.¹ That summer researchers from six nations united for an international field course in Arctic Industrial Heritage. During the ten-day course, researchers visited five separate mining areas including Old Longyear City, Advent City, Sassen Bay, Coles Bay, and Bruce City. Old Longyear City became an area of primary interest due to its convenient location in Longyear Valley (Longyeardalen) and a rich collection of documentary resources that could be used for comparison with the physical remains.

Surface features associated with the Arctic Coal Company (ACC) were divided into six separate sections, each related to a particular type of activity. The mine location became Area 5 (see Figure 4.01). The designation encompasses all Arctic Coal Company related mining features located on the northwestern slopes of Longyear Valley, above the remains of old Longyear City.

Due to the wide breadth and scope of the 2004 field school, Area 5 saw only limited levels of archaeological examination. These efforts focused mainly on the mapping of the more extensive features such as the standing coal hopper, mine surface plant and tramway tower foundations. Basic measurements were taken and a large detail map was produced with GPS data. More subtle features were not recorded.

The second examination of ACC Mine No. 1 took place during the summer of 2008 as part of the LASHIPA 5 research expedition. The effort was initiated to gather a more detailed understanding of the mine and its related features and technologies. Additionally, the MTU research team documented the physical remains of the Arctic Coal Company Powerhouse and performed field examinations in the Elveneset and Coles Bay areas.

¹ LASHIPA 1, Final Report. *Industrial Heritage in the Arctic: Research and Training in Svalbard, August 2004*. 2006.

Field Methods

Cameron Hartnell and the author performed the documentation of Arctic Coal Company Mine No.1 between July 27th and August 4th of 2008. University of Groningen students Wietske Aalders, Martha De Jong, Sara Dresscher, and Frigga Kruse provided additional support. Site documentation consisted of site mapping and photography. These efforts resulted in the location and close inspection of numerous structural and technological features including those related to the mine surface plant, coal hopper, and Bleichert aerial tramway. The team made a detailed hand drawn site plan using a compass and electronic distance finder. It also photographed many individual features and made scale drawings of several important ones. The team complemented these efforts with a digital map made using a Trimble GeoXT GPS receiver.

Documentation efforts were guided by photographic material and information gleaned from at least five separate archival collections. The most extensive collections are found at MTU's Copper Country Historical Collection, the J.M. Longyear Research Library and the Tromsø State Archive. Each collection contains a rich array of company-related documents including correspondence, maps and historic photographs. Such material proved extremely useful in the field for identifying ambiguous features and artifacts.

MTU / LASHIPA researchers assigned feature numbers to mine-related features in accordance with the Area 5 designation, consistent with the classification system designated in 2004. As mentioned previously, Area 5 is comprised of features directly related to the operation of Mine No. 1 including the mine surface plant, coal hopper, Bleichert aerial tramway, and other related surface elements.

After nearly one hundred years of disuse, the site complex has experienced various forms of disturbance. The most notable is that imposed by natural occurrences. Mountain slumping and erosion events have compromised portions of the mine surface plant and incline tramway. As a result, many related features have been either partially disturbed or completely obliterated. Other mine features have deteriorated through less intrusive events, associated with the influences of steep slopes and decay. The Bleichert aerial tramway terminal is collapsed to varying degrees. A large debris scatter found on

the slopes immediately beneath the structural footprint reflects a related course of events. The coal hopper is presently the last standing structure at the site complex. Years of harsh weather conditions have taken their toll on the feature. Much of the hopper's structure is sagging; various elements are leaning and therefore compounding the pressures placed on related components. Its future collapse is almost certain under these conditions.

Other features reflect disturbances due to human activities. The pit-mouth section of the mine surface plant is buried under mountain rubble and collapsed concrete. Its present condition looks more like a blast event than a natural phenomenon. Much of this condition is related to the 1920 explosion, which led to permanent closure of the mine. Historic photographs taken shortly after the explosion corroborate discoveries made at the pit-mouth during the 2008 survey.

Additional features have been affected by more subtle natural disturbances. All of the mine entries are now closed, attributable to gradual collapse and slope creep. Many of these features were barely recognizable, their locations identified by faint remnants of former structures. An isolated case of looting was noted during the course of the documentation effort. In 2003, University of Groningen and MTU researchers identified a horseshoe at the top of a waste-rock pile near the south end of Area 5. Despite a comprehensive documentation effort, the artifact could not be relocated in 2008.

In sum, the MTU / LASHIPA team produced a detailed documentation of Mine No. 1. Twelve separate features were identified within the Area 5 site complex. A variety of isolated artifacts were also noted. Individually, these items reflect a sense of use and abandonment, their locations providing evidence of purpose. Collectively, these features and artifacts convey broader concepts of arrangement within a larger mining system. The 2008 survey was successful in that it produced a more comprehensive understanding of the production system and related material remains associated with Mine No. 1.

Area 5: Overview

Area 5 as designated by MTU / LASHIPA is a site complex that encompasses all Arctic Coal Company related mining features located on the northwestern slopes of Longyear Valley (Longyeardalen), above the remains of old Longyear City. Area 5 is comprised of features directly related to the operation of Mine No. 1, and is best approached by ascending the old miner's trail located near the base of the mountain slope, southwest of the Longyearbyen church. Tram towers related to the Bleichert Aerial Tramway are accessed from the Upper Terminal (Fea.5.02) beneath Mine No. 1. The Tower 1 foundation is located immediately north of the Upper Terminal remains. Access the other tower foundations is accomplished by continuing north/northeast down towards the Store Norske Changehouse.

Area 5 includes eleven distinct features and a number of isolated finds (See Figure 4.01). Each feature has been assigned a unique number particular to the Area 5 site complex. These features are described separately in subsequent sections. Features F5.03, F5.06, F5.07, and F5.08 are all components of the Mine Surface Plant (Fea.5.01). See Surface Plant description for details related to these features. The isolated finds are comprised of varied artifacts, which are described in the following text.

Isolated Finds

Bleichert Tramway Debris Field

The debris field is scattered on the slopes beneath the Upper Terminal (Fea.5.02). This debris is comprised of numerous iron and timber artifacts associated with the tramway system and superstructure. Iron features include tramway track sections, suspension hangers, a tram bucket coupling/decoupling device, brackets, a brake band, tramcar axle, narrow-gauge rails, a brake band, and other unidentified hardware.

The tramway track sections located during the survey were once elevated sections of rail that guided tram buckets through the Upper Terminal (Figure 4.04). The sections hung from curved iron suspension hangers, which in turn were mounted to heavy timberwork. The sections were linked together with bolted tabs. Each section featured a rounded edge on both top and bottom, or "double-head." The top edge interfaced with

tram bucket hanger assemblies, the bottom one used potentially as a backup should the first become worn.

At least five suspension hangers were located within the debris field (Figure 4.05). The hangers feature a 'C-shaped curve and were used as an interface between Upper Terminal timberwork and the elevated track sections. The curved form permitted the tram bucket coupling assembly to roll by unimpeded. Each hanger featured embossing that read "A.B. 17122 – 350," "A.B. 17182 – 350," or "A.B. 26131." The reason for variation is unknown: "A.B." presumably stands for Adolph Bleichert.

The tram bucket coupling/decoupling device located within the debris field appears to be a specific section of the terminal's suspended track system (Figure 4.06). It consists of an extended track section with an attached bracket and wheel assembly; there are three wheels within the assembly. This artifact is likely associated with either the coupling or decoupling apparatus that diverted tram buckets from the traction rope and onto the suspended track system (or vice-versa). The attached wheel assembly potentially interfaced with the revolving traction rope. The wheels may have channeled the rope from tangling and/or rubbing. It is not known if the wheel assembly rested above or below the related track section.

An iron and wood band brake was observed near the base of the debris field (Figure 4.07). The brake measures 124cm wide (not a true dimension as the band is open ended) and 10cm tall. The interior side of the brake features 17 hardwood blocks, which exhibit wear on their outside surfaces. A number of blocks are missing. The tag ends of the brake are closed, which would allow for attachment to a manipulator device. The dimensions associated with the band brake are commensurate with those found on the Drive Sheave at the Upper Terminal feature.

Separate from those artifacts already discussed, the tramway debris field contains many additional features presumably associated with the Upper Terminal construction. Timberwork is strewn across the field, from top to bottom. Some of these timbers exhibit ironwork such as bolts and metal plating. Other types of ironwork are found on the hillside (Figure 4.09). One tramcar axle was identified, with a small wheel at one end. A number of unidentifiable iron pieces were also noted.

Utility Poles

Two utility pole bases were located on the hillside within the Tramway Debris Field. Each appears to have been cut down, possibly for salvage. These poles are likely related to three similar bases located at the base of the hill. All would have been associated with the mine's power system, which was installed at Longyear City and at the mine in 1910. The mine's telephone system may have rested on the same line.

Concrete Section

A large body of concrete was located within the small drainage found along the incline tramway corridor and west of the Tramway Debris Field (Figure 4.08). The section appears to be a component of the Mine Surface Plant (Fea.5.01). It resembles the intact concrete section found at the south end of the Mine Pad (on which the Eating-house rests). The section may have been part of the Hoist House Entry (Fea.5.07).

Tramcar

A wooden tramcar was observed near the base of the mountain and approximately 60m east of the incline tramway cable (Figure 4.11). It rests upside down and has no axles or wheels. A blazed maker's mark reads "1908 – Sheffield." The Arctic Coal Company ordered much of their mine equipment from Sheffield-based supply houses.

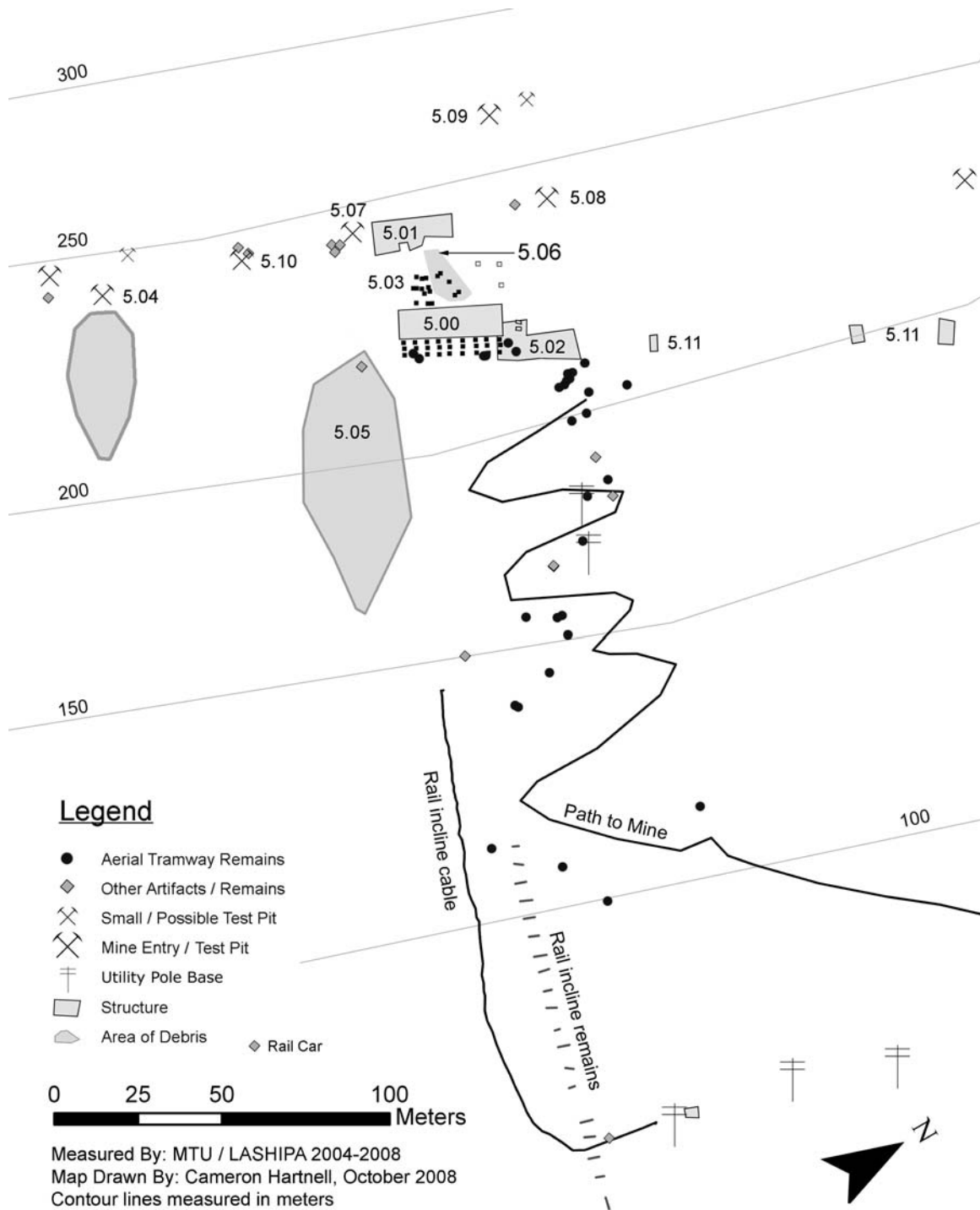


Figure 4.01: Overview Arctic Coal Company (ACC) Mine No. 1 Site Complex (Area 5 – ACC in Advent Bay)



Figure 4.02:
Overview of Area
5. 2004
photograph by
Larry
Mishkar/MTU.



Figure 4.03:
Cropped overview
of Mine No. 1.
2004 photograph
by Larry
Mishkar/MTU.



Figure 4.04: Track section with attached suspension hanger. 2008 photograph by Cameron Hartnell/MTU.



Figure 4.05: Suspension Hanger. Reads "A.B. 17122 - 350." 2008 photograph by Cameron Hartnell/MTU.



Figure 4.06: Track section with coupling/decoupling assembly. 2008 photograph by Cameron Hartnell/MTU.



Figure 4.07: Iron band brake with hardwood brake pads. 2008 photograph by Cameron Hartnell/MTU.



Figure 4.08: Concrete wall section. Once located at Mine Surface Plant. 2008 photograph by Cameron Hartnell/MTU.



Figure 4.09: Non-diagnostic artifacts within tramway debris field. 2008 photograph by Cameron Hartnell/MTU.



Figure 4.10:
Timberwork associated
with aerial tramway
terminal. 2008
photograph by Seth
DePasqual/MTU.



Figure 4.11: Wooden
tramcar. Blazed maker's
mark reads "1908 –
Sheffield." 2008
photograph by Seth
DePasqual/MTU.

Chapter 5: Area 5, Individual Features

The following is a description of features identified and recorded within Area 5. The order of features follows a sequence first designated during the 2004 MTU/LASHIPA field school. The 2008 survey of Mine No. 1 expanded this research effort by recording features not previously identified and by gathering additional data on features that had not been fully recorded.

Fea.5.00 – Coal Hopper

The Coal Hopper is part of the Arctic Coal Company (ACC) Mine No. 1 site complex, which is located on the western slopes of Longyeardalen, near the north end of the valley. The site aspect is SW. The hopper is approached today by following the old miner's trail from the bottom of the valley up to the feature.

The storage hopper rests on a relatively level footprint measuring approximately 7m x 30m, the length running parallel to mountain contours. The structural footprint may not have been absolutely level, since the interior floor surface is similar to exterior slope angles, and is completely covered with slumping coal. The hopper is framed of thick timbers joined with a network of tie rods, timber brackets, and spikes (See Figures 5.01 – 5.03). Most of the framework is “open” and devoid of cross-planks, which once covered and/or lined the entire structure to contain the coal. The hopper rests on a concrete foundation, part of which is exposed on the north half of the eastern face. A timber sill is the interface between foundation and framework.

The hopper is approximately 11m tall and features three levels of framework. The bottom level is comprised of vertical timbers backed with horizontal planking. Although much of the bottom level is intact, the mid-section exhibits a heightened level of dilapidation; many horizontal planks are missing and some of the vertical beams have detached from host timberwork. Ten framed openings are equally spaced at the base of the bottom level. These openings are coal-chute portals, which once conveyed coal from the hopper down into empty aerial tramway cars. A few of these portals still have coal pouring through them. Although the portals once featured coal chutes and related apparatus, no evidence of the chutes remains today.

The middle and upper levels of the hopper are more open than the bottom. These levels are comprised of vertical beams and diagonal cross-timbers. Although much of this upper framework is still present, some of the beams and timbers have detached and fallen over the years. All horizontal planks are missing from the upper two levels of the hopper's east side, while planking is still present on these same levels on the north and south sides.

Lengthwise, the hopper assembly has six distinct sections, evident by the placement of wooden tie-rod brackets and horizontal cross beams joining the east and west walls. These sections may be individual coal bins. A system of coal chutes was originally used to fill each section from above and behind the west wall.

The west wall lies against the mountainside and is smaller in height than the other three sides. This wall is severely dilapidated; only small portions of the wall currently survive (Figures 5.05 and 5.08). This wall is composed mainly of vertical beams that are connected to the hopper core via crossbeams that run east and west. These crossbeams are part of a timber frame similar to that found at the north and south walls, only without any horizontal planking. These interior timbers form the internal framework of the hopper and are in line with the six individual sections mentioned previously.

The north and south sides of the coal hopper are in various stages of decline. The south wall is partially obscured by natural slumping debris (Figures 5.04 and 5.05). The origin of this debris is related to an adjacent gully, which runs from above the mine down to the valley below. This earthen slump has wiped out the mine's return airway as well as many other features associated with the incline tramway. In consequence, the entire bottom level of the coal hopper is buried on the south side. Additionally, the slump debris is creating pressure, which is causing the immediate southeast corner to collapse or to blow outward. The upper levels of the south wall contain sections of horizontal planking behind the vertical beams.

The north wall tells a different story. Portions of all three levels are visible (Figure 5.06). The bottom and middle levels both include sections of horizontal planking. The upper section is relatively more dilapidated and has no remaining horizontal planking. Two vertical beams are missing at the west side and most of the

diagonal cross sections have detached and fallen. In consequence, the upper crossbeam is now hanging freely at its western end.

The bottom level of the north wall is more interesting. Although only three sections (or panels) are visible, two of these panels have features not found elsewhere on the hopper. The first, most eastern panel has a small cutout in the horizontal planking (Figure 5.09). Additional horizontal planking has since been added to block this cutout. It appears that this feature once acted as a side access to the coal supply. The cutout is crude in form unlike the formal coal ports found at the base of the eastern wall. It is likely related to the overall function of the work area which once bordered the hopper's wall. Although the cutout may have once accessed the coal supply, it is not clear how this coal was use, nor how the wall feature interfaced with the heavy tonnage of coal that would have been present in this part of the hopper.

The third, or westernmost, visible section of the north wall features what appears to be a tool rack (Figure 5.09). The horizontal planking is covered with black tar paper. Three wooden strips have been nailed to the tarpaper; two are vertical and one is horizontal above the former. Each of these strips is slotted, which gives the impression that tools were hung upon them, although no tools were found in the area. Additionally, a small, handcrafted wooden hook is located at the top-left corner of the section. No tools were found in the area. This feature, and the previous cutout, is likely related to machinery that was once housed in the level area immediately north of the hopper's north wall. Large concrete machinery mounts found here suggest that at least one heavy piece of equipment occupied the area, probably a hydraulic governor, which functioned as an automatic braking device for the Bleichert aerial tramway. The governor was part of the original purchase in 1907.¹ The tool panel was likely used as storage facility for tools related to the maintenance of the tramway and braking governor.

¹ Adolf Bleichert & Co. *Invoice for Messrs. The Arctic Coal Company, May 31, 1907.* Statarkivet i Tromsø, Box 91, Folder 1903-1907: Bi-By.

ACC Mine #1
 Upper Aerial Tramway Terminal (F5.02)
 and Coal Hopper (F5.00)
 Plan View - August 2008
 Measured by MTU/LASHIPA 2004 & 2008
 Drawing by Seth DePasqual

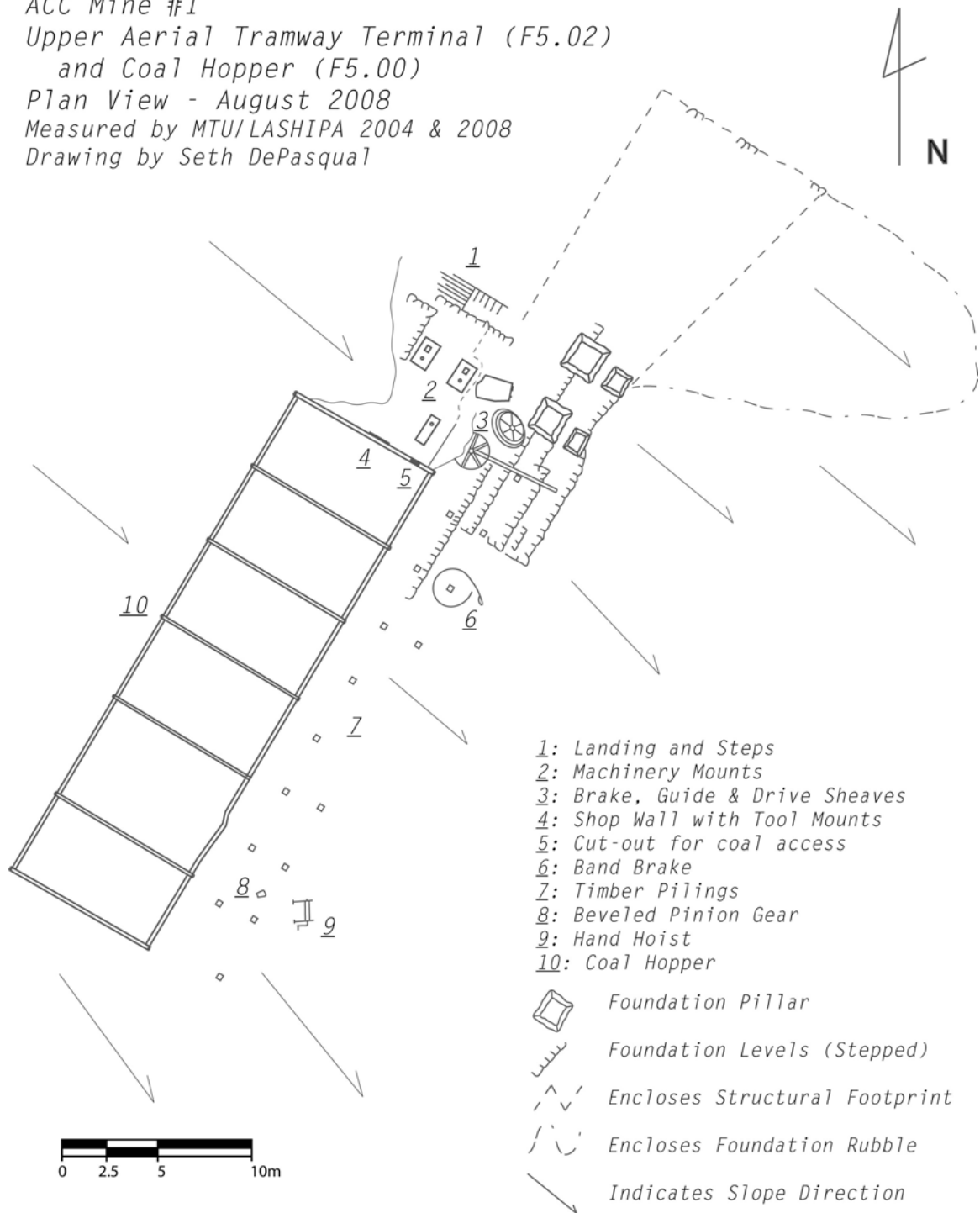


Figure 5.01: Plan View of Coal Hopper and Tramway Terminal.

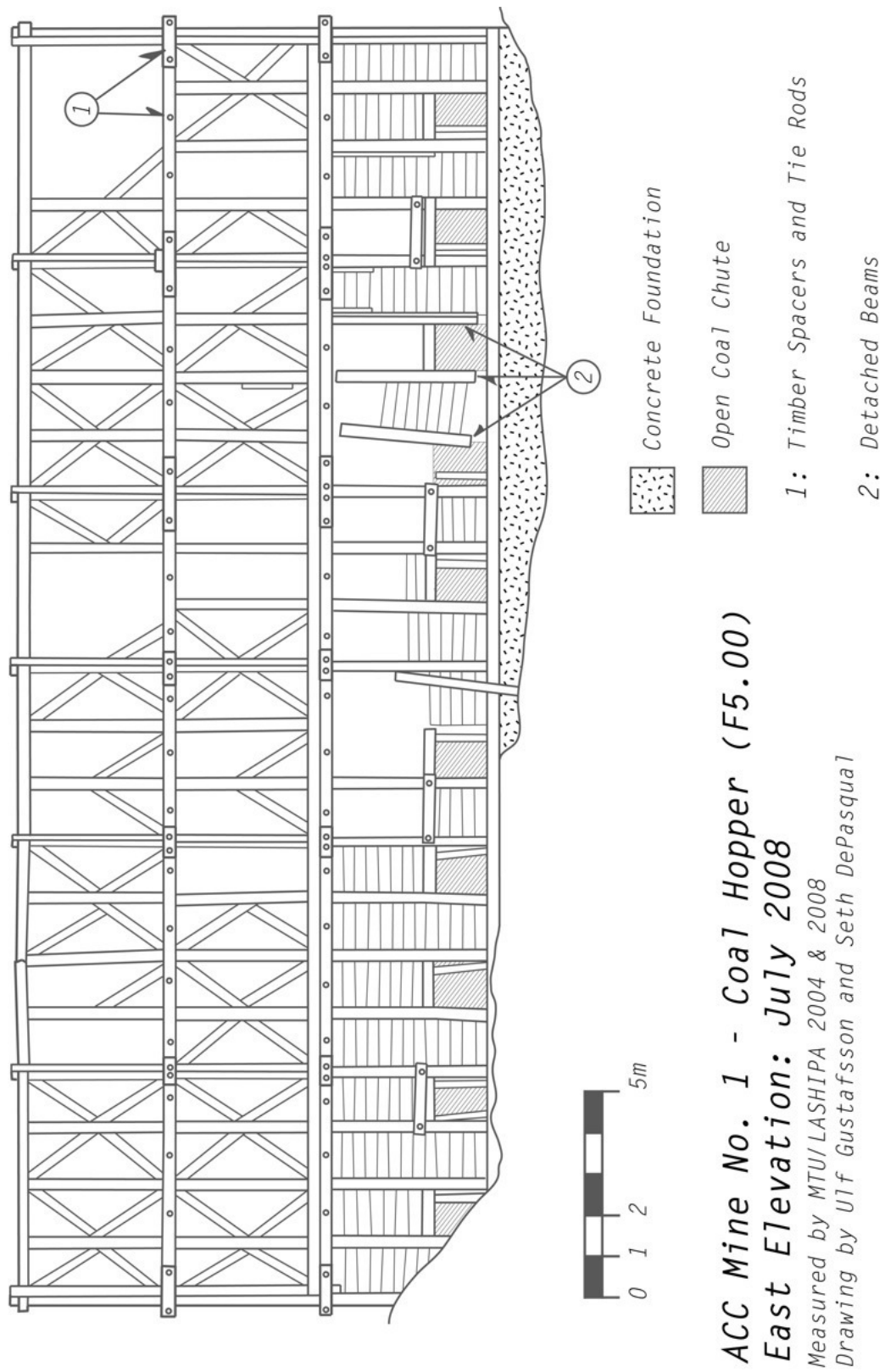
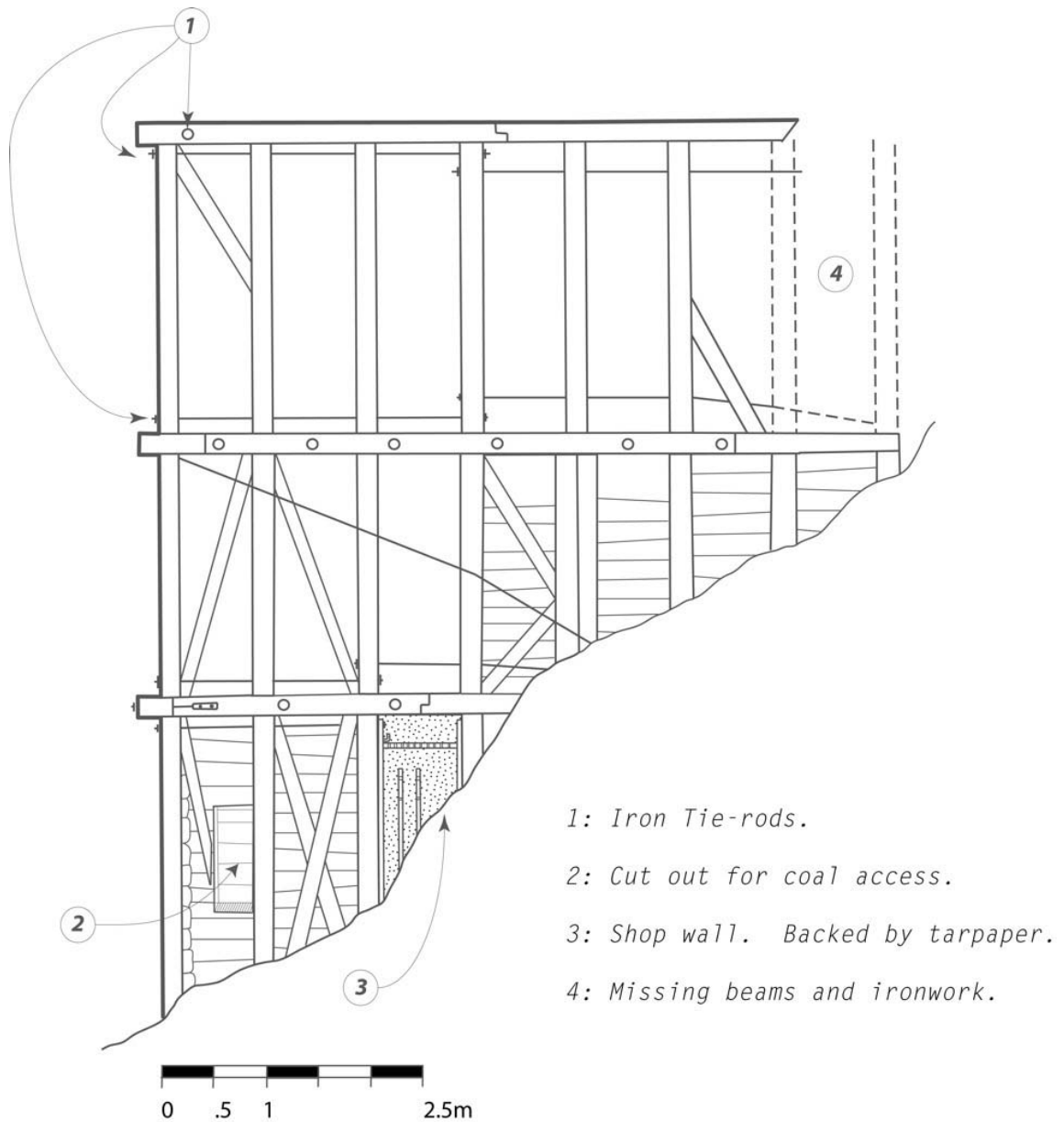


Figure 5.02: Coal Hopper, East Elevation.



ACC MINE #1 - Coal Hopper (F5.00)
North Elevation: July 2008

Measured by MTU/LASHIPA 2004 & 2008

Drawing by Ulf Gustaffson and Seth DePasqual

Figure 5.03: Coal Hopper, North Elevation.



Figure 5.04: Coal hopper's south elevation in 2004. Remains of tramway terminal are visible at bottom right. Photograph by Larry Mishkar/MTU.



Figure 5.05: Coal hopper's south elevation and top end in 2003. Coal chute remains are visible at top-left. Photograph by Patrick Martin/MTU.



Figure 5.06: Coal hopper's north elevation in 2004. A concrete machinery mount is visible to the left of the hopper. Photograph by Larry Mishkar/MTU.



Figure 5.07: Hopper's east elevation. Square coal portals are visible along base of bottom section. 2004 photograph by Larry Mishkar/MTU.



Figure 5.08: Overview of hopper from above. 2004 photograph by Larry Mishkar/MTU.



Figure 5.09: Detail of hopper's north elevation. Note cutout coal access at left and tarpaper section at bottom right. Slotted wooden strips are mounted to the tarpaper. 2008 photograph by Seth DePasqual/MTU.

Mine Surface Plant

The term ‘Surface Plant’ is used to describe a group of features located at the level of the mine’s main entry or “pit mouth” (See Figures 5.10 and 5.11). This grouping is comprised of structural elements and artifacts including the pit mouth (Fea.5.01), coal chute remains (Fea.5.03), the refuse dump for mine buildings (Fea.5.06), the hoist house remains (Fea.5.07), and the remains of the employee’s entrance (Fea.5.08). These features are discussed in detail below. The surface plant is approached by following an old miner’s trail from the bottom of the valley up to the feature. Features associated with the pit mouth are found directly above the standing Coal Hopper (Fea.5.00).

Fea.5.01: Pit Mouth / Main Entry

(Including the mine entrance and related outbuildings)

The Pit Mouth is located on the leveled surface above the Coal Hopper (Fea.5.00) and directly beneath a vertical sandstone outcrop (Figure 5.12). The surface is bounded on the east side by a tall retaining wall comprised of both ashlar stone (north of coal chute) and concrete (south of coal chute). The wall was constructed to bring the mine entry area to level. The face of the retaining wall is broken by a large gap that once held the mine’s primary coal chute. This gap runs in line with the main entry (now covered with rubble) and coal chute remains found beneath the retaining wall. The retaining wall is approximately 3m high at its tallest point (south). Portions of the north section have collapsed due to erosion and the weight of the remains of the concrete eating-house. The south end of the retaining wall drops sharply into a steep drainage feature (Figure 5.17). This drainage once held the incline tramway, which ran from the mine level down to the valley floor. The north end of the retaining wall’s reduced height and then blends into the mountainside just north of the eating-house remains.

Eating-House

Most of the level surface that is present today was historically associated with the covered main entry and eating-house (See Figures 5.13, 5.21 and 5.24). The smaller section found directly south of the coal chute alignment was likely a portion of the

blacksmith shop. Much of the south end has fallen into the drainage taking with it structural elements associated with the blacksmith shop, hoist house and ventilation tunnel entryway. The remains of some of these elements are found on the lower mountainside. For example, a massive concrete wall segment is located roughly two-thirds of the way down the drainage. The segment mirrors the one presently standing at the south end of the pit mouth.

The eating-house remains occupy the northern half of the pit mouth platform. The feature is constructed of reinforced concrete and is composed of partially standing walls and iron roof supports. Using the standing wall section extremities as a guide, the discernable footprint of the eating-house measures approximately 12.5m N/S x 6.5m E/W. The western wall has the tallest remaining sections of concrete, where the eating-house butts up against the vertical sandstone outcrop. The southern end of the eating-house is largely obscured by natural rubble that has tumbled down from above. The feature's eastern wall has collapsed eastward and is now cantilevered over the edge of the retaining wall. The 2008 site drawing of the pit mouth suggests that the eating-house featured at least four individual rooms (Figure 5.11).

The most intact section of the eating-house is found at the northwest end of the pit mouth platform. A small room is partially enclosed with one half of the concrete roof overhead. The roof itself is curved and exhibits iron mesh reinforcement at broken areas. The room is approximately 2 meters square and is accessed by a doorway at its eastern end. This doorway is fitted with a wooden sill and a window opening is located on the room's north wall. Two tall storage boxes are located at its NW and SE corners, both partially covered with rubble. The remains of a larger room are immediately east of the NW room. Although most of its construction has crumbled, the room still retains some of its original features. The bottom portion of a window is located on the room's north wall and the remains of a doorway are visible on its south-interior wall leading to a larger room area to the south. The north wall has collapsed and fallen to the east.

The largest room is at the mid-section of the eating-house footprint. It measures approximately 6m square and is best defined by its north and west wall dimensions. A small concrete section that juts east from the west wall identifies the south-interior wall

for this room, with the SE corner still visible. Most of the eastern wall has collapsed towards the retaining wall. A large amount of concrete roof debris is lying on the floor of this room. A single iron roof beam rises vertically from this debris field.

A smaller room is located at the southern end of the eating-house, measuring approximately 2.5m N/S x 6m E/W. The south-exterior and west walls are largely obscured by encroaching rubble, but a portion of the SE corner is visible. A large gap on the eastern wall suggests a doorway location. A relatively open area is found immediately east of this doorway. The Refuse Pile (Fea.5.06) is beneath this area, which suggests that much of the refuse material originated from the doorway.

Coal Chute and Mine Entry

(Including Fea.5.03 and related pilings)

The coal chute is comprised of features found on top of and below the pit mouth platform. A large gap in the retaining wall was used to transfer coal from mine level down towards the coal hopper. This gap measures approximately 2.5m square and dips at a shallow angle from west to east. The remains of a steel-lined coal chute rest within the gap (Figures 5.14 and 5.15). The north and south edges of this transfer chute are bounded by milled lumber. The eastern extremity of the metal chute juts out from the face of the retaining wall. A single post rises from the ground and connects at the NE corner of the protruding end of the chute. Another piling was observed below the SE corner.

Fea.5.03 is located below the retaining wall and in line with the primary coal chute (Figure 5.15). The feature is comprised of a mass of timber and sheet metal that once formed an elevated coal chute. A collection of wooden support pilings is found immediately below the heap of coal chute material. The piling arrangement suggests that a secondary chute ran E/SE towards the southern end of the Coal Hopper (Fea.5.00). A separate cluster of pilings was identified to the north of the first. This arrangement runs from the chute gap on an easterly course towards the north end of the hopper. Taken together, it appears that the main coal chute at the retaining wall served each of the secondary coal chutes.

The Main Entry of the mine is located west of the coal chute gap. Although the formal entryway is now covered entirely with natural rubble, its location can be determined by the coal chute alignment. All of the coal produced at the mine between 1906 and 1920 exited through this portal. The coal was then carted to the gap in the retaining wall where it was tipped over and the contents poured onto the recessed coal chute. The coal poured down this primary chute and was transferred to one of at least two secondary chutes. These chutes conveyed the product into the head of the coal hopper.

South Pit Mouth Features

The partial remains of a concrete structure are present on the south side of the coal chute gap (See Figures 5.17, 5.20 and 5.22). This feature is comprised of the bottom section of a north wall and a small section of a western wall. The north wall is approximately 4.5m long and butts with the concrete retaining wall at the east end of the former. The retaining wall is taller than the north and west wall sections. It is not currently known if the concrete retaining wall is related to the concrete mine building. Of special note is a thick iron chain that is attached to the north end of a step in the concrete retaining wall. The purpose of this chain is presently unknown. Three reinforced concrete roof supports were identified within the concrete structure's interior. These supports are roughly in line on a N/S axis. The northernmost of these pilings is found within the structure's NW corner.

The structural features found south of the coal chute are presumed to be associated with the mine's blacksmith shop. The presence of the shop at the mine level is part of the historical record; however, no detailed historic maps of the mine exterior are known to exist. A more intrusive archaeological examination might possibly yield evidence related to the structure's purpose.

Pit Mouth Artifacts

A small number of artifacts were noted on the pit mouth platform. The first is a steel pit-tub (tramcar), which is located just beneath the retaining wall at the section that

has blown out (Figure 5.11). The tub measures 1.8m long x 1.05m wide x 60cm tall. It is comprised entirely of iron and steel and features a number of riveted brackets. A stout hitch is attached at one end on the tub. A small chain runs from the body of the tramcar to a small hitch pin. Two axles were observed at the base of the feature, one of which featured a cast-iron wheel. An unrelated pipe protrudes from the center of this wheel. No identification marks were located on the visible sections of the pit-tub.

A second, wooden pit-tub is located on top of the platform, near the edge of the retaining wall (Figure 5.16). The feature measures 1m long x 80cm wide x 90cm tall. The tub features riveted iron brackets and a sheet metal lining on the bottom. A single cast-iron wheel was noted at the base of the tub. The wheel features spiraling arms that radiate from the center of its hub. Two sides of the tub are missing. A maker's mark is located on the side of a structural beam on the bottom of the feature. The blazed marking reads "Hadfield – 5 – 1909." Hadfield's was an industry supply house based in Sheffield, England. The Arctic Coal Company contracted with the company for a variety of mining supplies including pit-tubs.

A machinery fragment is located adjacent to the tramcar on its western side (Figure 5.16). This feature is part of a cutter disc used on a Diamond coal-cutting machine. The disc protrudes vertically from the floor of the mine pad; its true size and dimension are unknown since a portion of the object is buried in the ground. The disc is approximately 3cm thick and features three thick tabs on its outside edge. The tabs once accommodated "cutter-boxes," which featured replaceable iron teeth. On a disc-cutter, the arced band of open slots interfaced with a spinning drive gear. In reverse order, a power source turns the drive gear, which then spins the horizontal disc cutter. The spinning cutter disc made an undercut near the base of the coalface.

Fea.5.06: Refuse Dump

The refuse dump for the Mine Surface Plant is located below the retaining wall and is draped over a broad area between the wall and the bluff edge above the coal hopper (See Figure 5.19). The dump is narrow at its top and wider at the bottom. This fanning effect is suggestive of the dump's origin, which appears to be the south end of

the eating-house footprint. A doorway opening at this section of the eating-house is in line with the top of the dump. In a likely scenario, mine employees would exit the doorway and toss refuse over the edge of the retaining wall.

The dump's contents are quite varied and suggest that multiple users contributed to the pile. A large degree of charcoal and ash composes most of what is readily visible on the surface. Such material could be associated with burned scrap wood and trash. This could also be related to a large burn event, which occurred during the winter of 1911/1912. A fire on the mine pad destroyed the smithy, eating-house and mine portal. These facilities were constructed of wood. The fire prompted the 1912 construction of concrete facilities, which were regarded as fireproof and more resistant to rockfall.

Many bits of coal clinker were also identified in the refuse pile. Such material indicates the presence of a smithy forge. The clinker may also be related to coal burning stoves, which might have been used to heat the facilities at mine level. Separately, researchers noted a variety of small iron artifacts. This material largely consisted of nuts and bolts of ranging sizes; a smaller degree was unidentifiable.

Numerous bottle fragments are scattered about the pile. Most of the glass was either brown or green, neither of which featured diagnostic embossing. Two food-related items were noted in the pile, one a metal key for a sardine can and the other a cut animal bone. The bone resembled a small pork rib, which may have come from one of the many pigs that the Arctic Coal Company imported from Norway. The items were likely discarded after a meal at the eating-house.

A separate artifact found in the refuse pile is of special note. This is a small brass tag that reads "23" in antiquated script. Similar tags, or "check tags," were used in other mines as identification markers for employees. Prior to entering the mine, a worker would place the tag on a special pegboard. The peg might indicate the section of the mine he was working in that day. The tag was used as a way to keep track of the miner should an adverse situation develop. If the miner did not retrieve his tag at the end of the day or soon after a particular event, management would recognize this and take necessary steps to locate him. The tag found on the refuse pile may have been used in a similar fashion.

Fea.5.07: Hoist House Entry

(Including elements of the Incline Tramway [Fea.3.23; a component of Area 3 site complex])

Researchers identified the remains of the hoist house entry on the south side of a drainage that borders the south end of the pit mouth platform (Figure 5.18). The entry is barely recognizable, since slumping drainage material has obscured most of its composition. The feature is comprised of two vertical timbers and a protruding narrow-gauge rail. One of these timbers is found at the north end of a faint cut. This cut runs south for approximately 2.5 meters and then banks to the east where it intercepts the second timber. The cut appears to outline a portion of the now caved hoist house entry.

Two additional timbers are located approximately three meters south of the hoist house entry. Although the purpose of the south timbers is unclear, they may be associated with the buried ventilation tunnel. Concrete fragments were observed immediately below the timbers. The fragments are possibly related to the construction of the hoist house entry. A small section of a stacked-rock foundation was observed directly beneath the entry feature. The foundation remains are part of the incline tramway's infrastructure. This feature is likely the uppermost footing of the elevated tramway system. Separate foundations are visible at the base of the mountainside. Natural slumping has obliterated all footings in-between the upper and lower extremities of the tramway.

The hoist house was a recessed room carved into the mountainside (Figure 5.20), which housed the mechanical hoist that served the Incline Tramway (Fea.3.23). The hoist was used to haul men and supplies up from the valley floor. Coal used for domestic purposes in Longyear City was delivered to town via incline tramway. The original incline tramway was not elevated and rested on a prepared ground surface. Due to snow issues and safety concerns, the company upgraded the tramway system so that it was elevated from the ground. The stacked-rock foundations supported related scaffolding.

Fea.5.08: Employee's Entry

This feature is located approximately 24m north of the pit-mouth platform's northeast corner. It is composed of a single vertical post, which is largely obscured by rock and earth. No other features were noted in the immediate vicinity. Historic photographs show that the entryway was a modest construction, comprised of timber siding and a sheet metal roof. The roof offered limited protection from rock and snow slides. The mine's electric lines were run through this entry.

Additional Features

Two rock footings and a ladder were noted in the vicinity of the mine surface plant. The footings are located N/NE of the Refuse Dump's northeast corner. The first rests approximately 6.5m north of the refuse dump and is comprised of local rock and mortar. Its eastern face measures 1.7m wide, while the north and south faces are partially obscured by earth and rock. The west face is not visible. This feature may be related to the early construction phase of a second coal hopper. The plan was dismissed in 1908 due to high construction expenses. The footing appears in historic photographs from 1908.

The second footing is approximately 12m N/NE of the refuse dump and is comprised of local rock and mortar. This footing differs from the first in size and character. The exposed face (east) measures 1.35m wide. The north and south faces are largely obscured by earth and rock. The western face is covered completely. A large iron rod with a round eye is anchored in the middle of the footing. This anchor rod may have supported a guy wire for use with the coal hopper structure.

An improvised ladder is located east of the refuse dump. It presently rests on the steep slope behind (west) the coal hopper. It resembles a telephone pole with mounted steps. A similar feature is presented within historic images of the mine (see Figure 5.23). In these photos, the ladder stands vertically within the area of the secondary coal chutes. The feature appears to serve as a utility pole, perhaps that related to the mine's communication system.

Additional Information:

A large collection of debris related to the surface plant is scattered on the slopes directly beneath the hoist house. This section of the mine complex has been largely obliterated by a significant erosion event. Surface plant features lost during the event, or series of events, include: the concrete building immediately south of the coal chute gap, the hoist house, and the ventilation entry. In relation to this event, and subsequent natural phenomena, many of the related mine elements are found on the lower slopes in various stages of disorder. Additionally, this same event has obliterated much of the features associated with the incline tramway. The entire mid-section of the tramway has been either covered with rubble or completely destroyed. Only those features found near the bottom of the hill remain intact.

It is important to note that the destruction exhibited at the north end of the mine pad is largely a product of the 1920 mine explosion. Historic photos from this period show smoldering ruins and collapsed concrete buildings including the eating-house and coal chute facility (Figures 5.23 and 5.24).

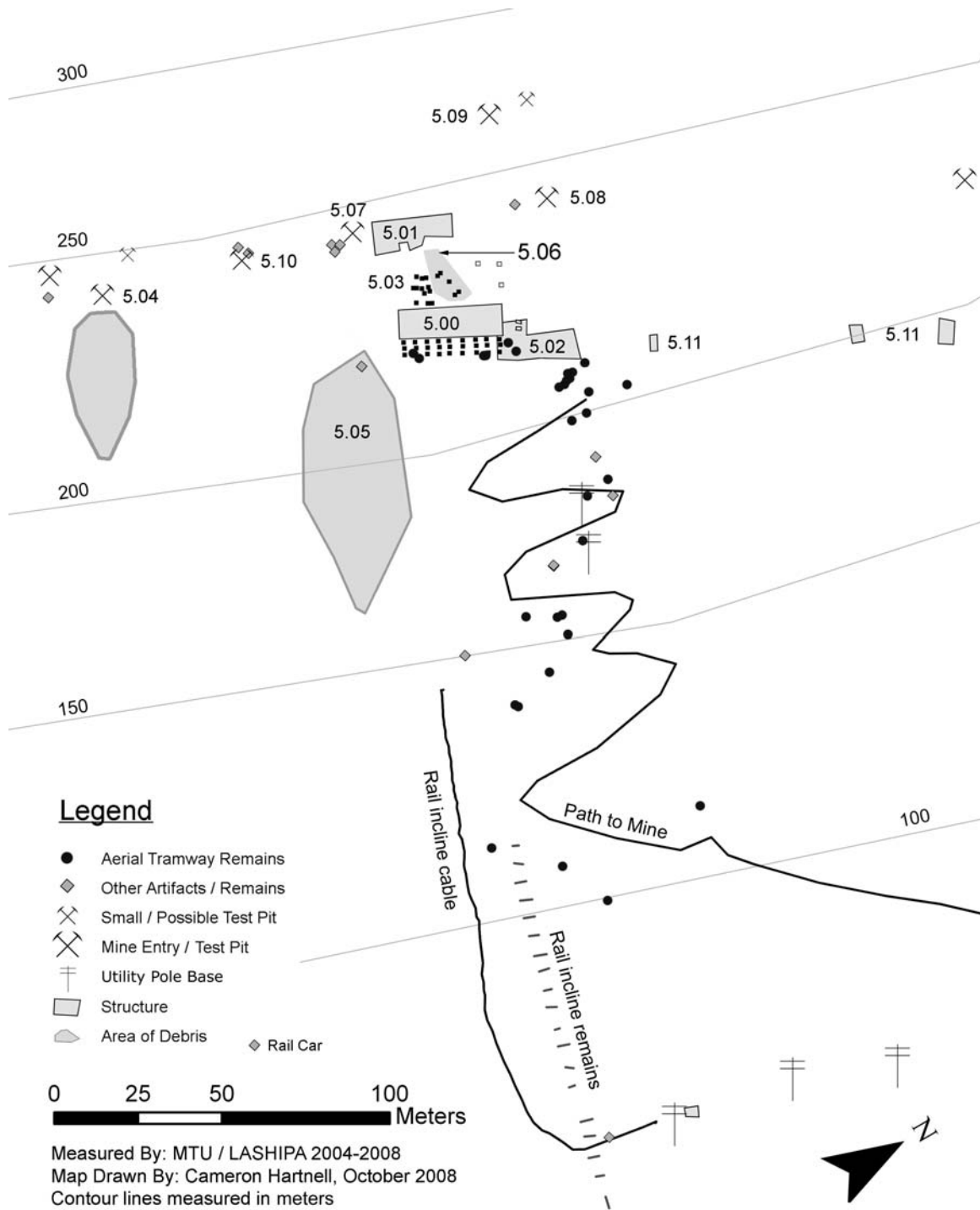


Figure 5.10: Plan view of ACC Mine No. 1 site complex. All features are labeled numerically.

Arctic Coal Company Mine #1
 Surface Plant Features - August 2008
 Measured by MTU/LASHIPA 2004 & 2008
 Drawing by Seth DePasqual

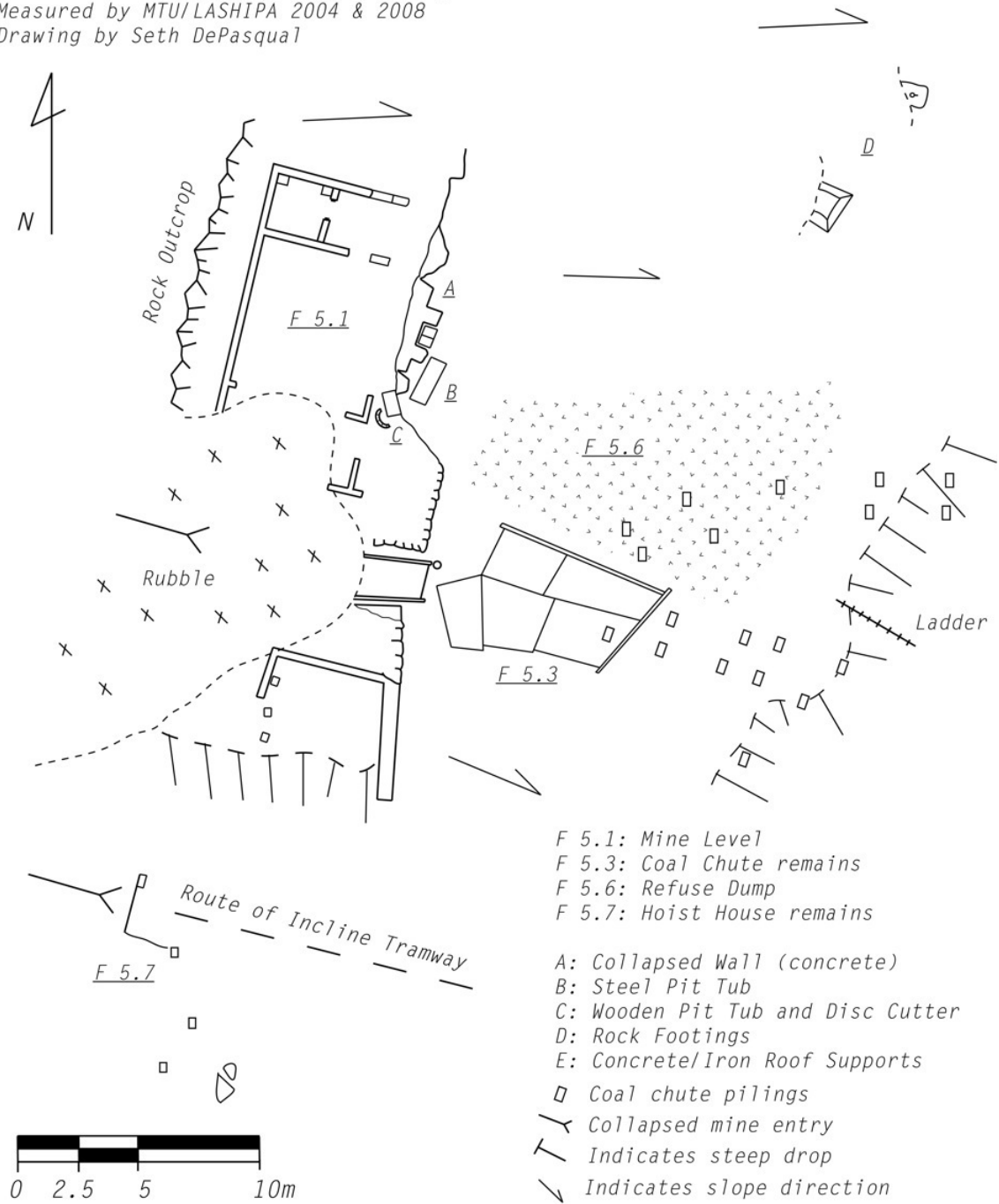


Figure 5.11: Plan view of Mine Surface Plant.

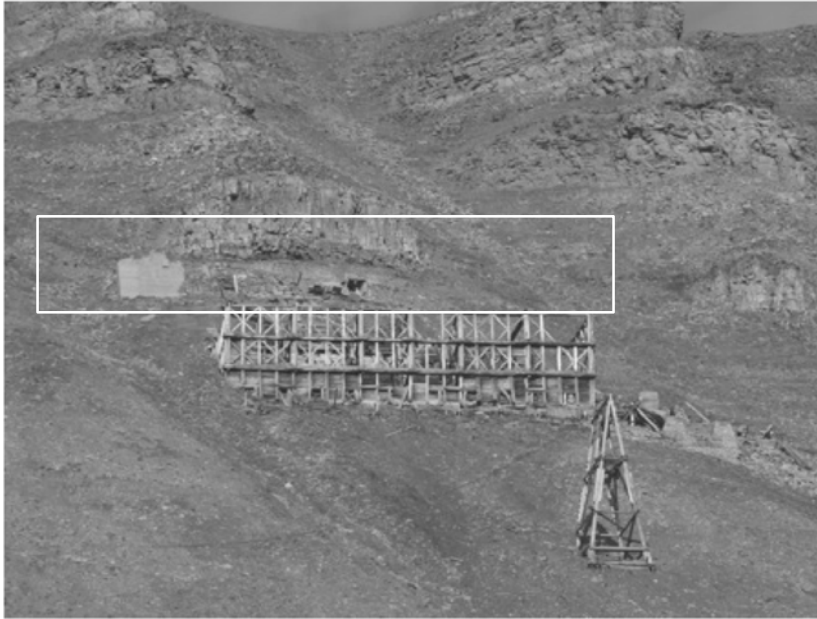


Figure 5.12:
Overview of Mine
No. 1 site complex.
Highlighted box
encloses the area of
the Mine Surface
Plant. Hoist House
is a far left,
Employee's Entry is
at far right. 2004
photograph by Larry
Mishkar/MTU.



Figure 5.13:
View of Eating
House remains. The
steel pit-tub is
visible at left-center.
2003 photograph by
Patrick
Martin/MTU.



Figure 5.14: Coal Chute gap when viewed from base of retaining wall. 2008 photograph by Seth DePasqual/MTU.



Figure 5.15: View of coal chute arrangement. Image taken from west end of coal chute gap. Compare with historic image depicted in Figure 5.23. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.16: 1909 Hadfield Tramcar. Disc cutter at top-left. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.17: South end of pit mouth platform. Image taken from Hoist House Entry. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.18: Cut associated with Hoist House Entry. Note narrow-gauge track at center-right. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.19: Refuse Dump beneath retaining wall. 2004 photograph by Larry Mishkar/MTU.



Figure 5.20: 1915 image of Mine 1 complex (cropped). Surface Plant visible at left-center. Keweenaw Digital Archives: Image# MS018-005-01.



Figure 5.21: Eating-house and coal chute housing (circa 1913). Keweenaw Digital Archive: Image# MS018-001-001.

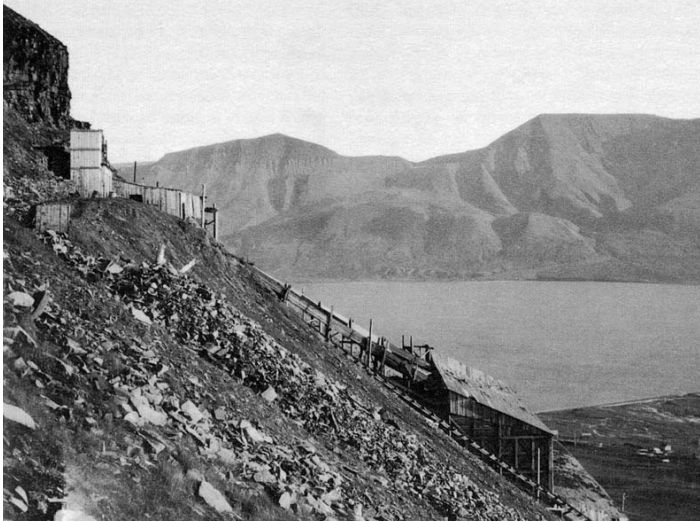


Figure 5.22: 1920 image of Surface Mine Plant and Coal Hopper. The tall building at top-left covers the ventilation tunnel. Photograph courtesy of Store Norske Spitsbergen Kulkompani (SNSK) Archives.



Figure 5.23: 1920 image of coal chute arrangement. The chutes lead into the storage hopper. Compare with Figure 5.15. Photograph courtesy of SNSK Archives.



Figure 5.24: 1920 image of Eating House taken shortly after mine explosion. Photograph courtesy of SNSK Archives.

Fea.5.02 – Upper Terminal, Bleichert Aerial Tramway

The Upper Terminal feature is comprised of many individual components related to the operation of the tramway system (See Figures 5.25 – 5.28). Attention will be given to the following areas: Foundation Work associated with the Receiving Platform; Loading Platform; Machinery Mount Platform; lower debris field. The Upper Terminal is approached today by following an old miner's trail from the bottom of the valley. The trail disappears near the east end of the terminal remains.

Receiving Platform and Foundation Work (Including Sheave Area)

Foundation

This section of the upper terminal is located below the northeast corner of the coal hopper and is comprised of foundation ruins, stepped levels of stacked rock, and a collection of cast iron sheaves (See Figures 5.29, 5.30 and 5.32). Although portions of the original foundation work remain intact, most of the northern section has collapsed onto the lower mountain grades. The foundation work is comprised of locally quarried rock and crude mortaring. Intact portions of the foundation are mostly level, although some slumping has occurred. Four rock pillars were observed within the main body of the terminal foundation. These pillars are roughly square with one another. The two uphill pillars are larger in size and height than the two lower pillars. Each pillar is level on its top surface. The location of the pillars is likely related to the placement of heavy equipment and machinery.

The foundation work disintegrates beyond the northernmost pillars. Despite severe dilapidation, the general outline of the foundation is still visible. Two small sections of intact foundation were noticed at the far northern end. Much of this foundation has collapsed downhill (east) from the terminal.

A section of intact timberwork juts out from the rubble immediately east of the brake sheave (Figure 5.32). This timber runs east from the sheave and then connects with a diagonal timber, which runs down at an angle back towards a vertical piling. This timberwork appears to be the last intact example of the terminal's timber structure. All other timbers have collapsed onto the slopes beneath the mine.

Sheaves

Three individual cast iron sheaves are located at the top of the foundation work (See Figures 5.26, 5.27 and 5.33). Two of the features, the drive and counter-rope sheaves, are piled atop of one another. The third is either a brake or belt sheave and is located just south of the first two.

The drive sheave once articulated with the traction rope, pinion gear and possibly a band brake (Figure 5.26). The sheave measures 224cm in diameter with a 20cm hub, and is 33cm tall. The sheave features four individual tiers. The upper side (historic orientation is presently unknown) exhibits 22.5cm teeth on its top surface. This surface likely interfaced with a pinion gear, which connected to the end of a separate drive shaft. A matching beveled pinion gear was located at the south end of the loading platform (Figure 5.35). The second and third tiers (mid-section of the sheave) feature cable channels on their lateral surfaces. These channels accommodated the tramway's traction rope. Although the sheave has two separate channels, only one cable would have been used for the Mine 1 application. The extra channel may have served as a backup or for use with an auxiliary cable or tensioning system. One of the channels is lined with a rubber compound, which exhibits wear marks from use. The second channel is bare and exhibits no signs of wear or use.

The drive sheave's fourth and final tier is located on the opposite side (presently the bottom side) of the sheave. Its lateral surface is smooth and resembles that found on the brake sheave described further below. This tier is 10cm tall and, if used as a braking surface, matches the dimensions of a band brake found in the debris field below the mine site complex (on the lower leg of the miner's trail). The drive sheave's hub features a small notch along its circumference, which likely articulated with a matching stem on a related drive shaft. This drive shaft was not located during the 2008 survey.

The counter-rope sheave was likely used to alter rope direction from horizontal to vertical (Figure 5.27). The sheave may have been used to direct a carrier rope down towards the ground where it was then anchored with heavy weights. A related shaft and bracket may have been used to mount the sheave to the terminal framework. The sheave measures 204cm in diameter and is 16cm tall at its hub. The inside diameter of the hub is

13cm; the outside diameter is 30cm. The lateral cable groove is 7cm tall. Six individual arms radiate out from the hub, one of which is broken. This particular artifact is interesting in that it shows signs of modification. The sheave body features three repair brackets, which appear to address stress cracks noted on the cast iron body. The first bracket is mounted to the hub on both sides and is joined with fastening bolts. The bracket appears to address cracking observed on the interior section of a connecting arm. The other brackets are mounted at the outside ends of two connecting arms. Again, the bracketing consists of two metal plates joined together with fastening bolts. The purpose of this bracketing likely relates to cracks observed in the cable groove. The plates have been cut to follow the circumference of the sheave. A portion of the sheave body is missing between two connecting arms. It is not clear if the sheave eventually failed or if its current condition is related to the collapse of the tramway terminal.

The isolated sheave is either a brake sheave or belt sheave (Figure 5.26). It measures 224cm in diameter, with a 20cm hub. The sheave is 20cm thick at its outside circumference. The face of the outside circumference is smooth and exhibits a single seam along its surface. Eight arms radiate from the hub to the outside diameter. The hub features a small notch at one point of its circumference, which is similar to the notch seen on the drive sheave. The drive and brake/belt sheave possibly shared a common drive shaft since both sheaves share the same measurements for hub and outside diameters and both are notched at the hubs.

If related to a braking device, the sheave interfaced with a separate band brake. Band brakes were circular metal bands with wooden blocks (brake pads) riveted to its inside surface. The brake would fit around the circumference of the brake or drive sheave, wooden blocks pressed against the braking surface. To decrease the speed of the spinning driveshaft (which is powered by the descent of loaded tram cars), a laborer would engage a lever that cinched the band brake onto the surface of the brake sheave. The resulting friction would reduce the drive shaft's rate of speed. A matching band brake was found south of the foundation work in the area associated with the loading platform.

If indeed a belt sheave, the sheave likely interfaced with drive belt arrangement. This arrangement may have been related to the tramway's hydraulic governor, which was an auxiliary braking device situated on the Machinery Mount Platform. If the sheave was mounted to the vertical drive shaft within the main terminal building, it would need to be situated at a high point so that related belts could operate clear of the tramway's rope system.

Loading Platform

The tramway's loading platform is comprised of features found along the face of the hopper's east elevation (See Figure 5.32). This area ties in with features associated with the foundation section of the terminal. Objects associated with this section include: timber pilings, a band brake, beveled pinion gear, and a hand hoist. Additionally, the area is covered with miscellaneous structural debris and small piles of coal that originate from the hopper's open coal portals.

The bottom portions of sixteen square timber pilings were observed on site. These pilings are arranged in two separate rows, which run parallel to the face of the coal hopper's east elevation. Eight pilings were identified in the uphill row, the remaining eight found in the lower. Three pilings extend into the foundation area. Additional pilings are presumed to exist and may be present underneath earth and structural debris. Each piling has two L-shaped mounting brackets on opposing sides of the timber. Each bracket features two mounting holes. One bolt runs at a horizontal into the timber, the other is vertical. The brackets were used to join separate pieces of timber. The platform superstructure that once tied in with these pilings is no longer present, having collapsed after years of disuse.

An iron band brake is located in this area just south of the foundation work (Figure 5.36). It measures 214cm wide (not a true width as the band is open ended) and approximately 12 cm tall. One end of the band features an open hoop, which likely interfaced with an operative cable or lever. Three metal blocks are attached to the inside surface of the feature. It appears that a number of similar blocks have gone missing. It is

not clear if wooden blocks were once part of this arrangement or if the metal blocks featured a separate braking surface. No wearing was observed on the metal blocks.

A beveled pinion gear and hand hoist were identified at the south end of the loading platform. The pinion gear measures approximately 25cm in length with 23cm gear teeth and a 20cm hub. The gear is beveled so that one end of each gear tooth is taller than the other (Figure 5.35). The teeth dimensions match those found on the drive shaft, which suggests that the beveled gear once interfaced with the distant drive sheave. To do so efficiently, the pinion gear needed to rest at an angle, perhaps in accordance with the arrangement of the hydraulic braking governor. The governor was likely attached to the concrete mounts on the Machinery Mount Platform.

The hand hoist is comprised of a cast iron frame with wooden spindle and steel crank (Figure 5.34). The overall dimension of the hoist is 1m x 1m. A connecting rod joins the two separate iron frames. Although its specific purpose remains unclear, the hoist may have been used for general maintenance of the tramway. A hoist and related cable arrangement would have been useful for manipulating heavy objects associated with the tramway system. Historic photos of the mine present an enclosed section of the terminal at its southern end. This section may have been used as a shop area for servicing elements of the tramway system, perhaps that related to tramway buckets.

Much of the loading platform area is covered with structural debris and coal. The debris pile is comprised of disarticulated timber likely related to the collapsed platform. The small coal piles originate from the open portals at the base of the coal hopper.

Machinery Mount Platform

The raised platform butts up against the north wall of the coal hopper (See Figure 5.31). The platform's designation derives from the presence of four concrete machinery mounts. The platform is essentially a level fill pad bounded on the north and east sides by stacked-rock retaining walls. This area measures approximately 5m NW/SE x 10m SW/NE. The eastern face of the platform is elevated above the three iron sheaves and foundation area. The northernmost portion of this wall has collapsed towards the drive and counter-rope sheaves.

The north face of the platform is elevated approximately 2m above the sloping ground surface. A wooden landing is situated at the western end of this wall. This landing is the top of a collapsed staircase, which runs down to the east, parallel with the north wall. The northwest portion of the platform is bounded by a stacked-rock retaining wall. This wall is elevated above the platform and appears to serve as a retaining wall for a related cut in the landscape.

The southern end of the platform borders the north end of the coal hopper (Figure 5.28). A section of this wall has been cut out, apparently for access to coal. The section was eventually closed with horizontal planking. This same wall also features a tarpapered section near its center. A series of slotted wooden strips suggest that the wall once accommodated a collection of tools, perhaps related to maintenance of the hydraulic governor and/or drive machinery. A single horizontal strip is mounted above two vertical strips and a wooden hook is attached at the top-left corner of this section.

Three standing machinery mounts are located on top of the platform. A fourth has collapsed onto the lower surface where the iron sheaves rest. Two of the standing mounts are located near the north end of the platform. Their placement is square to one another and to the adjacent hopper and terminal. These two mounts are equal in size and dimension. Both measure 155cm NE/SW x 70cm NW/SE and are at least 124cm tall. True height is unknown since the bases are covered with soil and rock. Iron and concrete mounting fixtures were noted on the top of these concrete mounts. The fixtures are rectangular at the north end, and circular at the south end. A threaded mounting rod runs vertically through each fixture into the concrete base. The collapsed mount resembles those previously described and appears to have been situated in line with them.

A smaller machinery mount is located at the southeastern corner of the platform, near the east end of the hopper's north wall. This mount measures 146cm NE/SW x 53cm NW/SE and is 48cm tall. A threaded rod is centered vertically on the mount's northern half. The four machinery mounts are presumed to be associated with the tramway's hydraulic governor. The device was a large, heavy piece of machinery that would require a stable surface to rest on.

To decrease the speed of the tramway cable, the governor transmitted mechanized power to a series of belts and drive shafts. A pinion gear at one end of a related drive shaft interfaced with the tramway's main drive sheave. The beveled pinion gear found at the south end of the terminal platform was likely a component of this system. The elevated nature of the grounded platform may have justified the use of the beveled pinion gear, which rested at an angle atop the level surface of the drive sheave. The angle was used to transfer power between the grounded platform and the lower drive shaft. A similar gearing was necessary at the level of the governor. This brought the power transfer back to horizontal. The band brake may have been used as a secondary braking device.

Lower Debris Field

A variety of tramway-related objects are found scattered on the slopes beneath the tramway terminal. These features stretch from top to bottom, their locations suggestive of a collapse event and subsequent dispersal by erosion and other natural phenomena. These features include suspension hangers, elevated track sections, track sections for attaching and detaching tram buckets, timber brackets, timber sections, and other items that could not be identified. These features were detailed within the Area 5 overview in Chapter 4.

Description of Tramway System

The Bleichert-designed upper tramway terminal runs parallel with the long axis of the coal hopper. Empty tramway buckets entered the terminal on the uphill side of the tramway system. After entering the terminal, the buckets detached from the traction rope (a continuous drive rope) and were diverted to a suspended track arrangement. The buckets hung below this rack, connected by a long arm with an attached roller and coupling mechanism. Terminal laborers carried the empty bucket to one of the ten portals at the base of the coal hopper. Here a lever was engaged and coal would pour from the open portal into the bucket. When the container reached capacity, the lever was released and the portal closed. The laborer then pushed the loaded bucket around the

suspended track system where it was reattached to the traction rope. Gravity transferred the tram bucket to either an awaiting ship or to an open storage facility on the bluff near the base of the tramway.

The Bleichert tramway at Mine No. 1 utilized a double-rope system to convey buckets from mine level to sea level. Two separate cables were employed; one rotated around two fixed points while the other was stationary. The mobile cable was the traction rope. This rope ran on a continuous loop, which revolved around two horizontal sheaves at opposing ends of the system. Tramway buckets were attached to the traction rope via a special coupling device that could be tripped to release the bucket from the rope. This rope worked in tandem with a second, stationary cable called the “carrier rope.”

Carrier ropes served as suspended causeways that “carried” the weight burdens imposed by the tram buckets. While the traction rope pulled the bucket, the carrier rope guided and supported the vessel throughout its course of travel. Since ‘empty’ and ‘loaded’ buckets had different weights, the respective carrier ropes were of different diameters; thicker gauge for loaded, thinner for empty. Unlike the revolving traction rope, the two carrier ropes were fixed to respective sides of the tram towers and anchored at the upper and lower terminals. At the bottom terminal, suspended counterweights were used to place tension at the ends of the two carrier ropes. Since the upper terminal occupied a space that was relatively confined, these same ropes were likely anchored behind stout timbers. The south ends of both carrier ropes were identified at the base of Tower 1, near the upper terminal remains. Both were fixed to a common anchor plate, which may have once been set behind heavy timberwork within the terminal infrastructure. The location and twisted state of the carrier ropes below Tower 1 is suggestive of violent recoil event, perhaps induced by the collapse of the tramway terminal.

Artifact Discovery

Much of the tramway terminal is in an advanced state of collapse. Therefore, many of the tramway’s features and artifacts are scattered below the terminal footprint.

Despite the variety of features identified during the survey, a number of those once associated with the terminal construction are not present at the site. For example, no other heavy machinery was identified separate from the drive sheaves. The hydraulic braking governor could not be located, nor were any of the drive shafts or tram buckets. Because of their large sizes and dimensions, one would expect to find related material evidence within the terminal remains if they were indeed present on site. The absence of these features suggests that they may have been salvaged for uses in separate mine installations sometime after the 1920 mine explosion.

ACC Mine #1
 Upper Aerial Tramway Terminal (F5.02)
 and Coal Hopper (F5.00)
 Plan View - August 2008
 Measured by MTU/LASHIPA 2004 & 2008
 Drawing by Seth DePasqual

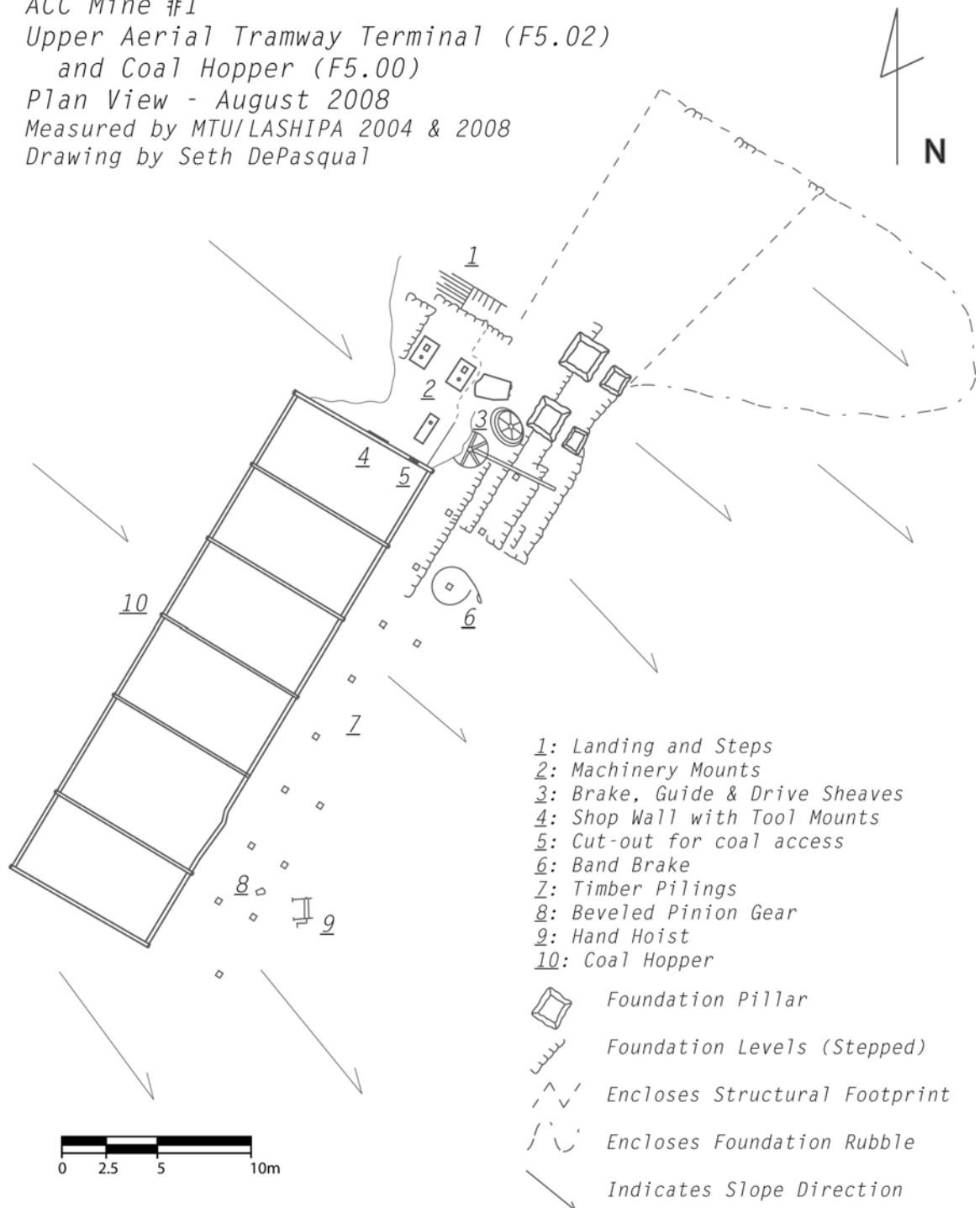


Figure 5.25: Plan view of Upper Terminal (Fea.5:02) and Coal Hopper (Fea.5.00).

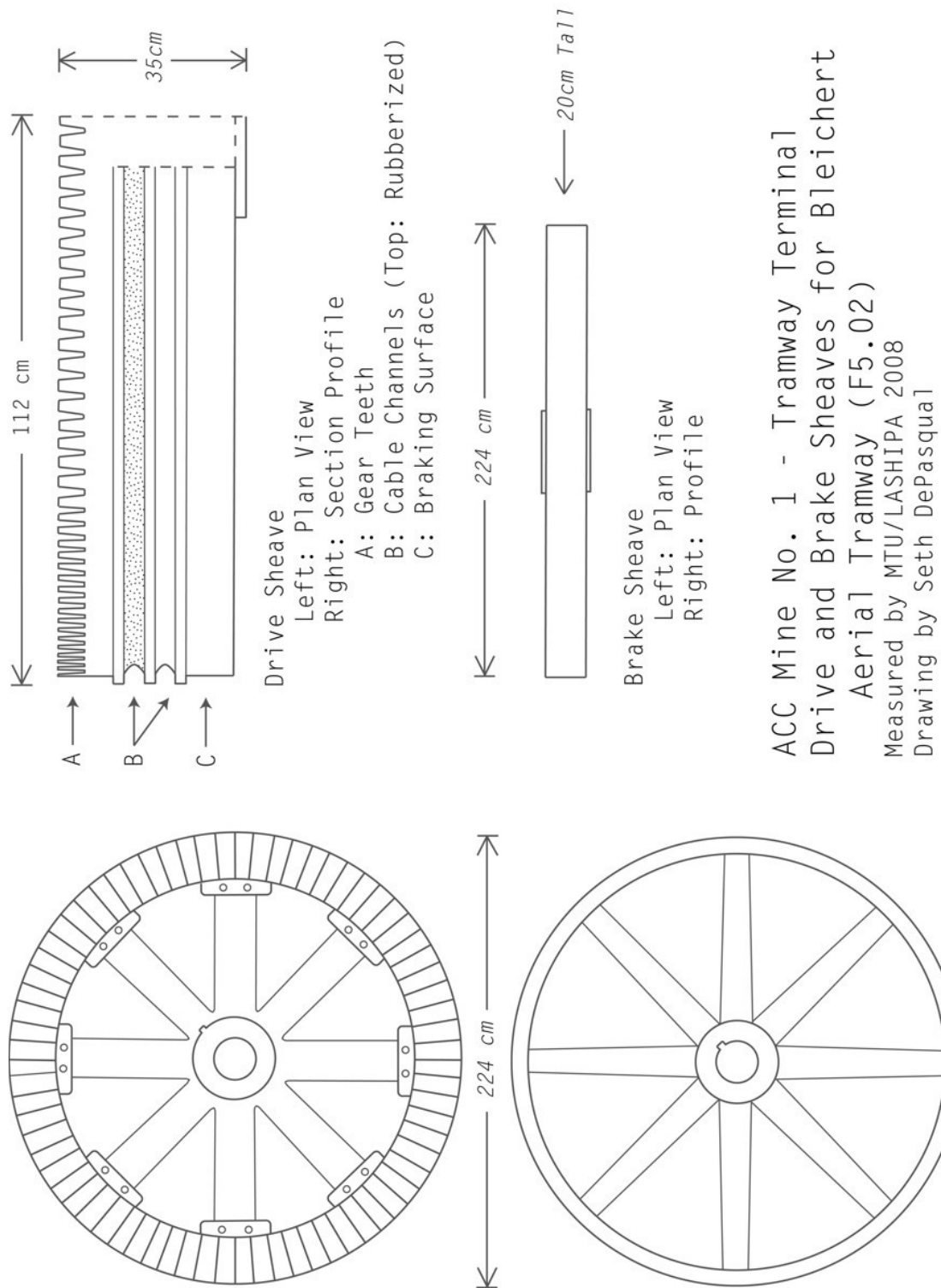


Figure 5.26: Drive and Brake Sheaves

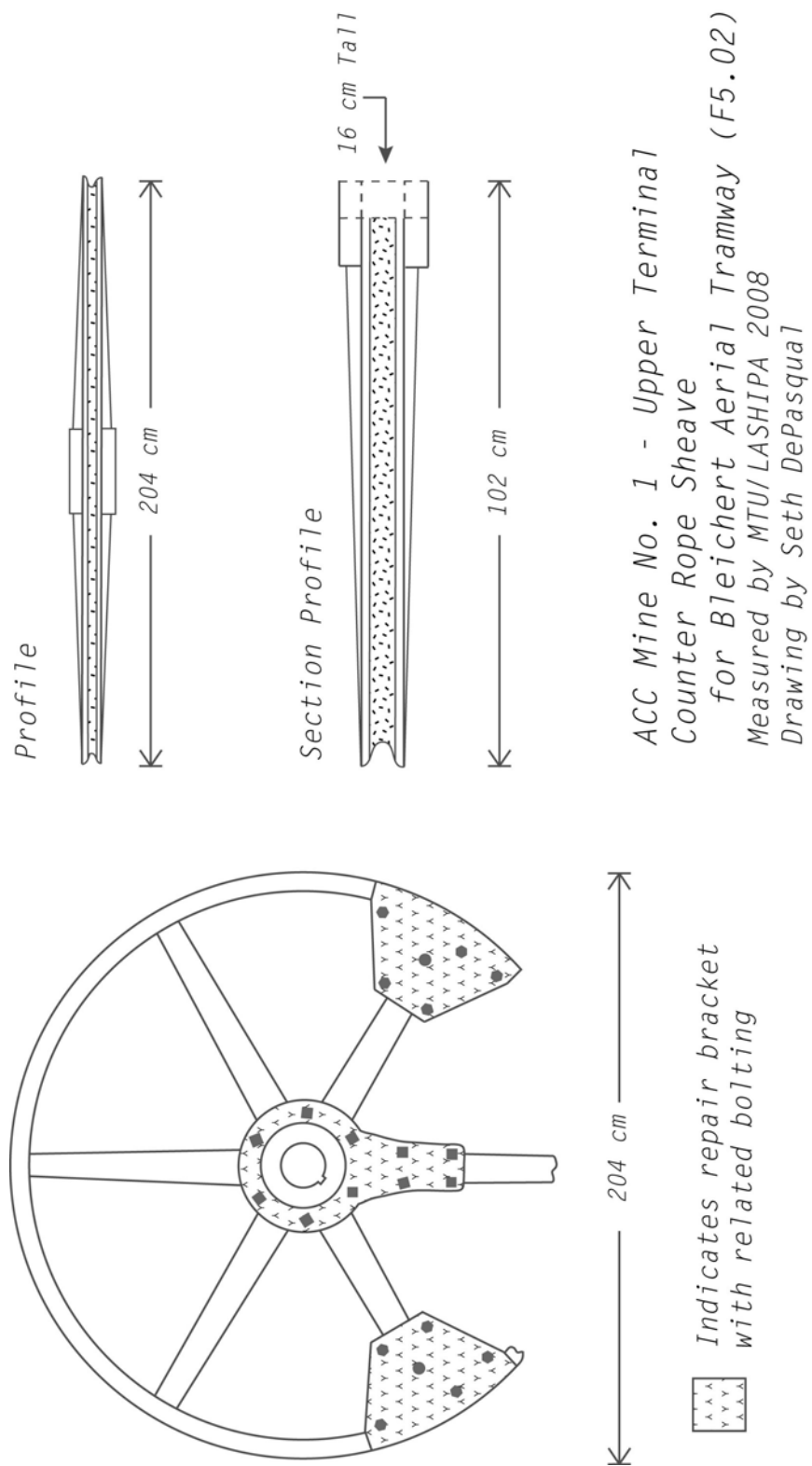
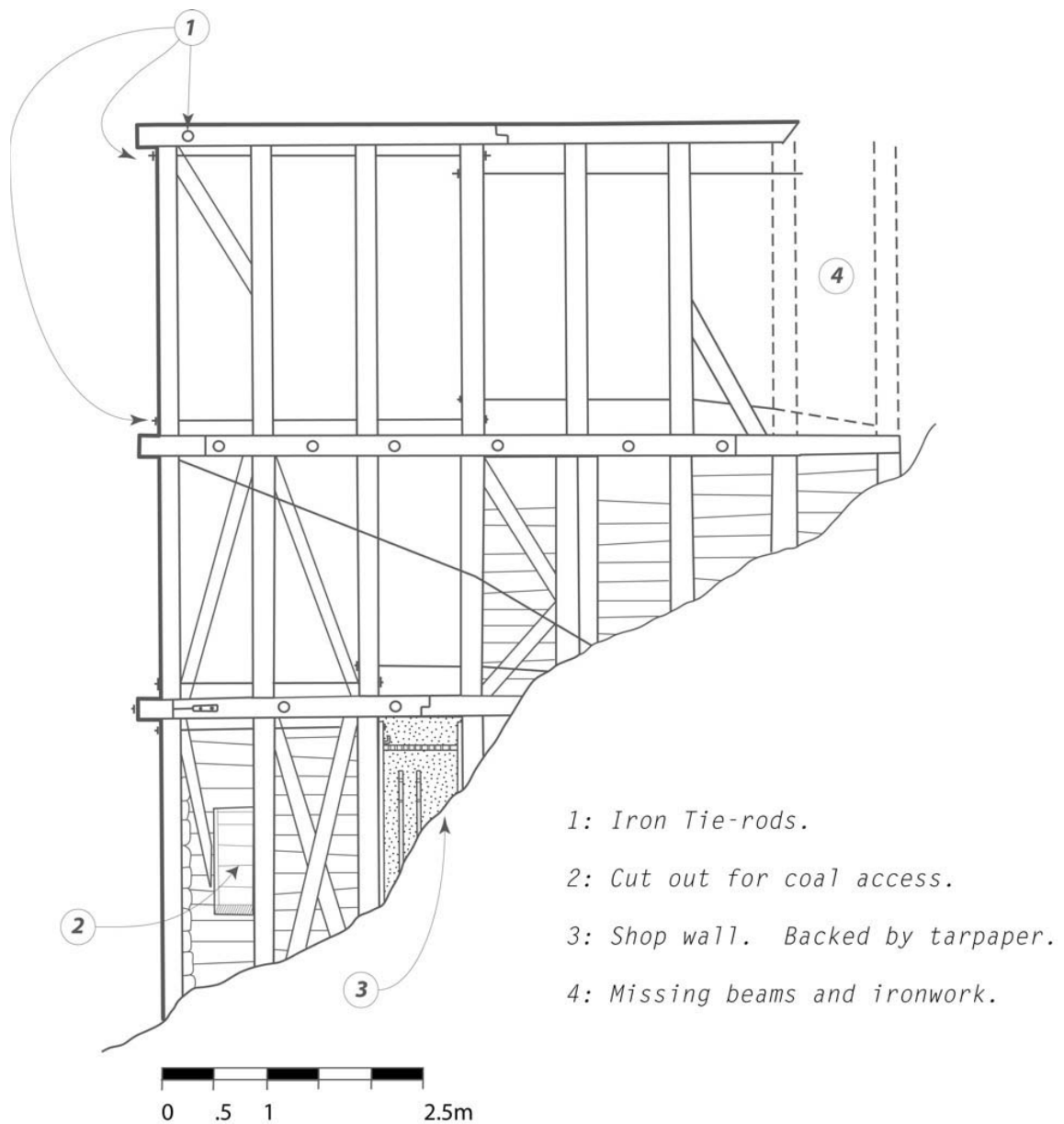


Figure 5.27: Modified Counter Rope Sheave



ACC MINE #1 - Coal Hopper (F5.00)

North Elevation: July 2008

Measured by MTU/LASHIPA 2004 & 2008

Drawing by Ulf Gustaffson and Seth DePasqual

Figure 5.28: North Elevation of Coal Hopper depicting shop wall and coal access cut-out. These features are associated with the Upper Terminal's braking machinery.



Figure 5.29: Overview of mine complex. The remains of the tramway are located directly beneath the coal hopper. Much of the tramway foundation is part of the large debris field to the right of the standing tower. Other tramway debris is scattered throughout the lower mountainscape. 2004 photograph by Larry Mishkar/MTU.



Figure 5.30: Tramway terminal remains when viewed from Tower 1 foundation. Tramway foundation rubble is at center of photo. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.31: Grounded platform at north hopper elevation. Concrete machinery mount is visible left-center. 2004 photograph by Larry Mishkar/MTU.



Figure 5.32: View of tram terminal remains from base of coal hopper's east elevation. Note square pilings in foreground and standing timber support in background. 2003 photograph by Patrick Martin/MTU.



Figure 5.33: Tramway sheaves and standing timber support. The counter-rope and drive sheaves are to the left. The counter-rope is resting on top of the larger drive sheave. The brake/belt sheave is partially obscured by rubble in the foreground. 2008 photograph by Seth DePasqual/MTU.



Figure 5.34: Hand hoist at south end of tramway terminal / loading platform. Hand crank on opposite side of wooden spindle. 2008 photograph by Seth DePasqual/MTU.



Figure 5.35: Beveled pinion gear at south end of tramway terminal / loading platform. The gear teeth measurements match those found on the drive shaft. 2008 photograph by Seth DePasqual/MTU.



Figure 5.36: Band brake at mid-section of tramway terminal. Metal blocks are visible at right side of band. 2008 photograph by Seth DePasqual/MTU.



Figure 5.37: 1915 image of Mine 1 complex (cropped). Tramway terminal and foundation work are visible at center. Image courtesy of Keweenaw Digital Archive: Image# MS018-005-01.



Figure 5.38: 1908 image of the coal hopper and Bleichert Tramway. Both the hopper and tramway are still under construction. Note the small structure in front of the hopper. This is the grounded platform, which hosts the machinery mounts. Image courtesy of Keweenaw Digital Archive: Image# MS018-007-02-12.



Figure 5.39: 1908 image depicting the south end of the tramway terminal. Note suspended track and hanging tramcar. A laborer is manipulating the loaded tramcar. Image used with permission from Fred Tibbitts.

Fea.5.04 – Waste Rock Entry 2

The entry feature is located beneath a prominent outcrop on the Level 2 coal seam, S/SW of the Mine Surface Plant (Fea.5.01). The feature is approached today by following an old miner's trail from the bottom of the valley up to the Mine Surface Plant (Fea.5.01). On reaching the Surface Plant, one should follow the mountain contour south/southwest to the location of the feature. The feature is comprised of a collapsed entry, waste rock dump, the remains of a tramcar trestle, an adjacent pile of timbers, and a small collection of related artifacts (See Figures 5.40 and 5.41). Two narrow-gauge tramcar rails that protrude from the rubble identify the location of the collapsed entry.

The remains of a wooden trestle are located immediately SE from the mine entry. The feature is comprised of a series of round and square pilings that run SE from the tramcar rails. Seven round pilings were observed at the NW end of the trestle, two of which featured milled lumber for additional support. Four square pilings were noted at the SE end of the trestle feature. All pilings rest in-situ, while additional milled pieces of lumber lay scattered about the trestle vicinity and directly downhill. The trestle feature rests on top of a large waste rock pile that spreads from the top of the trestle down towards the valley. The trestle supported tramcars, which rolled from the adit entry to the dumping location at the end of the causeway.

A pile of heavy timbers rests on the ground approximately 15m southwest from the collapsed entry. The feature is composed of approximately ten individual beams resting parallel to each other. Most of the beams run parallel with the slope contours; a few round timbers rest at perpendicular angles. Many of the timbers measure 16cm x 25cm thick and vary in length between 160 and 230cm. The size and dimension of all related timberwork suggests they were intended for use either inside the mine or around the entryway. Three small iron legs were identified on the hillside approximately 2m below the timber pile. All three are equal in size and shape and resemble those found on small cast-iron box stoves (Figure 5.44).

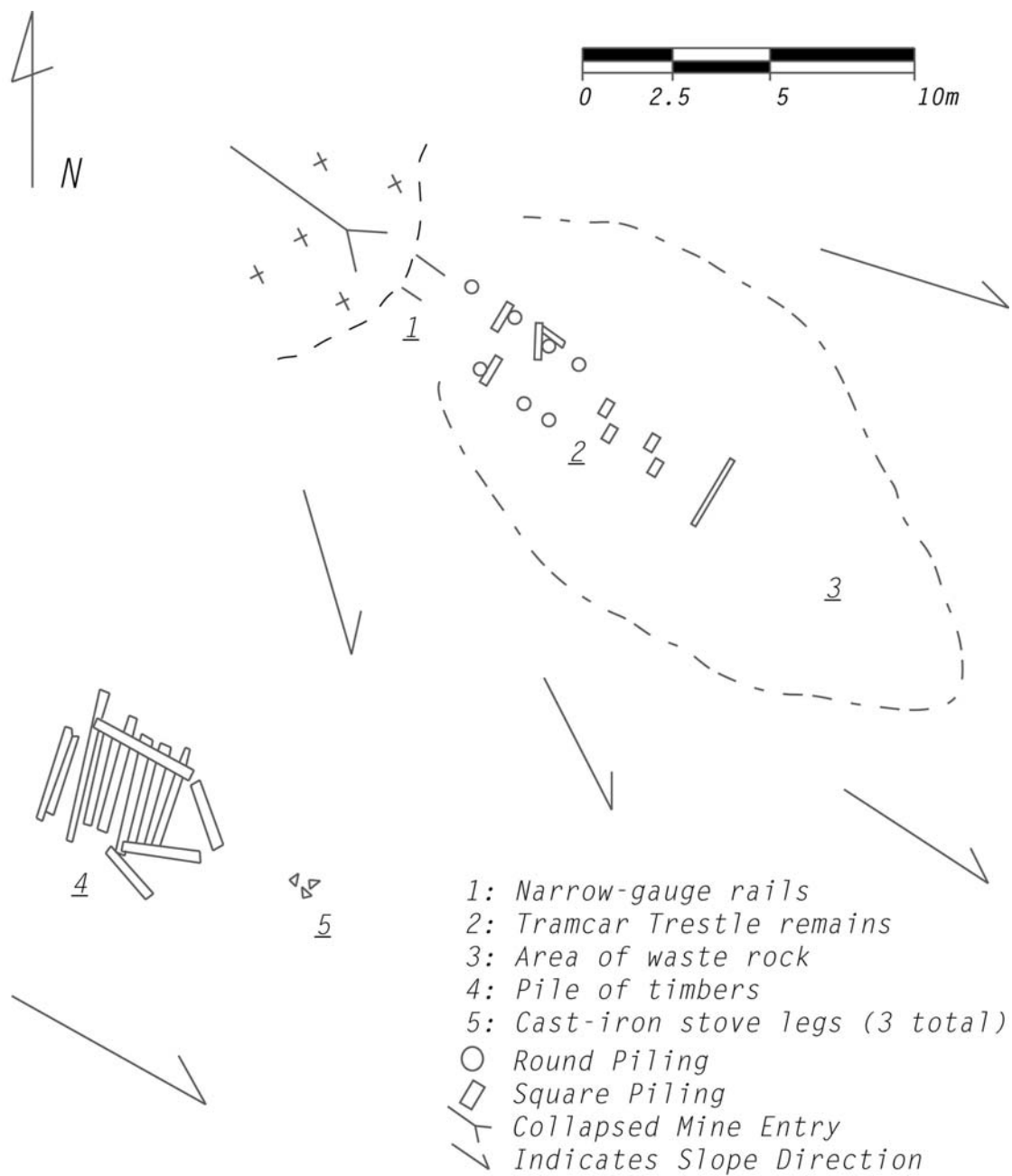
The piled timbers are likely related to small recess carved out at this location for the purpose of powder storage. A 1913 mine map presents two openings in this area (Figure 5.41). The northernmost opening was a formal entry into the mine, the other a

small recess related to the powderhouse. The stove legs are curious since the historic record does not indicate any related facility at this location. It is possible that the timber pile was part of an improvised shelter, where miners could take breaks in the open air. A box stove may have been used for warmth or for heating meals; however, such activities would not likely have been encouraged in the vicinity of a powder storage facility.

In 1912, a field engineer noted, "...a 20' entry was run here entirely in coal. The work was done as mine work, for the purpose of increasing powder storage at the mine."² Between 1912 and 1913, company managers opened a second entry in response to adverse environmental conditions inside the mine. A southerly dip had rendered tramming difficult since miners had to push their loads against the grade. The auxiliary entry allowed miners to remove cumbersome waste rock from the mine quickly and effectively. Coal however, was still pushed or hauled to the Main Entry.

An instance of looting was noted at Waste Rock Entry 2. During a 2003 visit, researchers Patrick Martin (Michigan Technological University, USA) and Dag Avango (University of Groningen, The Netherlands) observed at least one iron horseshoe near the mouth of the mine entry. This artifact could not be located during the 2008 documentation, having apparently been removed by unknown visitors.

² MacGavin, Drummond, 1912. *Report Covering Geological Field Work and Surface Exploration & Development during the Summer Season of 1912*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 12.



ACC Mine No. 1: Waste Rock Entry 2 (F5.04)

August 2008

Measured by Cameron Hartnell and Seth DePasqual

Drawing by Seth DePasqual

Figure 5.40: Plan View of Waste Rock Entry 2.

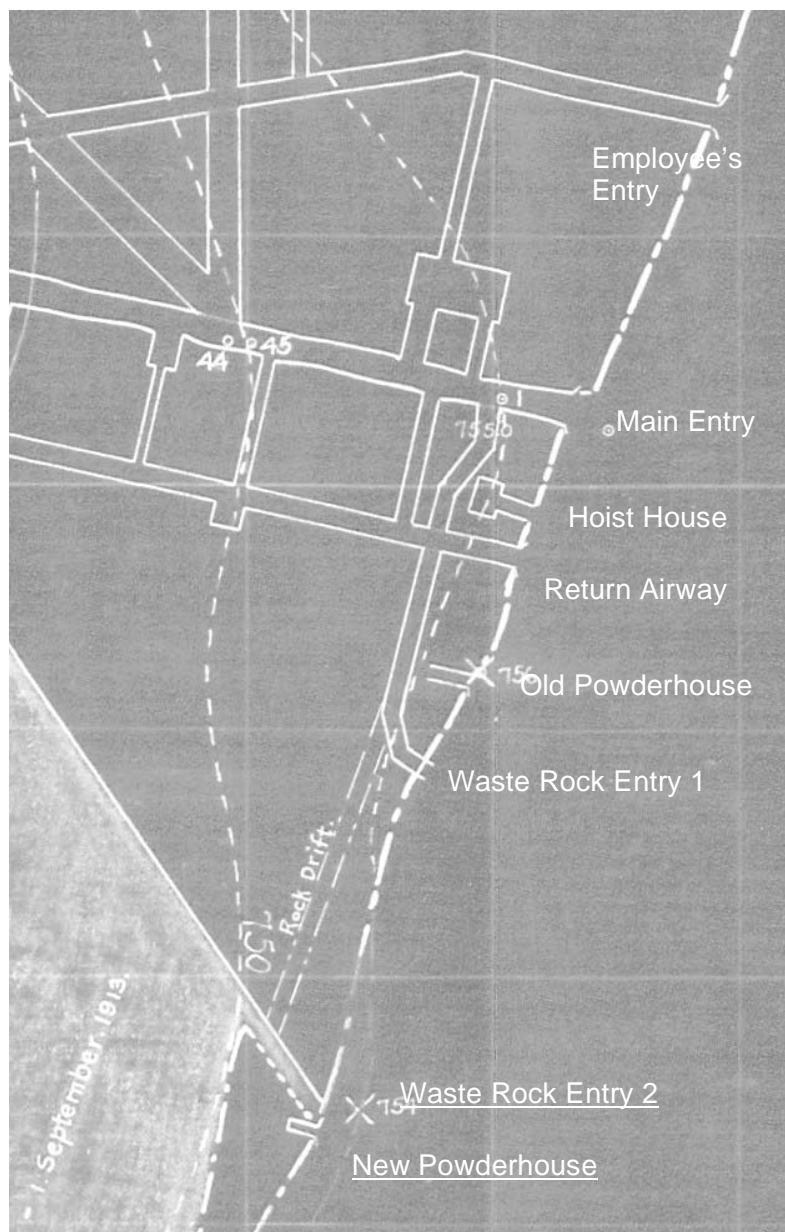


Figure 5.41: 1913 map of Mine No. 1 (cropped for detail). The image presents the arrangement of the mine and all exterior openings. Waste Rock Entry 2 is depicted at the bottom. The “New Powderhouse” is the small recess immediately south of the entry. The timber pile is likely the exterior remains of this recess. Image courtesy of Michigan Tech Archives, Longyear Collection, Box 4, Folder 13.



Figure 5.42: Waste Rock Entry 2 with rock pile and trestle remains. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.43: Timber pilings associated with tram trestle. Photo taken from mouth of collapsed entry. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.44: Cast-iron stove legs. 2008 photograph by Seth DePasqual/MTU.

Fea.5.05 – Lower Rock Dump

The Lower Rock Dump is comprised of a large waste rock dump and two narrow-gauge tramcar rails (See Figures 5.45 – 5.48). The feature is approached today by following an old miner's trail from the bottom of the valley up to the base of the Coal Hopper (Fea.5.00). The dump is located south of the hopper, on a level similar to the tramway terminal. The rails are located at the top of the rock dump at the center of a small, leveled surface. The present angle of the rails suggests that they ran back towards the incline tramway corridor, which is between the dump and the hopper. Both rails are parallel to each other and feature an 80cm gap between them. Approximately 1m of the northernmost rail is exposed while 2m of the south rail is visible. The rest of the rails is covered with earth and rock.

The purpose of this dump is not clear. If related to a waste rock dump, the location would be relatively inefficient in respect to Waste Rock Entries 1 and 2 (Fea.5.10 and Fea.5.04). To bring waste rock from Mine 1 to the feature's location would require that laborers handle the rock load multiple times, between the mine, incline tramway and dump. It may have been one of the first rock dumps during initial development of the mine, before others were available. However, this still would require excessive handling of the waste material.

The dump could possibly be associated with a rock crushing operation that commenced near the area in 1914. A contemporary manager wanted a related device to be erected "at some convenient point near the rock dump at the mine...and...the incline to the camp."³ Alternatively, the dump could be related to leveling work necessary for the construction of the coal hopper.

³ Arctic Coal Company. *General Manager's Report for the year from October 1st, 1912 to August 31st, 1913*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 13.

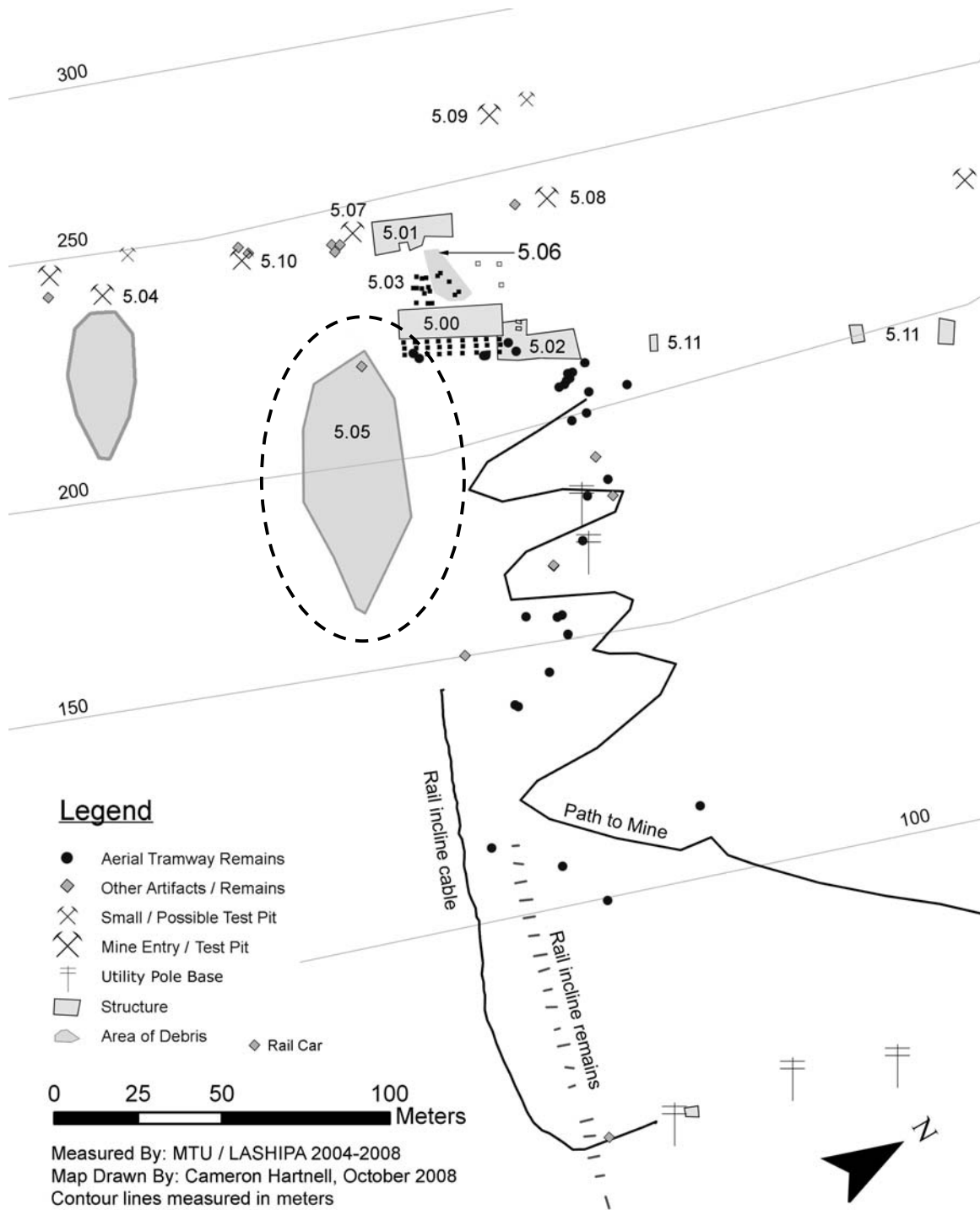


Figure 5.45: Site map for ACC Mine No. 1. Circle indicates location of Lower Rock Dump. Features are presented numerically.



Figure 5.46: View of rock dump from valley floor. Circle indicates location of feature. 2004 photograph by Larry Mishkar/MTU.



Figure 5.47: View from top of rock dump depicting the two narrow-gauge rails. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.48: View of north track rail with respect to Coal Hopper. 2008 photograph by Cameron Hartnell/MTU.

Fea.5:09 – Level 3 Entry

The Level 3 Entry is located on the side of a steep drainage found above the Mine Surface Plant (Fea.5.01). The site is accessed today by following the old miner's trail from the valley floor to the level of the eating-house. From the eating-house, continue north along the mountain contour to a point where the rock outcrop blends into a steep drainage, which is near the location of the Employee's Entry (Fea.5.08). The Level 3 Entry is located approximately 20m above the Employee's Entry at the base of a steep outcrop.

The Level 3 mine feature is comprised of a single, collapsed mine entry and related walls and timbers (See Figures 5.49 and 5.50). Mountain rubble obscures much of the feature. A partially intact rock wall is visible at the south side of the entry; the north wall is covered with rubble. Two vertical beams were noted, one at the western end of the south wall, the other at the east end of where the north wall would be. No other timbers were observed in the area. The entry measures 2.6m wide E/W by 4.8m long N/S and runs on a 76°/256° axis. The rear (westernmost) section of the entry is obscured by rubble.

The target coal seam is visible at multiple locations along the contour shared by the entry. It appears that portions of the Level 3 seam were exposed in this area. The most visible example of this activity is found south of the mine entry, where the steep contour blends into a vertical drop.

The Level 3 Mine appears within company documents from 1908. Mine manager Frederick Burrall stated "Sixty feet above the mine now being opened [ACC Mine No. 1] is a vein which appears to be a few inches wider than the one we are working, but not quite as fine quality of coal, although it appears to be a good coal."⁴ By 1909, the mine had been driven over 200 feet. As the mine penetrated further into the mountain, the coal quality diminished to such a point that the effort was abandoned by 1912. Drummond MacGavin reported that year that "the entry is sealed up at present, but is said to be 240

⁴ Burrall, Frederick. *Letter to Ayer and Longyear; February, 1908*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 19.

feet long and according to Coulson [1909 consultant], is the only part of seam 3 that is mineable.”⁵



Figure 5.49: Level 3 Entry when viewed from footprint exterior. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.50: Overview of Level 3 Entry. 2008 photograph by Cameron Hartnell/MTU.

⁵ MacGavin, Drummond. *Report covering Geological Field Work and Surface Exploration and Development during the Summer Season of 1912*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 12.

Fea.5.09 – Waste Rock Entry 1

The entry feature is comprised of a small rock wall, a narrow-gauge rail, and two vertical timbers (See Figures 5.51 – 5.53). The most visible portion of the entry is a section of stacked rock wall. The feature is approached today by following an old miner's trail from the bottom of the valley up to the Mine Surface Plant (Fea.5.01). From the Surface Plant, follow the mountain contour south/southwest to the location of the feature, which is indicated by the stacked rock wall.

The rock wall measures approximately 3.3m on an NW/SE axis. The uphill side of the wall is obscured by earth and rubble. The downhill side of the wall turns to the south and then tapers off. This turn represents the eastern side of the formal entry. Similar rock arrangements were noted throughout Longyeardalen, where the company had prospected frequently during its time of operation. The rock wall gives form to the south side of the entry. A similar wall was likely located on the north side of the entry, which is now covered or obliterated by natural slumping and erosion.

Two vertical timbers were identified directly uphill from the rock wall. Only the top extents of the timbers are visible. One of the timbers is situated along the same axis of the rock wall. The second is found 1.75m NE from the first. These timbers are spaced at a right angle from the rock wall and are likely part of the support structure for the mine entry. Taken together, the timbers essentially outline the width of the entry. A single narrow-gauge rail protrudes from the collapsed entryway, near the base of the rock wall. The rail's orientation is suggestive of a track system that ran from the mouth of the entry. No other artifacts were observed in the vicinity of this feature.

The specific purpose for the entryway is presently unclear although it was likely opened for use as a waste rock dump. The entry first appears on 1913 mine maps and appears to be part of a "rock drift (See Figure 5.51)." 1912 mine maps present the entry in dotted lines, which possibly indicate that it was scheduled for development.

It should be noted that a physical rock dump was not observed at this location during the 2008 survey. The absence of this feature would seem to contradict present assumption about the entry's use. However, historic images of this area indeed present a large waste rock dump (Figure 5.52). It is presumed that natural slumping phenomena

may have obliterated most of the rock dump, a fate similar to that experienced by the Return Airway and Old Powderhouse.

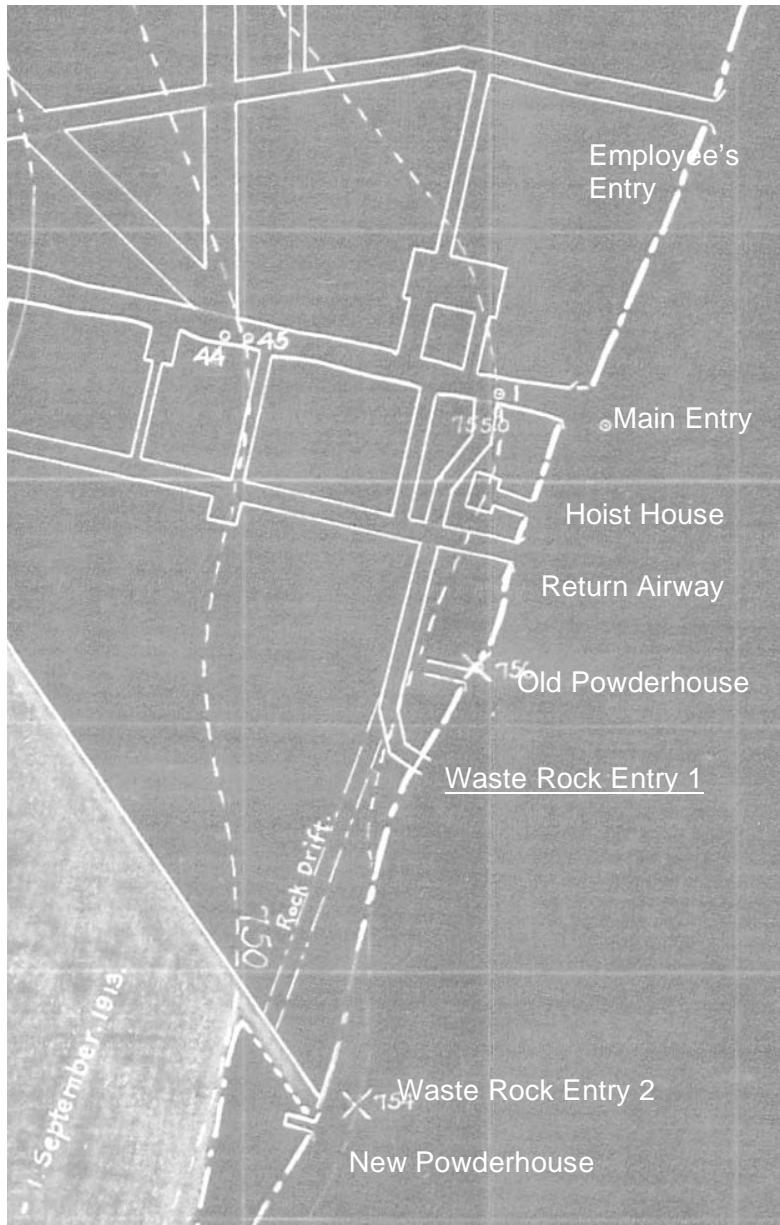


Figure 5.51: 1913 map of Mine No. 1 (cropped for detail). The image presents the arrangement of the mine and exterior openings. Waste Rock Entry 1 is depicted near center. No evidence of the Old Powderhouse was located during the 2008 survey. Image courtesy of Michigan Tech Archives, Longyear Collection, Box 4, Folder 13.

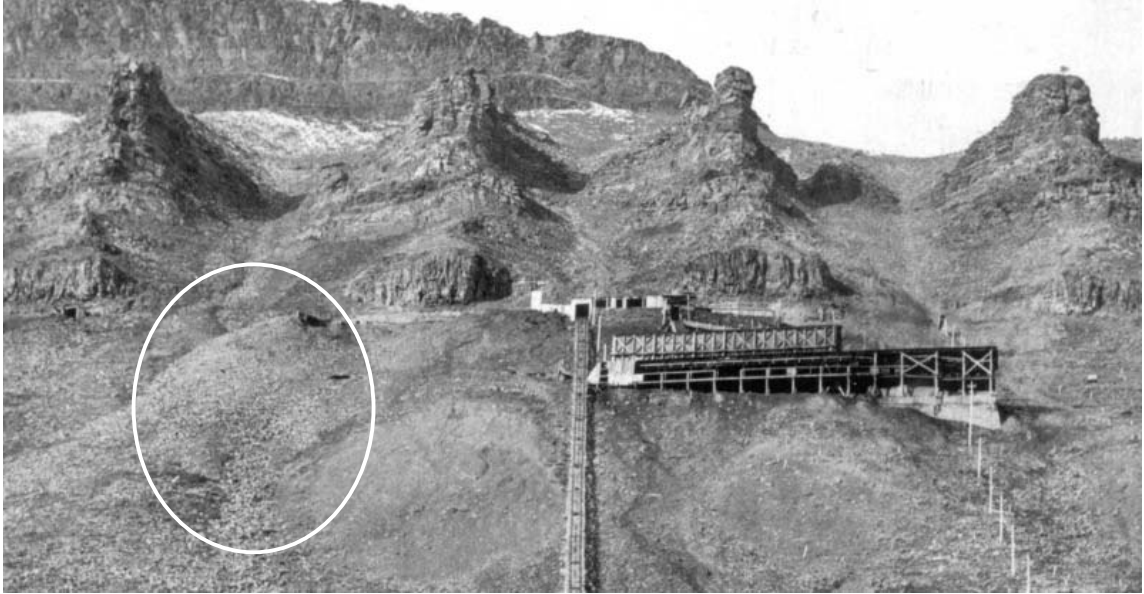


Figure 5.52: 1915 image of the ACC Mine No. 1 complex (cropped for detail). The enclosed area identifies the location of Waste Rock Entry 1, which appears to have been quite substantial. This pile was not identified during the 2008 survey. Natural phenomena associated with the nearby drainage likely obliterated most of the waste rock. The formal entry is all that remains. Image courtesy of Keweenaw Digital Archive, MS018-005-01.



Figure 5.53: Rock wall entryway. Collapsed entry at right. 2008 photograph by Cameron Hartnell/MTU.

Fea.5.11 – Bleichert Aerial Tramway Towers

The remains of twelve individual tram towers were identified during the 2004 and 2008 MTU/LASHIPA surveys of Longyear Valley (See Figures 5.54 – 5.56). The towers are best accessed from the Upper Terminal (Fea.5.02) beneath Mine No. 1. The Tower 1 foundation is located immediately north of the Upper Terminal remains. The remaining tower foundations can be approached by continuing north/northeast down towards the Store Norske “changehouse.” Two footings related to Tower 16 were identified at a bluff edge above the old Store Norske Powerhouse.

The tower remains are comprised of stone foundations and collapsed tower frames. All foundations are constructed of local rock and mortar. The bulk of all foundation-work is found on the eastern (downhill) side of the footprint. Iron mounting rods were noted on some of the foundations (Figure 5.66). The rods rise vertically from the foundation and were used to anchor the tower framework.

All mountainside towers have collapsed onto the lower hillside; the last (Tower 3) fell during the winter of 2006/07. Towers closer to level ground appear to have been salvaged for their timber while a few seem to have been obliterated entirely since no evidence of their presence could be located. The tower framework assemblies are comprised of thick timber framing and ironwork. The structures featured the ‘through-truss’ design, where tramway buckets would travel through a framed section of the tower assembly (Figure 5.67). Each tower had two “windows,” one for the loaded buckets (downhill) and one for the empties (uphill). For maintenance purposes, an improvised ladder was usually mounted to one of the tower legs.

Tram tower ironwork consists of assembly rods and that related to operation of the conveyance system. The latter is comprised of protection rollers, guide rods and protection saddles. Protection rollers were used to keep the traction rope from rubbing against the timber framework. The rope was relatively loose in comparison with the fixed carrier cable, and often sagged between each tramway bucket. The rollers identified on the Mine 1 towers measured 44cm in diameter (Figure 5.63). Each tower featured two of these rollers, which were situated on a cross timber about halfway up the tower. The rollers nested into an iron housing and spun on an axle (Figure 5.62). Beside

each roller, iron guide rods radiated up and to the side of the tower framework (Figure 5.62). These rods were used to “catch” a swaying traction rope as it traveled through the host tower. This action prevented the rope from rubbing against the tower framework.

Under a double-rope tramway system, tram buckets were hung from the stationary track, or “carrier,” ropes and conveyed between terminals by a revolving traction rope. The track ropes were mounted to each tower, near the top of the framework. Protection saddles were used as an interface between the tower and track rope (Figures 5.60 and 5.61). Each tower had two saddles, one for each track rope. A shallow convex curve was used to ‘saddle’ the stationary track ropes as they ran through each tower. Two saddle sizes were used on each tower, one for the “empty” rope and one for the “loaded” rope. The loaded saddles featured embossing that read “R-2500”, the empty saddles read “R-1500.”

Two separate track ropes were identified on the mountainside. These ropes were found between Towers 1 and 11. Both ropes disappear into the ground between Tower 11 and 12. The ropes are of different diameters, which corresponds to their use as either an *empty* or *loaded* rope. Heavier gauges were necessary for buckets loaded to capacity. The loaded rope (downhill) measures 38mm while the empty rope (uphill) measures 26mm. A cast-steel cable coupler was identified along the span of the loaded rope (Figures 5.64 and 5.65). The feature is located on the north side of Tower 2. The coupler was used to splice together the two tag ends of the continuous rope.

The anchor plate for the loaded and empty track ropes was identified near the base of Tower 1. This plate features two holes, through which run the two separate track ropes. Each rope was then splayed and wedged to prevent them from pulling back through the anchor plate. A thick steel casing covers each tag end. The anchor was likely mounted behind thick timbering beneath the decking of the Upper Terminal (Fea.5.02). At some point the terminal collapsed. This event released cable tensions, which allowed the anchor plate to pull free from its former environment. The object’s distance from the upper terminal, and the twisted position of the related track, reflects the violent nature of the collapse.

Although GPS data for Tower 2 was not recorded, the feature does exist on the landscape and is comprised of foundation work and a collapsed tower frame. The cable coupler is located at the north side of this feature. Towers 13-15 were not identified during the 2004 and 2008 surveys. These towers were once situated on a relatively flat area, which has seen some degree of use over the years. The Store Norske changehouse and a few tram towers associated with a separate mining system are located in the area. It appears that these towers and all related foundation work were obliterated by subsequent construction activities.

Almost no timber framework was identified for Towers 9-11. These towers are relatively accessible and therefore the timberwork may have been salvaged for use elsewhere in Longyeardalen. No timberwork was located in the vicinity of the Tower 12 foundation. Tower 16 is comprised of two rock and mortar footings. Each footing hosts a mounting rod with attached iron bracket.

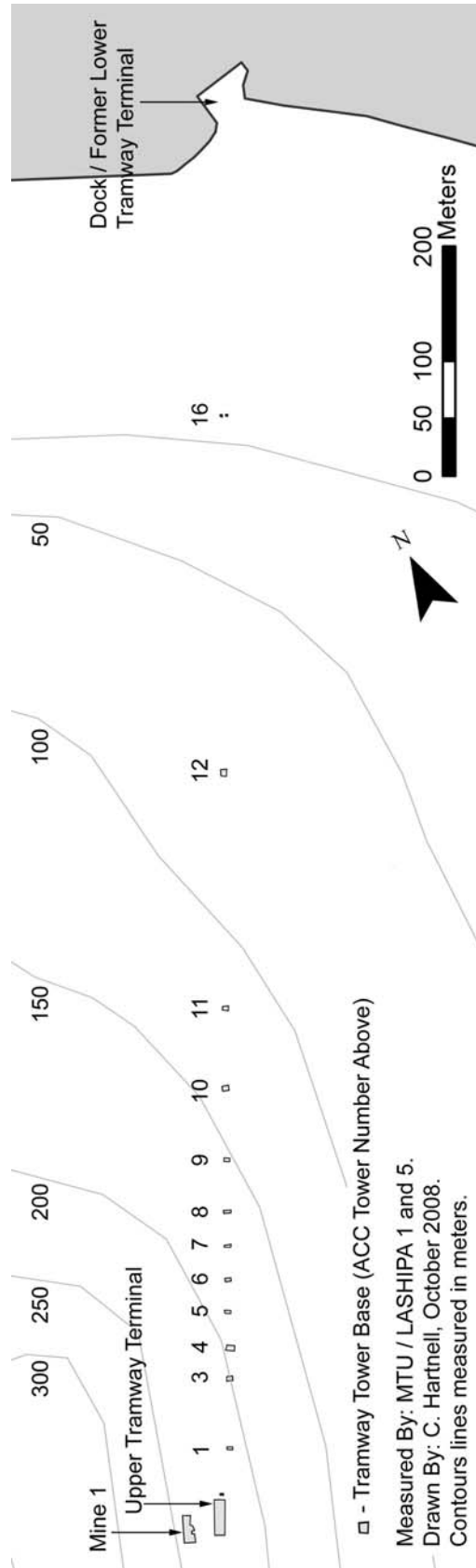


Figure 5.54:
 Plan View of Mine
 No. 1 Tram Tower
 features.



Figure 5.55: See Figure 5.56 for description



Figure 5.56: Original and cropped image of tram tower alignment from floor of Longyardalen. The photograph was taken in 2004. Figure 2 includes the location of Towers 1-3. Tower 1 foundation is at left. The Tower 2 framework is above and to the right of the middle, more recent Mine 1b tower. Tower 3 is still standing at right. This tower has since collapsed. Photograph by Larry Mishkar/MTU.



Figure 5.57: View of tramway alignment from northeast. The foundations visible at center-left are Towers 9-11. Note track cables spanning from tower to tower. Standing tower at right is a reconstruction erected by Svalbard Sysselmannen. 2008 photograph by Cameron Hartnell/MTU.



Figure 5.58: Tower 1 foundation and framework. The track cable anchor plate is located at bottom-right. Note how track cables have twisted. 2008 photograph by Seth DePasqual/MTU.



Figure 5.59: Anchor plate for tramway track cables. Located beneath Tower 1 foundation. 2008 photograph by Seth DePasqual/MTU.



Figure 5.60: Tower 1 framework with attached Protection Saddle. 2008 photograph by Seth DePasqual/MTU.



Figure 5.61: Detached Protection Saddle found beside tower framework. Embossing reads "3, R - 1500." 2008 photograph by Seth DePasqual/MTU.



Figure 5.62: Saddle for Protection Roller. Note bent iron guide rods at side of roller saddle. 2008 photograph by Seth DePasqual/MTU.



Figure 5.63: Protection Roller. The roller rested within the saddle depicted in Figure 6. 2008 photograph by Seth DePasqual/MTU.



Figure 5.64: Tower 2 framework and foundation. Note carrier cable coupler at bottom-left. 2008 photograph by Seth DePasqual/MTU.



Figure 5.65: Detail of coupler for “loaded” track cable. 2008 photograph by Seth DePasqual/MTU.



Figure 5.66: Tower 11 foundation footings. Note iron mounting rods and track cables. 2008 photograph by Seth DePasqual/MTU.

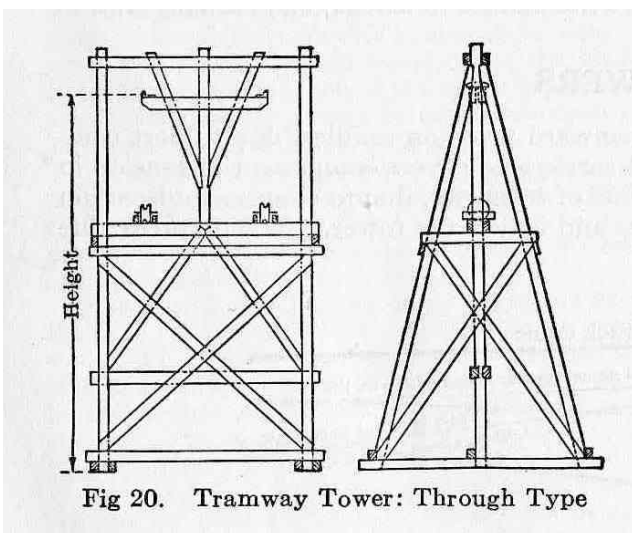


Figure 5.67: Diagram of a through-tower similar to those constructed in Longyear City. From Robert Peele’s *Mining Engineer’s Handbook*, Vol. II. New York, John Wiley & Sons, Inc. 1914.

Chapter 6: Analytical Considerations

This study examines the relationship of the mining system employed by the Arctic Coal Company at Mine No. 1 in light of the influences of environment, technology, and social organization present at the location during the American period of occupation. Primary attention will be afforded to several mining processes and their functional components. The purpose of this exercise is two-fold. The first is to examine the technological system in greater detail, drawing attention to the labor tasks involved. A secondary objective is to look at the system diachronically, where emphasis will be placed on the evolution of the system as shaped by a variety of influences. In so doing, this discussion stresses the ways that mining landscapes take shape within a complex, local order of technical, environmental, and social determinants.

Mining systems can appear straightforward and self-explanatory at first glance. Coal mines utilize a number of technologies and devices that are specific to a range of tasks. For example, every mine will incorporate some kind of transportation system be it a narrow-gauge track network, incline tramway or aerial tramway. Their presence is somewhat inherent and mining companies often follow similar trajectories of development. Environment also weighs heavily on how particular mining systems are arranged. Arctic snowstorms, for instance influence how transportation systems are laid out and maintained. And yet mining systems, like any other human endeavor, are also organized according to cultural behaviors and practices.

Social approaches to understanding technology have evolved steadily over the last fifty years and include contributions from the academic field of history (to the point of establishing a subfield in the history of technology), and to a lesser extent anthropology and archaeology.¹ These approaches emphasize the need to understand the social factors involved in the technical system. They recognize the importance of seeing technology not only as physical objects or artifacts, which early technological histories tended to do, but to see technology as a process embedded in the social world. This view stresses the worth of understanding a particular technology within broader frames of analysis that

¹ Good 'History of Technology' examples are found in Hughes (1983) and Staudenmaier (1984 and 2002). For anthropological examples see Lemonnier (1986) and Pfaffenberger (1988 and 1998). Archaeological examples are found in Schiffer and Skibo (2001) and Schlanger (1994).

account for how a technology materializes spatially and temporally. Furthermore, this approach seeks to understand how technological systems perpetuate and transform social relations. Recognizing the “social” within technology brings attention to explanations for technological change capable of connecting changes within a technical object to changes in the social world where technologies and humans interact.

Examinations of technology’s “social side” have proceeded along two courses that are closely related yet distinctly different in analytical scale. Research at the largest scale details entire technological systems. A notable example of this is Thomas Hughes’ investigation of the rise of the electrical power industry.² This “sociotechnical system” perspective views the creation and operation of technologies as relying upon the coordination of many variables and conditions extending far beyond the physical construction and technical maintenance of a given technology. Stepping back from a system of power poles and electrical boxes, Hughes illustrates how electrical power networks grew from a host of negotiations made with competitors, political entities, and subsidiary industries including fuel vendors and electrical component manufacturers. What is apparent is that each of these negotiations, on some level, influences the course and shape of technological practice and change.

Applied to Svalbard’s history, a sociotechnical system approach would no doubt highlight the sociopolitical contexts imbedded within the mining system, detailing for instance how various companies propagated business interests on “no-mans-land,” marketed an untried coal resource, hired labor, and selected the technologies to work the seam. The approach could offer key insights into understanding actions like why the Arctic Coal Company simultaneously maintained a presence on mining claims in Green Harbor despite paltry coal beds. It becomes apparent that John M. Longyear hoped to attract the interests of the United States to a possible annexation of the archipelago. Although this result never came to fruition, the example shows how a mining system can be as much a political process as technical.

² Hughes, Thomas P. *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore, John Hopkins University Press. 1983.

A second line of approach to social aspects of technology is that of the *chaîne opératoire* (chain of operation). As described in Chapter 1, the *chaîne opératoire* is a way of interpreting technical sequences with attention to the social aspects involved. Under this light, the sequences are guided less by standardized technical arrangements, and more by the forces that act upon them. In this particular case, those forces can be described as technical, environmental and social. The interaction of these influences amount to what might be considered a dialogue between the material, in this sense a mining system, and the agents with which it engages. Detailing the *chain of operation* for the mining systems at Mine No. 1 draws attention to the ways that technological systems are assembled and directed.

The analysis of sociotechnical systems and *chaîne opératoires* both emphasize the social construction of technology, albeit they differ markedly in scale. While the former gives attention to broader scales of technology and industry, the latter pares its focus down to the localized setting. Their relationship is best regarded as nested. With this in mind, *chaînes opératoires* complement larger sociotechnical studies by investigating the organization of work and related tasks. Information gleaned from investigations made on the local scale may prove useful to interpretations that seek to understand larger sociotechnical networks. Furthermore, the *chaîne opératoire* serves as a platform from which researchers can begin to reconstruct courses of technological change.

Mining on Svalbard could be analyzed just as productively from a sociotechnical systems approach as through an investigation of *chaînes opératoires*. Ideally, both lines might be employed. However, the *chaîne opératoire* offers a readily applicable frame of analysis that engages the fine scale of a mining landscape, thus complementing the fine-scaled nature of archaeological recording efforts performed at Mine No. 1 in 2004 and 2008. Moreover, the *chaîne opératoire* provides the researcher with the ability to compare work relations in specific locations to specific material features identified during the examination. How is *the chaîne opératoire* evidenced within material culture? And, ultimately, what new perspectives does this provide about how coal mining at Mine No. 1 proceeded between 1905 and 1915 under American management?

What follows is an examination of the mining system employed at Arctic Coal Company Mine No. 1. This study will examine the *chaînes opératoires* within two particular systems utilized at the mine including: methods of extraction and methods of product transportation and storage within and outside the mine. Although transportation and storage systems could be discussed separately as individual entities, this approach would be somewhat limited, as the systems remain interconnected in many interesting ways. This analysis parses out the various components of each system in an effort to fully understand their respective functions. Attention will be given first to the fixed elements inherent in each system. As the examination progresses, the *chains of operation* will reveal areas of flexibility, which point to choices made by various actors taking part in the mining system. When possible, I will draw connections to material evidence located during the 2004 and 2008 documentation surveys and that located during archival research. Information gleaned from the *chaînes opératoires* may offer some perspective on pivotal stages within seemingly standard methods of operation.

The two mining systems will be reviewed in context of the three period phases described in Chapter 3. Each system will be covered in detail, with attention to the methods, equipment and use of labor exemplified throughout the period of American management. When possible, I will tie in information related to archaeological and archival research. Although the mining systems utilized by the Arctic Coal Company are discussed within related archival material, the level of detail is often limited to general overviews of the processes involved. Therefore it will be necessary to refer to period literatures that describe these systems more adequately.

Extraction Methods: Introduction

Before attempting to discover areas of flexibility within the Arctic Coal Company's mining system, it would be worth noting those elements that are immutable, or rigid. Any coal mining system is built upon basic mining principles that cannot be altered. Coal must be extracted, sized, stored, and delivered to market. The first of these principles concern the physical process of mining. In order to sell coal, one must first know how to extract it. Coal can be dug out of the ground in any number of ways;

however, certain know-how is necessary to do so. The mining of coal is dependent on strategy and skill, and especially so at the commercial scale. Therefore, it is necessary that the company in question have some form of mining plan before they get started. However, the decision on a particular extraction method is a matter where technical flexibilities first become apparent.

Before the Arctic Coal Company could begin mining, acting managers had to decide just how actual mine operations were going to be performed. At the head of the 20th century, coal mines were developed in accordance with two predominant extraction methods, longwall mining and room-and-pillar mining. Each came with its own list of instructions and variations, which usually depended on the characteristics of a particular coal seam. Once a mining method was chosen, the work typically proceeded by either hand-got or mechanized extraction methods. Although mechanized mining apparatus was becoming more popular in the early 20th century, many coal mines throughout the world still used the basic pick and shovel as the primary means of wresting coal. Since mechanized operations were inherently expensive, most mines at least started with hand-got methods. The Arctic Coal Company was no exception.

The Arctic Coal Company hired workers from a varied labor pool that stretched between America, England and Northern Europe. The company organized the workforce according to an ethnic hierarchy. High-level management positions were reserved for English-speakers with educations and skill in mining. As a result, only Americans and British individuals held top-tier appointments. The reason for this is two-fold. The Americans wanted these positions held by their own interests, in no small part because the company was working on foreign soil and needed to maintain solid lines of communication, and perhaps loyalty, between the owners and field managers. Secondly, there were no coal mines in Norway and therefore nobody with any related experience. The one exception was a Norwegian citizen who served as chief-clerk for the company in Tromsø. This individual had spent several years in America and was fluent in both languages.

The company turned to England for its rich history and experience in coal mining. Early American managers relied on this proficiency, at least initially, for much of the

mine's development. British employees occupied many of the mid-level mining appointments such as mine foremen and machine-runners. These positions demanded much skill and know-how and so they were reserved for those with an extensive background in coal mining. Bertrand Mangham, the winter superintendent, for instance, came from a coal mining family and was well connected with English collieries and related supply-houses. Mangham held the highest level achievable by a non-American.

Scandinavian workers filled the bottom tier. The company hired from this pool of unskilled laborers because they did not want to pay increased wages for an expanded body of experienced British coal miners. The majority of these laborers were Norwegians and Swedes, with a smaller minority of Finlanders and northern Russians. This arrangement introduced a number of language difficulties that caused many mistakes through the course of the American operation.³ Most of these laborers came from non-mining backgrounds, experienced only in the farming and fishing industries. Those that did have mining experience were, company officials reported, the "worst of the lot," having been rejected by Norwegian mining camps.⁴ Regardless of their background, many laborers left the company after one working season. The company stated that "a practically new crew of green men must be broken in and taught the rudiments of mining twice a year, and no very high efficiency can be expected of this class of labor."⁵

Company records indicate that the managers of the enterprise thought little of its Scandinavian workforce. Negative, often blatantly discriminatory attitudes appear to have developed from adverse relationships between management and labor. Threats of strikes remained a perpetual concern. Regarding ethnic ratios, the company reported that "during the time that there were about 300 workmen on the Island [Summer, 1911], the proportion of white men was too small for safety...Probably there should be one dependable white man [read: American or British] to every 25 Scandinavians, if order

³ Mangham, Bertrand. *The First Mining in Spitzbergen*. Transcribed by Grant A. Mangham, 1993. Source date unknown.

⁴ Turner, Scott. *Letter to John M. Longyear, June 21st, 1912*. Michigan Tech Archives, Scott Turner Collection, Box A, Folder 22.

⁵ Arctic Coal Company. *General Manager's Report Covering Operations During the Year 1911-1912*. Michigan Tech Archives, Scott Turner Collection, Box Z, Folder 13.

and discipline are to be maintained and enforced.”⁶ Similar rules were eventually applied to upper-tier management positions, although the directives were not as degrading. In the same report a manager argued, “The Company would undoubtedly get better results if operations both Winter and Summer were under direct control of Americans.”⁷ Officials reasoned that it was inefficient to change control from one nationality to the other [British and American] twice a year.

The organization of labor within the mine varied through the years and also hinged upon the mine methods and activities involved. Labor arrangements are represented in part by an organizational labor chart for the winter of 1914/15 (Figure 6.01). Included are all mine-related positions found inside and outside of the mine. This document presents the labor necessary to run Mine No. 1 during the winter season, a time when production was at its peak. Two methods of mining are presented at the far left of the chart. These methods and their respective labor needs will be described in detail throughout the following discussion.

Wage rates corresponded with the ethnic hierarchy, a reality common to numerous mining industries. Those in upper management made the most, not surprising given their level of experience and the responsibilities with which they were tasked. Archival records examined in this study include some information about how wages were organized. The following wage rates were gleaned from a batch of contracts from the third phase of the Arctic Coal Company operation (1912-1916).⁸ The American winter-superintendent (Frederick Dalburg) made \$200 a month during the year 1913. The British manager (whom Dalburg replaced) made \$175 per month for the winter year 1910/11.⁹ The difference between the two wages suggests that American managers received better compensation; however, the range of years may account for this apparent discrepancy.

⁶ Ibid.

⁷ Ibid.

⁸ Michigan Tech Archives, Scott Turner Collection, Box AA, Folder 01.

⁹ Arctic Coal Company. *Contract for Bertrand Mangham, 1910*. Michigan Tech Archives, Scott Turner Collection, Box BT, Folder 04.

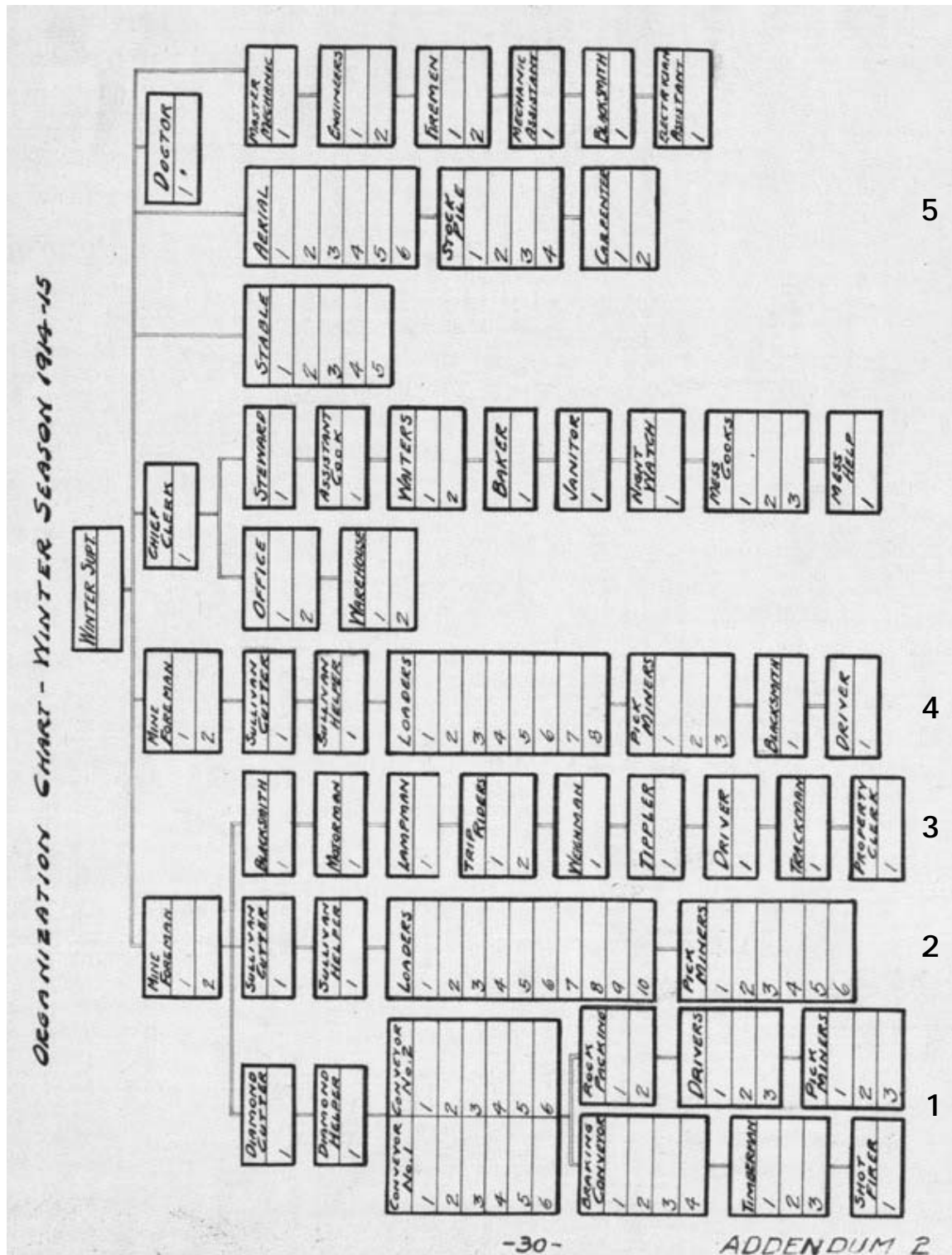


Figure 6.01: “Organization Chart – Winter Season 1914-15.” Michigan Tech Archives, Longyear Collection, Box 4, Folder 15. Designations are as follows: 1: Longwall Mining; 2: Room-and-pillar mining; 3: Surface Plant (Pit-mouth) positions; 4: Room-and-pillar mining at Mine No. 2; Aerial Tramway and Stockpile positions (carpenters are used throughout property).

Dalburg's 1913 wage does not appear to match his level of responsibility, considering that the summer field engineer (whose responsibilities largely concerned survey and prospect work) made \$300 per month that same year. The seemingly unbalanced level of compensation among American management might be related to varied levels of experience. The American surface manager, Kenneth Gilson, was paid \$175 per month to handle valley-based engineering projects during the summer season.¹⁰ This rate is commensurate with that paid to the British manager in 1910/11.

A British mine foreman earned approximately \$117 per month. Yearly contracts for machine runners stipulated that the employee would perform multiple duties including the operation of coal-cutters and conveyors, general mining duty, and shot firing. British machine runners made 225 Norwegian Kroner (NOK) per month (\$60 USD by 1913 exchange rates).¹¹ American machine runners made significantly more at \$100 a month. No explanation is given for the discrepancy.

Information related to the wage rates for ordinary miners is more difficult to interpret, in part because some worked for a daily wage while others worked under a contract system. Contract work paid in accordance with tonnages and distance. For instance, a miner might be paid for the amount of coal produced while a shot-firer was paid by the yard. In 1912, a party representing Swedish interests visited the mine and reported on its operation.¹² The team observed a number of pay rates between the different levels of work performed. A contract rate of 1.30 NOK was assigned to miners using hand-got methods where coal was shot, filled, and trammed to a side-gate. It is assumed that a separate trammer handled the load back to the main entry where it was hoisted to the surface. Since less work was involved, conveyor miners made .90 NOK. "Ordinary" laborers made 6 NOK per shift (approx. \$1.60), which suggests that the former work was done by the contract.

¹⁰ Turner, Scott. *Letter to W.F. Bentinck-Smith, December 11th, 1911*. Michigan Tech Archives, Scott Turner Collection, Box A, Folder 19.

¹¹ The amounts are derived from a 1913 exchange rate of 3.75. Rates assembled by Statistics of Norway, Oslo Stock Exchange and Bank of Sweden. http://www.norges-bank.no/templates/article___42331.aspx

¹² Atkinson, J. B. *Spitsbergen Coal, 1913*. Spetsberenarkivet, Vol. 4. Riksarkivet, Stockholm, Sweden.

Contract work was preferred, although it remained dependent on conditions within the mine. On one hand it was purported to benefit the employee, giving him a chance to earn more wages. On the other it reduced operative costs. A company report stated, "On contract work the men work much longer hours and with more zest, earning about fifty per cent more per day, than when paid by the hour, yet accomplishing the work cheaper for us."¹³ Despite these alleged benefits, mining conditions sometimes worked against the contract system. Changing conditions in the mine required some miners to work harder than others. For instance, a "bad" section of the mine might demand increased time and energy from those working therein. Under these circumstances, the miner expended more energy to achieve the same level of tonnage. Such occurrences resulted in perceptions of unfairness and so Arctic Coal Company miners fought for a minimum wage clause, which was seen as a way to offset adverse conditions within the mine.¹⁴ These socialized aspects of the mining system suggest a connection between the labor system and production methods employed by the company. It would be worth examining these systems more closely since each of them changed significantly over time.

In the following discussion, I will detail numerous aspects of the mining system employed by the Arctic Coal Company. This examination is the product of information gleaned from primary sources including company records, trade journals, and manufacturer's catalogs. Company records such as annual reports and correspondence offer the most vivid description of what happened within the mine at any given time. Trade journals and manufacturer's catalogs provide many supplementary details on technology and mining, which enhances our understanding of the methods and systems utilized at Longyear City.¹⁵ Where possible, this information will be tied to material remains identified during the 2004 and 2008 archaeological surveys. Ultimately, the

¹³ Arctic Coal Company. *General Manager's Report, November 5th, 1910*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 23.

¹⁴ Turner, Scott. *Letter to John M. Longyear, August 16th, 1912*. Michigan Tech Archives, Scott Turner Collection, Box A, Folder 22.

¹⁵ Secondary sources are equally helpful. The article *Some Social and Psychological Consequences of the Longwall Method of Coal-getting* by E. L. Trist and K. W. Bamforth (1951) is a worthy example. The piece effectively describes the longwall extraction process with attention to the work arrangements and individuals involved.

various mining systems will be understood not only for their general characteristics, but also for how people, environment and technology interact within them.

Extraction Methods: Phase I (1905-1908)

Longwall Mining: Initial Development Using Hand-got Methods

Within the first phase of operation at Mine No. 1, the Arctic Coal Company employed hand-got methods to extract its coal. This type of work was mostly related to development, which entailed the ‘blocking-out’ of the coal seam through a network of tunnels and drifts. This network was arranged in accordance with the longwall mining process, a particular method that extracted coal in large sections usually 100-yards in length.¹⁶ Production at the mine did not increase until the winter of 1908/09’, after the roadway network had been adequately driven. During the initial stages of development, then, practically all mine laborers were drivers and trammers.

Between 30 and 45 individuals performed early development work at Mine No. 1.¹⁷ These numbers were likely divided into smaller groups, each working in a designated tunnel or drift. From the beginning, two primary entries were driven simultaneously, separated by approximately 100’ of coal. One of the entries served as a main haulage tunnel, the other as a ventilation tunnel. In driving the two entries, a natural draft was therefore created, which kept the accumulation of explosive coal dust under control. The primary tunnel, or “main entry,” served as the mine’s main traffic corridor; all coal leaving the mine traveled through some portion of the passageway.

A series of gates, or drifts, were then driven at right angles off the main entry and ventilation corridor. At Mine No. 1, the ACC drove its gates at varied intervals between 90 and 120 feet.¹⁸ These gates served as secondary haulage corridors that bounded each

¹⁶ Trist, E. L. and K. W. Bamforth. *Some Social and Psychological Consequences of the Longwall Method of Coal-getting*. Human Relations, Vol. 4, No. 3. 1951.

¹⁷ These numbers are derived from company reports covering the years 1907-1910, before mechanized mining. The numbers concern winter work only, since this is when most of the mining was performed. Surface work, such as construction and coal handling, took precedence during the summer months. Winter Labor (Year and # of people): 1906/07 - 30 (1st winter); 1907/08 - 40; 1908/09 - 40; 1909/10 - 45.

¹⁸ Coulson, William L. *Examination Report sent to the ACC, October 6th, 1909*. J.M. Longyear Research Library, Spitsbergen Papers: 3.

side of a mine section, or 'block.' The first 120' (along the gates) of each block was left intact to preserve the main entryway and ventilation corridor from collapse. This includes the coal between the two primary entries. The main entry was enlarged in height and width to facilitate better movement within the high traffic area. Mine mules needed the extra height and two-way traffic required increased width. The rockwork involved extra time and expense since the miners had to remove, or 'rip', rocky portions of the roof and floor sandwiching the 4-foot coal seam.

The same type of rock work was performed in the mine's secondary haulage tunnels although on a smaller scale. Since these gates served as permanent haulage tunnels, time was invested in their upkeep by shoring their sides with the rock, or 'gob', that had been ripped from roof and floor. This improvement method is otherwise known as 'packing.' The necessary activity benefited from the amount of gob available within Mine No. 1. Had conditions not been so favorable, the company might have had to invest in excessive timbering, which would be expensive since all timber had to be imported from the Norwegian mainland.

After driving the side gates 120' beyond the main entry and ventilation corridor, miners then drove a separate tunnel, or cross-cut, through the back end of the preserved block to the adjacent gate. This tunnel effectively opened a 'face' for mining. All of the coal produced at this time came from the driving of tunnels and drifts, which was necessary before any large-scale mining could commence. The miners performed their work using picks and shovels, but sometimes used blasting charges to bring down coal in wider sections of the mine. Miners next conveyed coal from the face in tram cars, or 'pit-tubs'. A team of mules assisted with haulage in the main entry and widened side-gates.

Extraction Methods: Phase II (1909-1911)

From Hand-got to Mechanized Longwall Production

Upon completion of the Bleichert aerial tramway and 1100-ton coal hopper, the company entered its second phase of production (1909-1911). The improved transportation system initiated a push for increased production as the mining system could now handle larger volumes of coal. Until this point the tonnage had been kept at a

minimum. Although longwall mining formally began in 1906, most of this work was related to development. The formal 'production' stage of mining at Mine No. 1 commenced during the winter of 1908/09, when the company began working the longwall faces that had been prepared since 1906.

The number of tasks associated with the longwall method can be organized into four groups, which include: the preparation of the coal-face for shot-firing (this includes driving, timbering and tramming); shifting forward the track system (or conveyor); ripping and building up the main and side gates; and moving the shot coal on rails (or conveyor).¹⁹ Even after electrification of the property in 1910, the company continued to employ hand-got methods in areas where conveyors were impractical.

English longwall faces typically averaged between 180-200 yards in length.²⁰ The Arctic Coal Company adopted similar lengths, which were usually blocked-out in 100-yard intervals. Smaller faces did exist and were more practically worked during the years when mining at Mine No. 1 was non-mechanized. Six to eight laborers would likely have worked these faces, four doing the mining while the rest assisted with tramming.²¹ This type of mining could be slow going; however, the early work performed at Mine No. 1 was not meant to be large scale, at least not until the arrival of mechanized equipment.

After developing the mine's network of side-gates and cross-cuts, mine laborers then initiated the first task of the production process. Longwall mining moved from the face forward, *advancing* in a direction opposite that of the main entryway or ventilation corridor. As the face advanced, a separate group of laborers simultaneously extended the side gates to keep up with the mining. If extra manpower was available, the gates could be run far ahead of the longwall face. All of the rock produced during this activity was used either for packing purposes or disposed of on a rock dump outside the mine.

At least three rows of mine props were placed along the newly opened cross-cut. Once the timbers were set, preparation work then began on the face. The first task was to

¹⁹ Trist, E. L. and K. W. Bamforth. *Some Social and Psychological Consequences of the Longwall Method of Coal-getting*. Human Relations, Vol. 4, No. 3. 1951.

²⁰ Ibid.

²¹ Ibid.

bore blasting holes in the coal face just below its ceiling. Proper placement was necessary so that the shot was not wasted. A hole placed too far below the ceiling might leave coal on the roof. Shallow holes, or those not drilled to a proper depth, might leave coal at the back of the cut section after the shot has been fired. Either situation required extra work for the individual tasked with coal removal. Blasting occurred after another set of steps had been performed.

The use of timber was necessary at the mine face as it kept the working environment open and relatively free from the danger of collapse. Two or three rows of light props were used to protect the face at Mine No. 1. Three rows created two separate corridors for use in the mining process. The corridor closest to the face allowed free movement of the mine laborers. The second corridor hosted a temporary low-gauge track system, which permitted use of tram cars, or ‘pit-tubs.’ As the mining progressed, the miners removed the back row of timber props and reassembled them at the ‘new’ working face. The narrow-gauge rails were then disassembled and forwarded to the corridor where the previous face once stood. The mine ceiling was allowed to collapse naturally after the rear timbers were eventually pulled.

Miners cut the coal in small increments with pick-axes. This work progressed only as far as the pick could reach, which ultimately limited the amount of coal produced. The production process entered its second stage after the entire coal face was cut. This stage involved the shifting forward of the low-gauge tramway system. The action of moving equipment forward was laborious. This is because laborers had to move the material between a standing row of timber props.²² These props remained in place since they supported the ceiling at the middle portion of the open section. After the track system was moved, miners filled the back end of the cavity with rock to protect the new corridor from collapse. Although not as delicate as the packing work done in the side gates, the process could be fairly time consuming.

The production process entered its third stage after the track system was relocated. A separate group of workers known as “drivers” set to driving forward the side gates at least as far as the undercut. They packed the walls with rock from earlier

²² Ibid.

ripping' activities. These walls were built solid because they needed to remain open indefinitely. Should the packing fail, because of poor construction, the face workers risked the chance of entrapment in the cross-cut. Upon completion of the driving and packing, a blast technician, or 'shot firer,' entered the face tunnel and set charges within the boreholes. After placing the charge, the hole was packed, or 'stemmed', with a non-flammable material. Clay, the preferred material was not locally available, but workers found ready substitutes. Scandinavian laborers initially used coal dust as a stemming material: hardly the safest practice, and one that apparently caused several small fires and explosions.²³ By 1908, workers found a safer alternative that also held the advantage of being locally abundant: snow. From this time, the operation began tramming cars of snow down in the mine for use in the boreholes and to spread around the main roads and side-gates to keep dust levels down.

After tamping the snow behind the charge, the area was cleared and the shot was fired. If done properly, the downward force of the charge penetrated the bulk of the hanging coal body, pounding it against the undercut and floor. Ideally, the coal fragmented in a consistent manner throughout the face, facilitating easy removal for the tub fillers. If the shot fired improperly, a filler might have to contend with 'stuck' coal on the roof and rear of the newly opened section. This situation resulted in extra time for coal removal, thus hampering further production as well as frustrating the tub loader.

The fourth stage of the mining process concerned the filling and removal of tubs along the face. To remove the coal, the three or four men started at one end of the longwall face, loaded their coal into a tub, and then rolled the tub down the rest of the face and out the opposite haulage tunnel. The work had to be properly synchronized in order for it to run efficiently. Company reports indicate that management was aware of bottlenecks occurring when the slow progress of one worker held up those behind him. Furthermore, the height of the seam limited the height of the tubs, therefore reducing the amount of coal that could be removed at once. Only after the entire face had been 'filled off', could the cycle renew itself.

²³ Mangham, Bertrand. *The First Mining in Spitzbergen*. Transcribed by Grant A. Mangham, 1993. Source date unknown.

As the mining progressed, the Arctic Coal Company commissioned American mining consultant Walter Coulson to look over the property in 1909 and make any suggestions for its improvement. The resulting report framed out the benefits of electrifying the property and mechanizing the mining system. The company adopted these suggestions and installed all related machinery by the close of 1910. The arrangement of mechanized tasks differed little in this sense from hand-got methods. Although the two styles of longwalling are technologically different, they apply the same functional tasks in the same sequential order. In fact, the only real difference between the two is the equipment and number of men employed.

The most notable change within the mechanized longwall system was the use of an electric coal cutter, a device evident outside the mine also by the presence of a cutting disc fragment near the pit-mouth. Resting atop a low-gauge track system, the electric coal cutter utilized a spinning disc cutter capable of cutting 5' into the base of the coal seam (Figure 6.02 and 6.03).²⁴ When compared to hand-got methods, coal-cutters greatly increased the amount of coal that could be dropped in a single blast event. At least two operators pulled the cutter along the working face; one positioned at the front, the other at the rear.

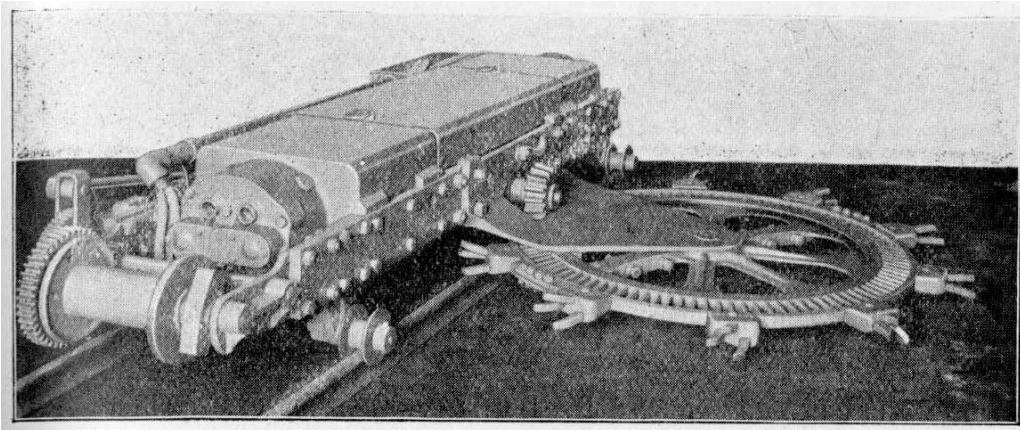


Figure 6.02: Diamond Coal Cutter. From Duncan & Penman, ref. 24.

²⁴ Duncan, William G., and David Penman. *The Electrical Equipment of Collieries*. London: Scott, Greenwood & Son. 1908.



Figure 6.03
Cutting-disc (upper-left) and pit-tub located near the entry of Mine No. 1. The tab at the top of the cutter-disc once featured a 'cutter-box', which housed replaceable iron cutter bits. The disc is buried within a rubble pile. 2008 photograph by Cameron Hartnell/MTU.

Due to the level of multi-tasking involved, coal cutter work was reserved for those possessing significant levels of experience. At Mine No. 1, English or American workers manned the coal-cutters, sometimes with an unskilled, Scandinavian assistant. The company experienced some difficulty with this work arrangement because of novice miners who feared that the noise and vibrations would shake loose the roof supports.²⁵ Eventually the wary miners grew accustomed to working near the cutters. While the undercut advanced with the cutting machine, a separate group of workers cleaned out the loose material (if not removed, the loose coal hampered the blasting process since the hanging coal had nowhere to fall). After cleaning out the cut, the laborer placed wooden wedges in the open gap. The wedges prevented the 'hanging' coal from sagging into the cut before it could be dropped with blasting charges. If left to sag, the coal failed to break properly when blasted.

Coal cutters did away with the laborious task of pick-mining the undercut. A reduced workforce of men could cut more coal during a single shift. Although fewer miners were needed for the actual cutting, more were necessary in other aspects of the mining process. Coal faces could now be mined in 100-yard lengths with relative efficiency. Since more coal was therefore available for extraction, the number of miners

²⁵ Mangham, Bertrand. *The First Mining in Spitzbergen*. Transcribed by Grant A. Mangham, 1993. Source date unknown.

necessary to perform the task increased. Previously, miners worked in groups of six to eight. This number grew to approximately 20 individuals with the introduction of coal cutting technologies.²⁶ Furthermore, the organization of tasks shifted slightly.

Before electric cutters were used, the pick miners typically cleaned out undercuts themselves. Since cutter operators needed to keep moving along the face, a separate team of men followed the cutter and cleaned out the loose coal, or “gummings.” This same group of men placed wedges in the cut. After the cutting shift was completed the organization of tasks continued as usual. The cutter ran on a separate track system, which would likely have been compatible with the adjacent tramcar system. It remains unclear on whether the tramcar rail system had to be moved forward at this time or sometime after the coal had been shot down and removed.



Figure 6.04: Brass “check-tag” discovered in refuse pile beneath mine entry. The tags were used to keep track of miners during a particular shift. 2008 photograph by Seth DePasqual/MTU.

A small check-tag found in a refuse dump outside the mine is suggestive of a safety-system used to keep track of laborers within the mine (Figure 6.04). Each mine laborer had a personal identification number, which he carried with him on two separate tags. Before entering the mine, the miner placed one tag on a large peg-board with designated mine sections. The other tag was kept on his person for the rest of his shift. At the end of his shift the miner retrieved his tag from the peg-board. If he did not, a mine official would recognize the potential dilemma and take appropriate action.

²⁶ Trist, E. L. and K. W. Bamforth. *Some Social and Psychological Consequences of the Longwall Method of Coal-getting*. Human Relations, Vol. 4, No. 3. 1951.

Although small in size, the tag is significant in meaning for it represents a system or order that enabled company officials to gauge how many men were inside the mine at any given time.

Figure 6.05 features a mine map depicting all development and production work performed up to 1912. Location “A” indicates the site of the mine’s primary entries. The middlemost portal is the main entry, the left portal is the ventilation tunnel, and the angled portal at the right is the employee’s entry. The dashed lines represent side-gates, which remained open for access to extant mine workings. Blank spaces such as “B” are mined-out longwall sections. Location “C” indicates a barrier pillar, which has been left intact to protect the mine’s main entry from collapse. The light dotted lines at the bottom-right are related to a new method of mining initiated during the winter of 1912/13.

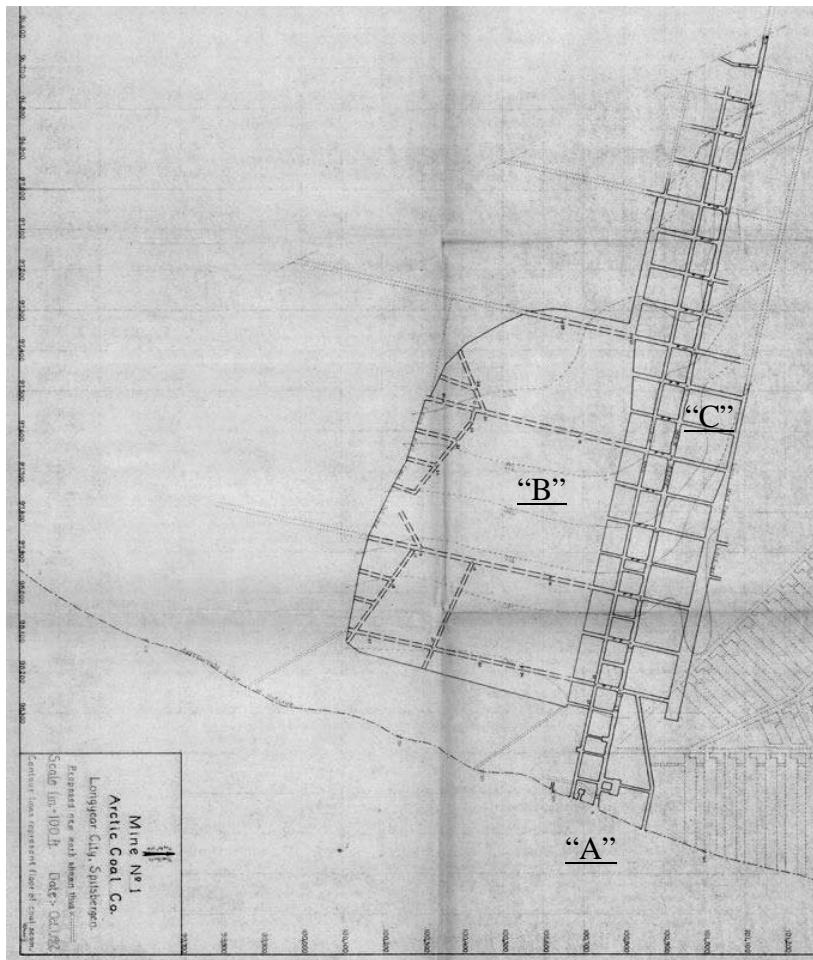


Figure 6.05: “Mine No. 1 – Oct. 1st, 1912.” MTU Archives, Scott Turner Collection, Box Z, Folder 13.

Extraction Methods: Phase III (1912-1915)

The mining process at Mine No. 1 continued with no further advances until 1912, the year that Scott Turner took charge of the property. His arrival marks the shift into the third phase of operations at the Advent Bay property. This change is largely attributed to the management practices of Turner, who was tasked with bringing the operation into the black, so to speak, after years of mining at a loss. Turner quickly made changes to the technological and social components of the mining system. Among the early transformations was the introduction of electric coal conveyors to the longwall system, the first part of a broader experiment to introduce labor saving devices.

The Arctic Coal Company did not employ coal conveyors in their longwall system until 1912. Prior to this date mine laborers removed all of the coal from the mine via pit-tub, which was time intensive and prone to organizational breakdown. The installation of conveyor systems transported coal directly from the face to one of the adjacent side gates. This subsequently freed men from running tubs through congested cross-cuts where the bottlenecks tended to occur. Trammings remained necessary, but this activity was now designated to the side-gates where they could be moved about with relative ease.

After the coal face had been dropped, a filling crew of six laborers came in and spread themselves equally across the cross-cut (Figure 6.01, column 1). They then set to loading the coal onto the conveyor, which was directly behind them in the adjacent through corridor. Within this routine, a filler had to prop his section of the roof as he worked into the five-foot cut. For safety reasons, these props were usually set at three-foot intervals. A separate crew of trammers stationed at the receiving end of the conveyor filled the pit tubs. Once filled, trammers pushed them to the mine's main entry, sometimes with the assistance of a mule. A mechanical hoist hauled the tubs to the mine opening, or 'pit mouth.' A diagram of a typical mine set-up is seen within Figure 6.06.²⁷

The introduction of conveyors at Mine No. 1 improved production to some degree, but the new technology also presented the company with a new batch of issues.

²⁷ Redmayne, Richard A. S. *Modern Practice in Mining, Vol. III, Methods of Working Coal*. New York: Longmans, Green and Co. 1914.

The biggest problem with conveyors centered upon the time it took to reposition them. After the coal was loaded out, a breaking crew took charge of the dismantling and reassembly of the system. Since the contraption was 100 yards long, the task was long and arduous. After all the sections were moved, the crew had to adjust the tension of the drive chain so that it would work properly. The process usually took an entire shift. Furthermore, the use of these machines was dependent on conditions within the mine. The fault line discovered in 1910 eventually worked its way towards the eastern outcrop in a southeasterly direction. This condition essentially pinched off portions of the southern coal body. Therefore, conveyor use was limited in this section as they could only go so far south before running into the fault line. If a separate longwall face had not been prepared in time, a conveyor stood the chance of going idle. Such a breakdown occurred during the first winter of installation, and thus formed the prime reason for that season's low production rate.

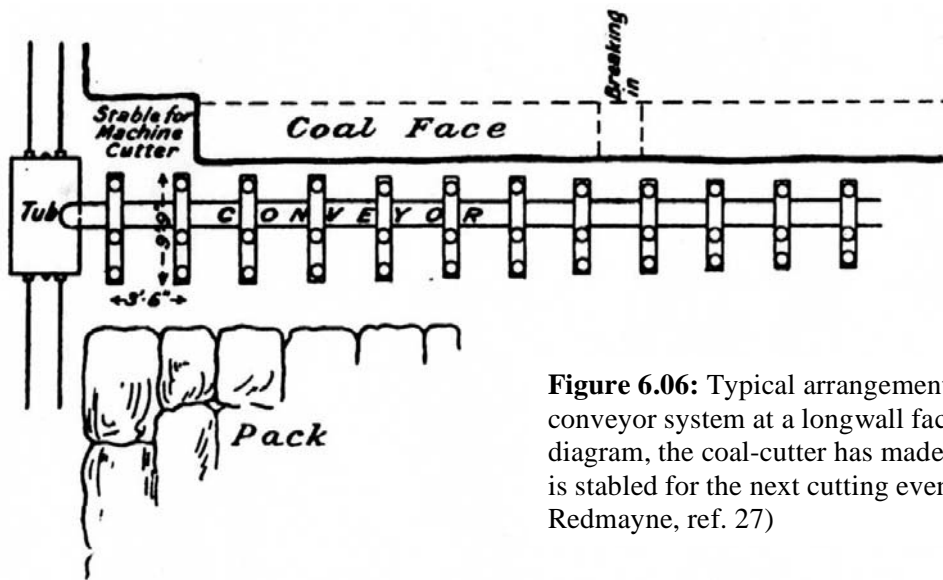


Figure 6.06: Typical arrangement of a conveyor system at a longwall face. In this diagram, the coal-cutter has made its cut and is stabled for the next cutting event. (From Redmayne, ref. 27)

Scott Turner's experiment with electric conveyors was stifled by what he viewed as incompetence. He pointed notably to a situation that had developed on the south side of the mine, where the conveyor stood idle at the head of 1913. A result of this situation was the shift of conveyors to the north side of the mine, where longwalling could proceed for a longer span of time. Furthermore, the company decided to replace its English

winter manager for one with American experience. The new manager came from a coal mining background based in Pennsylvania, and this may have contributed to a new method of mining being implemented at the property that summer.

Introduction of Room-and-Pillar Mining Method

In light of the company's frustration with the longwall mining method, Scott Turner inaugurated another experiment, one featuring the American room-and-pillar mining design. Instead of mining a continuous face, where the entire coal body was removed at once, the room-and-pillar method featured a series of individual "rooms" that were mined by smaller groups of men. A barrier of coal, or "pillar," separated the rooms from one another. After a network of rooms, sometimes called "stalls," had been opened up and cleared entirely, the miners would back out of the section, pulling all standing pillars as they retreated. Although the room-and-pillar design was typically employed within thick-seamed coal mines, like those found in America, Turner considered the method applicable to conditions found at Mine No. 1.

Room-and-pillar arrangements are wide and varied, and are as much dependent on mine conditions as they are on managerial preference. In this sense they can be regarded as flexible. At Mine No. 1, mine managers employed the "single stall" design, which featured a series of single rooms driven off a main corridor or gate (Figure 6.07). To start the process, a main haulage gate was driven to predetermined extent. The roof and floor were ripped to accommodate necessary haulage systems. A smaller, secondary gate was driven parallel to the first. This gate served as a ventilation tunnel that ensured proper air circulation within the system. After driving these two gates, a series of room entries were driven at right angles to the main corridor.

Side entries were driven into the coal body beyond a length allotted to a protective barrier pillar. This pillar ensured the integrity of the main haulage gate and ventilation tunnel. After passing the pillar section, the miners then opened a room thus preparing a small coal face, or 'short wall', for production work. From this point forward, mining was performed through either hand-got or mechanized methods. Rooms were generally between 5 and 6 yards wide, which meant that a different type of cutter-machine was

needed. Longwall disc-cutters needed to be started from an open gate. Since room-and-pillar stalls were not open-ended, the Arctic Coal Company employed a Sullivan short-wall chain-cutter, which was capable of cutting in confined areas.

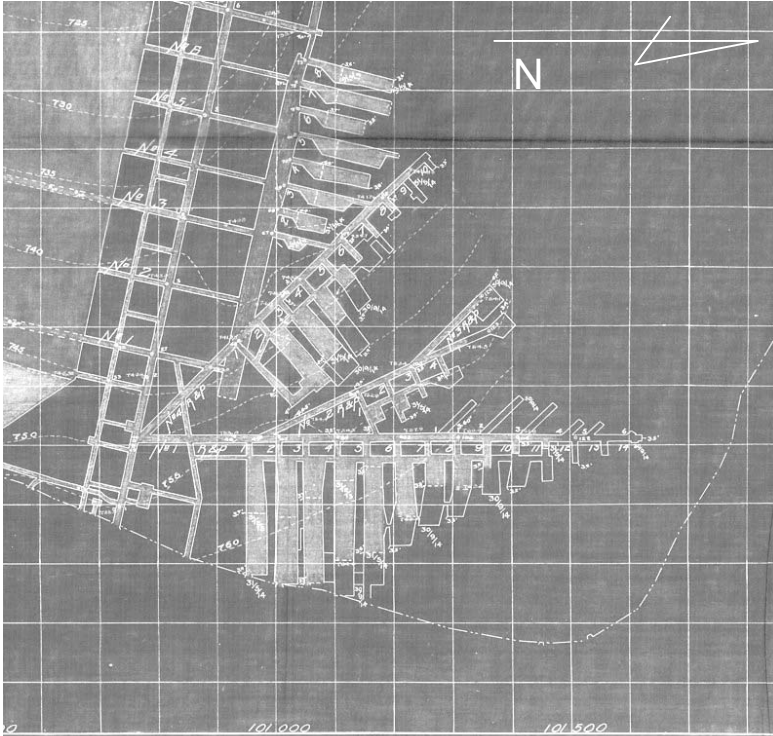


Figure 6.07: “Mine No. 1, Sept. 30th, 1915.” MTU Archives, Scott Turner Collection, Box Z, Folder 7.

Starting at one side of the room, the chain-cutter excavated the coal seam from the front of the face to the hilt of the cutter bar, which was usually between 5 and 10 feet in length.²⁸ After reaching maximum depth, the machine cut sideways towards the opposite side of the room, pulling itself along a length of chain anchored to jacks at both ends of the room (Figure 6.08). Once the undercut was finished, the cutter was backed out, placed on a special truck, and carted to an adjacent room. Like the Diamond longwall cutter, only the most skilled workers were allowed to operate the Sullivan machine. In all likelihood the machine operators were again British or American, perhaps with a Scandinavian assistant (Figure 6.09).²⁹

²⁸ King, S. B. *Bulletin of the American Institute of Mining Engineers*, No. 85. New York: American Institute of Mining Engineers. 1914.

²⁹ Atkinson, J. B. *Spitsbergen Coal*, 1913. Spetsberenarkivet, Vol. 4. Riksarkivet, Stockholm, Sweden.

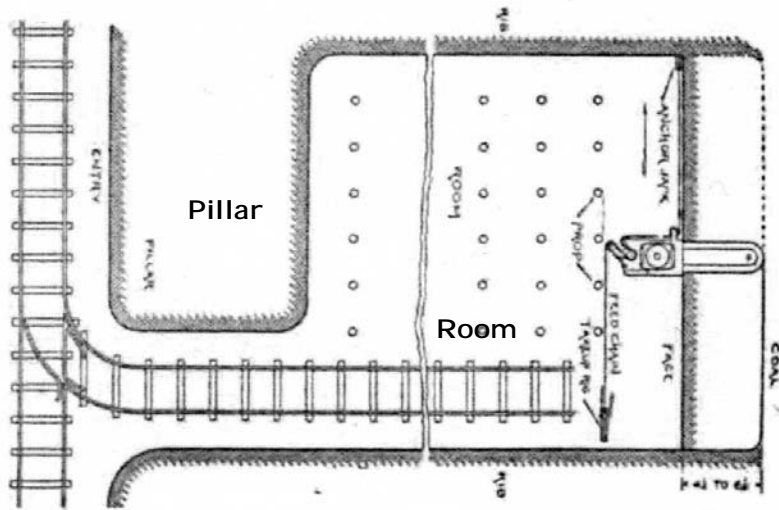


Figure 6.08: Room-and-pillar mining with Sullivan chain-cutter. The design is similar to that used in Mine No. 1. (From S. B. King, ref. 28).



Figure 6.09: Miners using a short-wall coal-cutter in Mine No. 1. Photograph courtesy of Keweenaw Digital Archive, Image#: MS018-001-031.

After making the undercut, blast charges were set by a single shot-firer and the hanging wall was dropped. Two fillers then entered the room where they proceeded to load out the broken coal via a narrow-gauge track system. The coal was carted into the main haulage tunnel and then on to mine's main entry. Once the room was cleared and propped, the chain cutter returned to make another cut in the face. If for some reason the

cutter was not available, two unskilled miners could perform the work themselves using hand-got methods or perform work in a separate room.³⁰

A 1915 engineering map of Mine No. 1 (Figure 6.10), drawn near the close of American ownership, presents the culmination of all work performed in the mine under American management. The two mining methods are displayed side-by-side, longwall mining on the left, room-and-pillar on the right. The map illustrates each method with their corresponding impacts on the physical layout of the mine, with shaded areas indicating “filled out” sections of the mine.

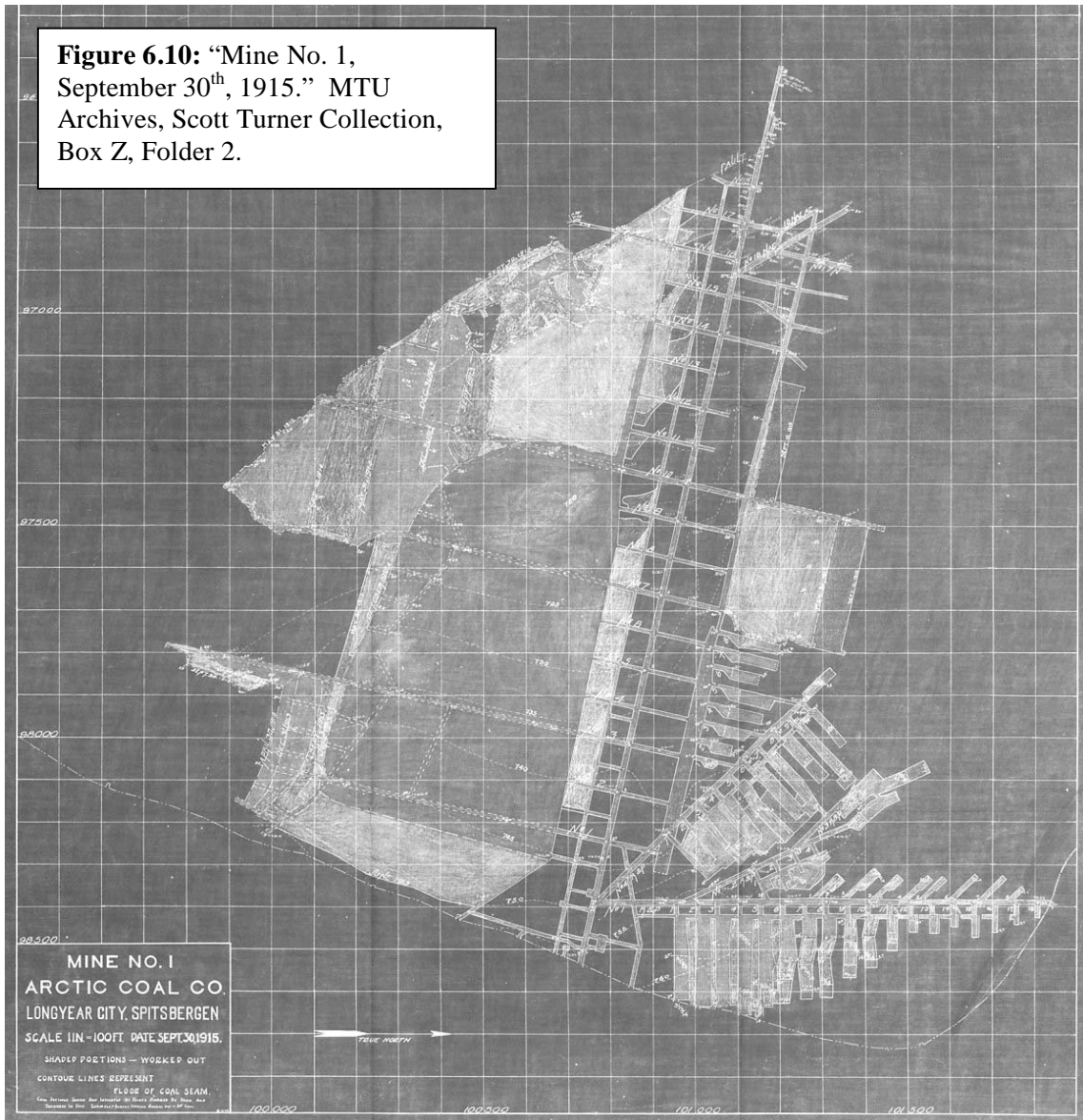
Coal Company managers praised the room-and-pillar system as it seemed to make better use of the company’s unskilled Skandinavian workforce. Turner had grown frustrated with the performance of the English longwall system in this regard and saw the American room-and-pillar method as the answer to organizational problems experienced with longwalling. One of its many benefits was its relative simplicity. Unlike longwalling, where efficiency was subject to the proper execution of a series of interdependent tasks, room-and-pillar work enabled miners to work in smaller, more autonomous groups. These groups were often as small as two people, who could perform much of the mining and filling work themselves.

Turner saw the room-and-pillar system as a benefit to both the men and the company. Under a contract system initiated during the winter of 1908/09, the men were encouraged to mine as much coal as possible, being paid by the tonnage.³¹ While the men theoretically increased their own income, the company benefited by having more coal to sell. However, since the longwall process was prone to breakdown, the men saw their contract income fade as they struggled to bring the system back into operation. The less coal they produced, they less money they earned.

³⁰ Arctic Coal Company. *General Manager’s Report Covering the Operations During the Fiscal Year September 1st, 1913 to May 31st, 1914*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15.

³¹ Gibson, John. *Report titled “Evidence”, November 18th, 1909*. MTU Archives, Longyear Collection, Box 1, Folder 13.

Figure 6.10: “Mine No. 1,
September 30th, 1915.” MTU
Archives, Scott Turner Collection,
Box Z, Folder 2.



than they may have otherwise been able to achieve.³² Observations such as this one are suggestive of frustrations within the body of laborers.

The room-and-pillar system employed at Mine No. 1 appears to have utilized a similar number of laborers when compared to the longwall system (Figure 6.01, column 2). Two or three rooms were assigned to one or two miners. These miners were thus responsible for their own tonnage, with little dependence on outside variables. The system increased motivation, at least in Turner's view, as the miners stood to gain more for their efforts. On laying out the room-and-pillar design, mine managers ran the main haulage tunnel at level, at the top of the grade. This did away with the need for a mechanical hoist, as the miners could push the pit-tubs with relative ease. Most of the rooms were opened on the eastern side of the main haulage tunnel. This way, the rooms ran uphill thus taking advantage of the grade. The coal mined in these rooms could easily be removed and trammed out to the mine entrance.

After a row of rooms was exploited, mine foremen diverted the labor to a new road where work could continue unimpeded. Mine managers appreciated the system because the men could keep their own working places for weeks at a time.³³ Unlike longwalling, which was prone to breakdown at any point in the process, the cycle of room-and-pillar mining could continue irrespective of the work performed elsewhere. For example, if all of the pit-tubs were in use and filling work could not continue in one room, a miner could shift his efforts to a separate room where coal could be mined by hand.

Room-and-pillar mining may have been selected for use at Mine No. 1 for a separate reason, one that relates to a secondary effect on the labor system. Since 1906, the company had experienced a handful of debilitating strikes on the Advent Bay property. The loss of a single workweek, or even a single day, had a diminishing effect on the company's ability to mine coal profitably. In consequence, company managers had to ship out groups of rabble-rousers thus prompting mid-summer hiring campaigns

³² Gibson, John. *Letter to Kenneth Gilson, June 30th, 1911*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 12, Folder "Gibson – July."

³³ Arctic Coal Company. General Manager's Report Covering Operations During the Fiscal Year September 1, 1913 to May 31, 1914. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15.

down on the mainland. Although never mentioned explicitly, the room-and-pillar system did keep men from congregating within the mine, while they could within the longwall system. By keeping the men divided, or at least in smaller groups, the company tacitly improved their control over the Scandinavian workforce. By lessening the chance for people to congregate during work hours, managers saw less chance for collusion against the company.

After Scott Turner initiated the room-and-pillar method in 1913, he paid close attention to its progress and compared it with the longwall practices on the south side of the mine. Ultimately, he became so convinced of the efficiency of room-and-pillar method that he employed it in the company's second mine on the opposite side of Longyear Valley (Figure 6.01, column 4). Nevertheless, the benefits of this method could only do so much in the face of other business concerns. The company's 1910 powerplant proved to be a constant nuisance for it was rife with functional deficiencies. In consequence, the mine could only run half of its electrical equipment at any one time. Coal conveyors could not be run simultaneously with coal cutters or hoisting equipment. Therefore the mine had to carefully synchronize its use of mechanical equipment, a challenging practice that no doubt teetered on the verge of breakdown in light of the difficulties experienced with the longwall system.

Transportation and Storage Systems at Mine No. 1: Introduction

Through the course of its operation on Spitsbergen, the Arctic Coal Company labored constantly to develop an efficient system of mining. We have now seen how the company expended considerable effort in revamping and tweaking underground mining systems, but several important changes also occurred outside the main openings. These exterior systems have particular importance to an archaeological examination of the *chaîne opératoire* because many related components and features remain observable, unlike the underground components. Much of this material was documented during the archeological research project performed in 2008, and reported in Chapter 5.

The transportation systems employed at Mine No. 1 vary in form and function. They range from simple narrow-gauge track systems erected throughout the mine and

property, to the sophisticated Bleichert aerial tramway capable of conveying large volumes of coal. Storage systems utilized by the company include voluminous coal piles, mine-based repositories and storage bins that delivered coal to aerial tramway buckets.

Each system features its own series of arrangements. Most are straightforward, relating more to essential extraction practices than anything else. Others are less obvious, suggestive of complexities within related decision-making processes. The contrast between the uncomplicated and the complex allows one to identify the fixed and flexible aspects of particular systems and arrangements. To develop a mine properly, managers had to first decide how to transport and store their product. Sometimes these decisions were simple; however, others were relatively complex requiring raised levels of ingenuity. Narrow-gauge track systems were a given, at least inside the mine. The same might be said for coal piles, although their use on Spitsbergen was a subject of concern for a brief period. Coal produced over the winter months had to be stored somewhere, somehow. Outside storage was the norm in coal mining, but could be problematic in the Arctic. On the surface, the Mine No. 1 mining system and related infrastructures feature seemingly normal arrangements. However, a closer inspection indicates that some of its components developed in respect to influences that were less than conventional.

Transportation and Storage Systems: Phase I (1905-1908)

During the initial phase of operations at Advent Bay, company managers immediately set to development of the new mine location. One of the first improvements was a narrow-gauge tram system that ran from the Advent Bay shoreline to the base of the mountain beneath the mine. This tramline was necessary for two reasons. The first related to the transfer of materials and equipment up to the mine location; the second for the conveyance of coal to the mining camp (Longyear City) and also to the shoreline for sale to the company's earliest customers. Although high-volume transportation devices ultimately superseded this system, the valley-based tramway was utilized for light purposes in town and at the mine for the remainder of the American ownership.

After installing the valley tramline, work shifted to a separate, mountain-based incline tramway. The incline, or "jinny track," was erected so that materials and

equipment could be transferred up the steep mountain grade to the mine. Since no electricity was yet available, the system employed gravity to move pit-tubs up and down the track alignment. The incline was comprised of two pit-tubs and a single wire rope. Although two cars were used, only one line of tracks was necessary for the system to work. Each car was situated at opposite ends of the line, one car up top, one down below. The wire rope ran from one car, around a mountain-based pulley, and then connected with the second car.

At the top of the mountain, a narrow-gauge track line connected the incline to the mine entry. At the pit-mouth this exterior line then tied in to the mine's interior network of tunnels and drifts. The same type of narrow-gauge track was used throughout the mine. Line extensions were constructed as the network expanded. These tributary lines facilitated the removal of coal from the mine's expanding development. Although men could do much of the tramming, the company employed a small number of mine mules to assist with the haulage in the main entry, which featured a shallow incline.

At this time the mine work was focused on development only and therefore all coal removed was from driving and tunneling. From the interior branches, laborers hand-trammed the pit-tubs to the main entry and then hitched the tubs to a mine mule. Most of the mule work took place in this primary tunnel since the roof and floor had been ripped to accommodate their size and stature. The mules hauled the coal to the mine entrance where it was detached and hand-trammed to the incline terminal. The coal then descended down the mountain, the weight of which facilitated the ascent of the bottom car. Along with timber and equipment, the bottom car carried up materials for masonry work at the surface plant.³⁴ Coal arriving at the lower tram terminal was carted through town to a shore-based coal pile where it could be used by the company ship or sold to passing whalers.³⁵

The infrastructure just described forms the first mine-based transportation system to be employed by the Arctic Coal Company. Although basic in composition, the system

³⁴ Gilson, Kenneth L. *Letter to ACC, September 1st, 1907*. MTU Archives, Longyear Collection, Box 4, Folder 18.

³⁵ Longyear, John M. *Reminiscences by John Munro Longyear*. Marquette, J. M. Longyear Research Library, Longyear Collection, Box 26. 1912.

permitted the company to transport coal and mine on a small scale. In respect to the *chaîne opératoire*, the transportation system, at this point, can be regarded as flexible. Although this particular system was guided by standard methods of procedure, the resulting arrangement featured a varied set of stages tuned to the conditions present at Longyear Valley. The same rules applied to the storage pile at the beach. Coal was needed at the shore for use and sale and since no other system existed, the company trammed the supply to the shoreline. This required multiple stages of handling. To pile it anywhere else along the way would require even more handling, an unnecessary action for an already toilsome arrangement of work.

During this phase of development, the Arctic Coal Company erected an aerial tramway system to facilitate large-scale production. The tramway had been planned from the start as a necessary fixture to deliver coal straight from the mine to awaiting carrier vessels. The valley track and incline system was simply a device to get things up and running. Like the incline, the Bleichert design employed gravity to convey coal from the mine down to a lower discharge terminal. Detachable tram buckets were filled at a mine-based coal hopper and then sent down the ropeway, the weight of the load conveyed the buckets to the lower terminal where they detached again and were dumped into a sea-going vessel. At least six men worked in the terminal; one man as a foreman and the others as bucket handlers (Figure 6.01, Column 5).³⁶

The Bleichert tramway interfaced with a new 1100-ton coal hopper, which stored the coal and delivered it to the tramway system (Figure 6.11). The device was installed amid growing concerns over outside coal storage. Prior to the completion of the aerial tramway, all coal produced by the mine had to be stored on the beach at the lower terminus of the valley tramway. A company manager noticed that the shore-based pile, when impregnated with snow and ice, had become difficult to work with and load. Moreover, the work necessary to build and transfer the pile required multiple handlings of the coal product by an indeterminate number of laborers. The hopper required much less handling and labor since the coal went straight from the mine to an awaiting ship

³⁶ Arctic Coal Company. "Addendum 2: Organization Chart – Winter Season 1914-15," *Annual Report Covering Year September 1, 1913 to May 31, 1914*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 15

with minimal human interaction. The bin sheltered the coal from the elements and served as a delivery vehicle for the tramway. However, it could only store 1100 tons, which was far below projected outputs for the improved mining system.



Figure 6.11: ca. 1915 image of the Bleichert aerial tramway and coal hopper. Enclosure at center sheltered tramway braking machinery. Photograph courtesy of Statsarkivet i Tromsø, Box 241.

Company officials initially considered placing additional coal pockets on the mountain, but scrapped the idea after some preliminary foundation work on the account of expense. The first coal hopper alone had cost the company a significant amount of money for labor and timber. The alternative was to store coal inside the mine. A consultant suggested that approximately 2000 tons could be stored in the main entry during the winter season, and the acting manager selected this storage alternative at the close of the first phase of production.³⁷

Upon completion of the aerial tramway and related coal hopper, the mine operation was now capable of delivering coal on a significantly larger scale. Instead of having to send all of its coal down the incline and through the valley, which was labor intensive and extremely inefficient, the outfit could now send its coal directly to awaiting ships for transport to market. Material evidence of these systems is located throughout the Mine No. 1 site complex, most obviously the coal hopper, the upper terminal, and

³⁷ Burrall, Frederick P. *Letter to Bertrand Mangham, July 19th, 1908*. Statsarkivet i Tromsø, Arctic Coal Company Collection, Box 2, Copybook: 1907-1908.

tower foundations for the aerial tramway. Features associated with the incline tramway and narrow-gauge rail lines are far subtler; mountain rubble and natural slumping have obscured most of their related contexts, but several incline foundations persist near the base of the mountain. Three footings identifiable on the hillside between the coal hopper and mine level are likely associated with the coal hopper that company managers planned to construct in 1908 but later abandoned (Figure 6.12).



Figure 6.12: Foundation footing for proposed coal hopper. The footing was constructed in 1908 as part of an effort to increase storage at the mine. The idea was abandoned by the following summer. 2008 photograph by Seth DePasqual/MTU.

Transportation and Storage Systems: Phase II (1909-1911)

The completion of the aerial tramway and coal hopper marks a significant change in the mining system, which is here regarded as the second phase of operations for the Arctic Coal Company. Up to this point, the company had been holding back on production since it had no way to effectively remove large volumes of coal. Now, with the new system, more coal could be produced and transferred from the mountain. However, the storage method for this increased coal tonnage remained in a state of flux.

Despite having decided to go with a mine-based storage plan, the concept was abandoned during the 1908/09 winter mining season for a separate, more convenient storage facility. Instead of piling all the excess coal in the mine, the winter mine manager identified an outside location closer to the lower terminal. The large, open area between tram towers 15 and 16 remained relatively free from snow due to the constant gust of prevailing Arctic winds. At the time, managers worried about melting snows and their

effect upon the quality of the coal. The new storage method pleased company executives on their return, for it seemed to allay their concerns about how to store properly the increasing volumes of coal produced at the mine. Furthermore, the lower coal pile saved the expense of constructing an additional hopper at the mine.

The creation of the winter stockpile introduced a number of modifications to the transportation system and organization of labor. To facilitate dumping at the pile, an elevated platform was constructed to bring at least four workers to the level of the descending tram buckets (Figure 6.01, Column 5). When a bucket passed by, a worker tripped a lever and the coal dumped onto the ground below (Figure 6.13). As the stockpile grew in volume, it expanded from the aerial tramway at right angles. On top of the growing pile, the team of laborers carted the coal from the elevated platform across a narrow track system. The company installed a small railway at the base of the pile to facilitate the transfer of coal to a separate surface incline. This incline bisected a prominent bluff and ran down to the lower pier. The lower incline tramway utilized gravity to transfer its load.

Most of the stockpile work was likely performed in the spring after the coal hopper had filled and when dangerous snowstorms had subsided. Since nothing could be offloaded until the summer, the stockpile incline saw little use until the first boats arrived. The incline system was set up to run simultaneously with aerial tramway loading. In 1910 the company installed a steam-powered crane that transferred stockpiled coal to the incline at a much faster than a team of laborers. The device rested on a steel traveler and moved along a heavy-gauge railway. When shipping season began, a crane operator loaded the coal into large cars, which were then sent down the incline to a landing platform. From this point the cars were hitched to a cable and hoisted across a long pier to a transfer station beside the lower aerial tramway terminal. The company employed a steam-powered winch to do the hoist work from the dock.

The year 1910 marks a significant upgrade in the mining system at Mine No. 1. This is when the company invested in a power plant to provide electricity to the mine and property. At the mine, the upgrade supported the installation of new mechanical apparatus including coal-cutters and rope hoists. While the former assisted with how the

mining was performed, the latter proved useful for product transfer. Inside the mine, at the head of the main entry, the company installed an electric main-and-tail hoist so that more pit-tubs could be removed at one time. The machine greatly improved haulage capability since it could raise a train of 25 cars at once.³⁸ The increase reduced the amount of laborers and time necessary to haul tubs to the mine mouth.



Figure 6.13: 1909 photograph of coal stockpile between tram towers 15 and 16. A wooden scaffold is visible at the top of the pile. The incline cable system is seen at lower-right. Photograph courtesy of Keweenaw Digital Archive, Image#: MS031-01-01-15.

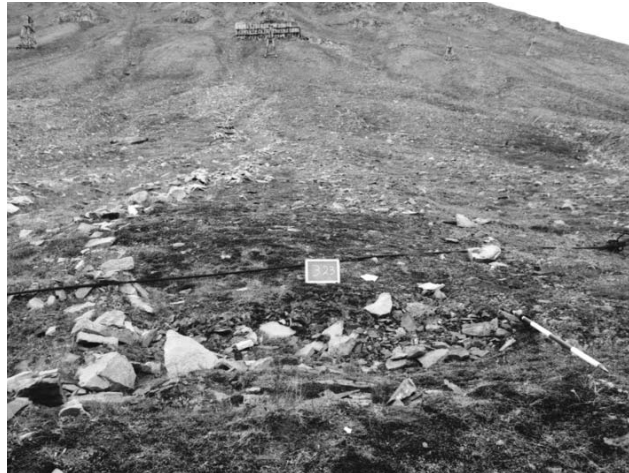
The company installed a second electric hoist at the top of the mine's surface incline. This device did away with the gravity system, which depended on a top load to bring up materials from below. Furthermore, the hoist was capable of lifting heavier loads than had previously been possible. In addition to timbers and construction materials, mine workers could be hauled up from the valley floor aboard an improvised man-car. Until then, the only way up to the mine was a steep, arduous miner's trail that took upwards of 45 minutes to hike. The company saw this as an improvement to the mine's overall efficiency since the men were on site and available for work after a three-minute ride up from the valley floor.³⁹ Additionally, the incline was elevated to a height of five feet in order to keep the causeway free from heavy snow accumulations. Before this improvement, winter laborers had to constantly clear snow from tracks, which were covered with each passing storm or wind event.

³⁸ Atkinson, J. B. *Spitsbergen Coal, 1913*. Spetsbergenarkivet, Riksarkivet, Vol. 4. Stockholm, Sweden.

³⁹ Arctic Coal Company. *General Manager's Report, November 5th, 1910*. Michigan Tech Archives, Longyear Collection, Box 4, Folder 23.

The 2004 and 2008 surveys at Mine No. 1 identified a number of features related to these systems. Portions of the incline tramway survive; however, natural slumping has obliterated much of the related superstructure. A series of small foundations were located near the base of the incline (Figure 6.14). These features are part of the 1910 upgrade, which represented a small, although significant shift in how work was arranged at the mine.

Figure 6.14: Stacked-rock foundation for incline tramway. Foundations such as this one were used to elevate the incline from the ground surface. The improvement was made in 1910. 2004 photograph by Larry Mishkar/MTU.



The lower stockpile also represents a shift in how the company organized its transportation and storage systems. In adopting the outside storage plan, the company (or winter manager who located the site) introduced a whole new system of infrastructure and labor arrangement. At least four men were now needed at the stockpile, which necessitated the installation of a new track system and incline. Despite the added expense, the company saw this new arrangement as necessary. Coal tonnages were expected to increase and they needed a place to store related output. Although the stockpile is separate from the Mine No. 1 site complex, the operational chains are interrelated and therefore worth noting. The creation of the stockpile between towers 15 and 16 represents a certain degree of flexibility within the arrangement of transportation and storage at the Longyear Valley property.

Transportation and Storage Systems: Phase III (1912-1915)

The two electrical hoists at the mine greatly increased the effectiveness of the transportation system by enabling larger volumes of product and material to be transported at one time. Moreover, fewer men were necessary to perform the same amount of work. However, there remained a number of inefficiencies at the mine, which would require further refinement. What's more, increasing tonnages at the stockpile demanded additional improvements to the conveyance system. So by 1912, after all that had transpired, the mining system at Longyear Valley left much to be desired.

To facilitate increased haulage at the stockpile, the company widened the lower incline from two tracks to four. The same was done to the 600' pier, which connected the line to the sea-based loading station. An additional steam-powered crane was placed at the stockpile in 1913, although the first permanently broke down shortly thereafter. In 1914 the company installed a second ropeway to assist with haulage at the stockpile. Powered by an electric engine, the horizontal branch line conveyed coal from the dumping station beneath the aerial tramway to the far extension of the stockpile. The tramway did away with the need to hand-tram coal across the top of the pile, which freed men for use on other aspects of the system.

At the mine, a new electric hoist was installed approximately one-third of the way down the main entry. The company used the device to haul pit-tubs from the south side of the mine, which had been affected by a steep roll in the coal seam. The miners complained about having to hand-tram the heavy tubs up steep grades to the main entry. Furthermore, a batch of new, steel tubs frustrated the men since they were heavy and unwieldy, so much so that they refused to use them until the haulage system could be improved.⁴⁰ The installation of the new mine hoist in 1913 rectified some of these problems.

Although many other improvements to the mine and property were proposed, little development was performed after the summer of 1914 due to associated costs and the escalation of World War I. By 1915, the company had reduced its workforce and

⁴⁰ Arctic Coal Company. *Manager's Report Covering the Fiscal Year October 1st, 1911 to October 1st, 1912*. Michigan Tech Archives, Scott Turner Collection, Box Z, Folder 13.

limited mine work to production only. The following winter, the Advent Bay property and all related infrastructure was sold to a Norwegian interest.

Since the 1916 transfer of ownership, the stockpile site has seen a variety of industrial events that have obscured many of the features related to Arctic Coal Company activity. However, some features related to the former stockpile site are still present on the landscape. For example, the carrier chassis for the Brown hoist remains in situ on top of a sunken section of railway (Figure 6.15). The crane was brought to the site in 1913 as part of Scott Turner's expansion project for the auxiliary loading system. This feature is evidence of the company's constant attempt to improve the efficiency of its delivery system for transport ships. The crane represents a period of flexibility within the transportation and haulage system. The hoist was not brought to Advent Bay because of its significance within a larger company plan; instead, the crane was purchased as a reaction to changes in a technical chain that had preceded it.



Figure 6.15: Carrier chassis for *Brownhoist* crane. The crane was brought to Advent Bay in 1913 to assist with haulage at the stockpile. 2007 photograph by Seth DePasqual/MTU.

Summary

Archival records and features discovered at the Mine No. 1 site complex and lower stockpile offer many tangible residues of the mining systems just examined. Each provides some level of connection to how labor systems were organized throughout the technical landscape. The mine maps presented earlier in this chapter present clear renditions of mine activities guided by technical, environmental and social influences.

The dichotomy between the longwall and room-and-pillar methods is visible in Figure 6.10. The map gives us a partial sense of how labor and technology was ordered within the mine. Our understanding is enhanced when we compare the map with the organizational chart in Figure 6.01. Although we may understand how many people worked in the mine at any given season, the chart shows us clearly how people were ordered within the technical system. These historic records, or artifacts, engage the viewer by offering them a visual perspective of a now-closed mining environment.

Material residues of social involvement within the Arctic Coal Company mining system are also found on the physical landscape that hosts the Mine No. 1 site complex. At least three rock dumps were located along the coal outcrop, each the product of “ripping” and tramming practices within the mine. Miners used these dumps to dispose of excess rock material deemed unnecessary for packing. Furthermore, a fragment of a cutting disc for a Diamond coal-cutter was located on the level platform outside of the mine. Although useful in a technical sense, the artifact also tells of a particular arrangement of tasks that took place within the closed mine.

This landscape also retains evidence of the mine’s varied transportation and storage systems. Foundations found on the slopes beneath Mine No. 1 relate to the mine’s incline tramway, a system that experienced multiple improvements over the years. The stacked-rock formations are manifestations of the company’s intent to keep its men mining as opposed to clearing snow from the lengthy track. The standing coal hopper, unfinished hopper foundations and lower stockpile area are testaments of attempts to effectively store and move coal through the mine’s continuously evolving mining system. The unfinished hopper foundations evidence a period of managerial indecision, when company supervisors attempted to sufficiently adapt methods of coal storage to arctic conditions.

Within each feature lies a back-story in which company managers juggled men with varied pieces of equipment in an effort to create the ideal. On first glance, these features seem to reflect standard methods of operation, sequentially ordered in respect to managerial decisions made over time. While technical and environmental influences no doubt had a role in the placement of these items, socialized aspects had some weight in

related decision making processes. When these artifacts and features are viewed in their respective contexts, and related operational chains are examined, one gains a sense of the impacts that they had on the larger, technological system. Looked at the other way, these same artifacts reflect the impacts of social organizations with which they interacted.

Chapter 7: Conclusions

This thesis represents my attempt to contextualize a mining system with focus on the technical, environmental and social influences that shaped its development. By recognizing these influences and their impacts on a given technological system, one can discern fixities and flexibilities that are not always accounted for in historical discussions and archaeological research. These elements are responsible for the evolution of a particular method, practice or technical system. Stepping back from Arctic Coal Company Mine No. 1, so that that the mining system can be seen in its entirety, one begins to appreciate the interconnectedness of the subsystems at play. In many ways, these systems are examples of decision-making processes that were guided by technological determinants. The Bleichert aerial tramway is an apt example. From the beginning, Arctic Coal Company managers knew that an aerial tramway system was the most suitable method for conveying coal from the mine to the ship loading facility. Although relatively expensive, the gravity-powered system transferred the coal with fewer instances of handling.

Less apparent in these systems are the aspects brought on by social and environmental influences. This complication steers us towards the *chaîne opératoire* approach, which allows researchers to parse out the details of technical processes in order to recognize areas prone to modification and change. Once these areas are understood, we begin to take in the ways that technological systems are assembled and directed. Given an appropriate system, in this case the material remains of Mine No. 1 mining system, researchers might benefit from examinations that attempt to find social meaning within technological arrangements.

This brings us back to one of my original research questions: how is the *chaîne opératoire* evidenced within material culture and how does this approach help us understand social involvement within industrial contexts? Chapter 6 offers plenty of examples where social involvement is visible within the material record. From mine maps to hopper foundations, we can see aspects of diverse efforts to perfect the organization of tasks.

The mine map in Figure 6.10 presents a clear rendition of the company's decade-long attempt to mine coal profitably. This struggle is manifested on the map through depictions of tunnel networks, shaded areas and the outcrop delineation. When combined with relevant history, the map becomes even more useful as an example of "active" *chaînes opératoires*. All of the systems employed within the mine, each with its own chain of operations, are presented on the mine map. The technical aspects of mining methods can be deciphered through consideration of the size and shape of shaded tunnels and polygons. Environmental influences, like those related to the fault and south-side "dip," are represented by the fault line and secondary opening south (left) of the main entry. Socialized elements are embodied within the longwall and room-and-pillar mine workings displayed on the map.

Many of the map's features can be regarded as transitional; they are tuned to the contingencies at play. Related shifts in mining strategy hint of embedded flexibilities within the system. The transition from longwalling to room-and-pillar is probably the best example of variability on the map. These renderings exhibit some of the skills necessary to effectively mine a coal resource. We can trace the application of longwall methods to the south, and the resulting room-and-pillar to the north. By doing so, we essentially retrace the efforts of management to mine coal efficiently in the face of untoward mine conditions and unskilled bands of laborers. Moreover, we catch glimpses of the effects that employees had on the system. Their actions, and *inactions*, no doubt shaped sections of what is seen on the map.

Since physical evidence related to the interior mining system is limited to what can be found outside the mine, researchers lean heavily on archival records to answer questions related to underground activities. Mine maps, such as those presented in Chapter 6 serve as worthy alternatives to ground-based artifacts and features. When coupled with analyses of related history and mining practices, these cartographic artifacts offer much to those seeking material residues of the *chaîne opératoire*.

Outside the mine, archaeologists look to physical manifestations of the mining system for clues relating to the processes that took place inside. The three or four rock dumps discovered in the area identify the locations of collapsed mine portals, which tie

into the mine's closed tunnel network. The piled rock is a by-product of the mining process, having been extracted from the roof and floor to make room for haulage tunnels. Although much of this rock was used for pack walls, excess quantities needed to be disposed of elsewhere outside the mine.

The dumps are not placed at random, but are firmly tied to conditions within the mine. Those located south of the main entry are related to the longwall method, and are positioned at elevations beneath that of the main entry. This is because the coal seam dipped towards the southwest, south of the main entry. These features represent the company's effort to make rock disposal more efficient. Without them, the labor would have been forced to haul the rock against the grade to the main entry where it was then hoisted to the surface. The southern dumps bypassed this laborious process, which had become frustrating for all parties involved.

The cutter-disc fragment and wooden pit-tub found near the mine's entrance enhance our understanding of the methods employed within. The cutter-disc relates directly to the use of the mechanized longwall method. From this artifact we can infer probable arrangements of men and work that took place inside the mine. When the disc fragment is compared with available mine maps, we can logically speculate on areas where the artifact was employed. The object certainly points to a task performed by two skilled laborers, one whom undoubtedly American or British. While the cutter-disc represents many technical aspects of the mining system such as those related to the electrification of the property, the item is also a reflection of the organization of men within the mine and the skills necessary for its operation.

Similar connections are made with the wooden pit-tub, which rests adjacent to the disc fragment. The short height of the tub is attributable to the environmental conditions experienced within the mine. Furthermore, the "1909" date stamp on the tub's body hints of use within a pre-mechanized mining system. If so, the tub reflects a period of time when mine laborers had to push carts to the longwall faces. This particular system relied heavily on the efficiency of the individual laborer, where progress was a function of how fast one could fill and remove a single tub so that others could proceed behind him.

Taken separately or together, the disc fragment and pit-tub amplify what is known about production processes and how they were organized within the mine.

Chaînes opératoires are equally visible when looking at the mine's transportation and storage systems. The stacked-rock foundation pads located beneath the mine tell of the company's effort to streamline the operation of the incline tramway. Heavy snow and wind events rendered the earlier system inefficient since men frequently had to clear the causeway for it to function properly. Furthermore, the elevated track system enabled the company to convey men directly to the mine from the valley floor. The upgrade greatly improved system efficiency and the productivity of labor at the mine. The remains of the Bleichert aerial tramway exemplify the company's effort to bypass the extensive handling of coal, which was necessary during the initial phase of mine development. However, this system improvement forced the company to redress its method of storing coal on the property.

The remains of the coal hopper are an example of the company's intent to store coal within a protected environment. The sheer expense of this feature proved to be prohibitive, forcing the company to pursue viable alternatives. The three foundation footings identified below the mine entrance attest to this moment of transition, when company managers shifted from enclosed storage systems to open stockpiles of coal. For a brief period, the company considered coal storage inside the mine. This action would have compelled the company and its laborers to handle the coal multiple times before it reached a ship's cargo hold. The company may have adopted this burdensome process if not for the winter manager's decision to go with open storage.

The stockpile is another example of flexibility within the mining system. Although the site and related infrastructure has largely vanished over the years, the area does feature some material components associated with the former storage deposit. The most prominent is that of the Brownhoist carrier chassis. This feature relates to the company's effort to streamline the transportation branch-line between the aerial tramway and lower incline. While the decision to purchase the machine was likely based on concerns with a separate, unreliable hoist, the device also represented a particular organization of work, where smaller teams of men could handle larger volumes of coal.

Its presence on site represents a flexible aspect of the transportation system, where machinery was purchased to address deficiencies in previous work arrangements. However, these mechanical devices introduced their own set of problems. This is exemplified by the reliability of the first hoist, which broke down frequently enough to warrant the purchase of a second, more reliable apparatus.

As we have seen, the coal mining system applied by the Arctic Coal Company featured a variety of technical subsystems whose arrangements reflect determined efforts to produce and transport coal efficiently. Clearly these systems were subject to changes due to technological and environmental conditions and yet mining systems are fundamentally a cultural practice. Mine managers actively labored to design the most efficient system possible under a variety of expected and untoward conditions. Labor bodies needed to be modified and manipulated between ranges of tasks in order to keep the mine running effectively. Viewed from the other direction, mine laborers struggled with the arctic climate, unfamiliar work environments and seemingly low wages.

This brings us to another question: what new perspectives does the *chaîne opératoire* approach provide about how coal mining at Mine No. 1 proceeded between 1905 and 1915 under American management? The mine site serves as a great backdrop for analyses of industrial mining systems in the Arctic. The various subsystems employed by the company are some of the earliest attempts to mine coal at a large scale on the archipelago. These systems, and their physical manifestations, reflect aspects of contingencies that were encountered and negotiated by the company. Sometimes these events were uncomplicated, relating more to standard methods of procedure than anything else. Others posed as dilemmas, themselves products of complex arrangements between technology and men. The environment levied its own pressures, be it heavy snow accumulations outside the mine or the conditions of the coal seam within. Either way, the mining system employed by the Arctic Coal Company was unique, featuring a composition that resulted not from ordinary ways of doing things but from a hybrid of events and influences that were special to the Spitsbergen location.

Aside from a rich inventory of site descriptions, this investigation has also produced a detailed analysis of the mining system employed by the Arctic Coal

Company. This examination considers a number of related subsystems that are each comprised of specific tasks and work organizations. In parsing out the details of each system, this study has brought to light areas that are flexible or open to change. On recognition of these areas, we begin to understand how particular systems take form and progress. The *chaîne opératoire* shows us that these systems are rarely guided by linear courses of thought or action. Instead, they develop through interactions with multiple variables including those related to environmental and social influences.

The *chain of operations* approach provides researchers with a particular lens of interpretation that can be useful for understanding industrial settings. The method takes into account the effects of human agency and influence on the technological systems involved. In the case of Mine No. 1, the author found the method to be helpful when considering aspects of the production, transportation and storage systems represented on site. Wanting to offer more than a discussion of technological applications in the arctic, *chaînes opératoires* allowed me to delve into the archival and material records with a new perspective, one that enabled me to discover meaning within the “softer” elements of technical arrangements. I believe that the resulting discussion offers a fresh perspective on industrial development in the Arctic, where the environment, technology, and men interacted in many interesting ways.

Directions for Further Research

Although this examination was fruitful in many respects, several arguments can be made for further research related to the history of the Arctic Coal Company. Despite the sheer immensity of company records and documents available between four separate archival repositories, this information offers little from the perspective of labor. Much of what is available is written from the standpoint of management, which is often indifferent and/or adversarial towards the dispositions of lower-tiered employees and laborers. Ideally, we could compare the known archival materials with a body of diaries and texts written by the common peoples that hired on with the company. Right now, the voice of these laborers remains largely unheard. If such material does exist, it would most likely be found in private family collections between Norway and Britain. This type of work

can be difficult to perform from America; however, a recent connection with a relative of Bertrand Mangham, the English mine superintendent, offers some incentive for this line of research.

The State Archives of Tromsø features a massive collection of company documents that cover the entire period of American ownership of the property. Within this collection there is wide range of “copybooks” that cover daily expenses incurred by the company. Although it is not for certain, these logbooks might contain information about the individual employees and how much they were paid. This data could prove useful to questions concerning the company’s use of an ethnic hierarchy, where pay rates are presumed to reflect the ethnicity of a particular employee. Furthermore, if these logbooks do contain the names of the people employed, one could use this information to track down the whereabouts of family documents that might offer a bottom-up perspective on the Arctic Coal Company enterprise.

While performing research at the State Archives of Tromsø in July of 2008, MTU students learned of an additional collection located within a separate, downtown museum. The collection was donated by the family of Carl Sæther, the Norwegian clerk who worked for the company between 1907 and 1916. He then worked for the Store Norske Spitsbergen Kulkompani after the purchase of the Advent Bay property. Sæther’s position was unique in that he interfaced with both upper management and common labor. He performed much of the company’s hiring out of the Tromsø office and was privy to the activities of company managers. The author understands that this collection contains a batch of photographs of the Spitsbergen region; however, it is not clear if it also includes diaries and/or correspondence related to Sæther’s time with the Arctic Coal Company. If it does contain this type of material, such information might prove useful to understanding more about the perspective of labor during American ownership of the property. Sæther was Norwegian, and might have felt some level of compassion for his fellow countryman. His journals or correspondence might offer new insight into how Norwegians reacted towards the company and its management practices.

Archaeological research perhaps offers the greatest potential for gathering information on working class histories that transpired at Advent Bay during the early 20th

century. Old Longyear City is an ideal setting for this line of investigation since many of the buildings and facilities were manifestations of work-related hierarchies. For example, housing arrangements were dependent on an individual's level of skill and, sometimes, ethnicity. Although these barracks are now reduced to ruins, their integrity remains intact due to moderate levels of site disturbance. These ruins, and any related privies, offer a chance to examine the more personal lives of those employed by Arctic Coal Company as well as the early configuration of the Store Norske Spitsbergen Kulkompani. Evidence could be compared between dwelling sites habited by upper managers, families, miners, and general laborers. Information gleaned from archaeological research could be compared to that found within the historic record. Moreover, it would be interesting to see what, if any, changes occurred after the property was purchased by the Norwegian company. If changes did occur, how might they be manifested in archaeological record? And what does this tell us about the companies and the actors involved?

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