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Imprints on the Resource Landscape

The Long History of Mining in the Arctic

ABSTRACT For several years, public debates about the future of the Arctic have included the growing global needs in minerals and energy resources. To explain and manage this development, it is important to understand impacts of previous extractive industries in the north. Using theoretical approaches from economic geography and science and technology studies, the aim of this article is to describe and explain the growth of mining in the Arctic and its consequences for people and environments. How and why have minerals in the Arctic been constructed as natural resources? What systems have been built to extract them, and what were their consequences? How has the legacies of mining been managed when the extraction has ceased and why? The development of mining is explained as resulting from not only economic interests, but also geopolitical considerations, institutional frameworks and cultural-ideological trends. The same drivers are involved in the making of post-extraction futures and the way people relate to the mining legacies through environmental remediation, re-purposing and heritagization.

KEYWORDS mining, environmental impacts, social impacts, socio-technical systems, heritagization, environmental remediation, Arctic, Norrbotten, Greenland, Svalbard

The dramatic decline of the summer time ice coverage in the Arctic Ocean, has raised hopes that it might become easier to access natural resources in the Arctic.[1] For several years, public debates about the future of the region have often reflected an interest in minerals and energy resources. It is mainly global economic forces that lie behind this thirst for resources, driving up prices and demand for minerals. To explain and manage this development, it is important to understand how the interest in the Arctic's natural resources has grown over time and the consequences this has had (Avango & Högselius 2013; Avango *et al*. 2014; Vikström & Högselius 2017).

The mining industry in the Arctic is not new. On the contrary, it has been operating since the seventeenth century. Mining, although it has not been the only raw materials industry in the circumpolar region, occupies a special position historically, partly because of the great economic value it has generated, partly through its often far-reaching implications for communities and environments. The mining industry has meant different things to different people. What some have perceived as a hope for economic

growth, a geopolitical resource, a source of income and the basis of a functioning life, has for others meant an unwanted reshaping of living environments, a threat to culture, lifestyle and other land use. The mining industry has also left its imprint on landscapes and minds—a legacy that people have had to deal with.

The definition of a mine is sometimes a topic of debate, especially in controversies over new mining projects. Is it just the mine itself that should count as an environmental consequence? Or should we also take into account the impact of transports and energy supply? Without taking a stand in such debates, more and more researchers are trying to apply as holistic a perspective as possible. Inspired by the historians of technology, in this chapter I have used sociotechnical system theory (Hansson 1994; Hansson 1998; Hecht 2004; Hughes 1983; Hughes 1987; Kaijser 1994). The basic idea is that technology cannot be understood outside its social context, but always as part of larger systems that also have societal elements. This means that mining consists not only of mineral deposits, pits crushing and enrichment plants, but also of infrastructures for transport and energy, and of people such as workers, service personnel, and engineers, and of entire communities with housing and service. Considered as sociotechnical systems, the mining industry also consists of organizations—companies, government agencies, associations—as well as the laws, rules, and practices that govern the activities. The system also includes market players who influence demand and prices. A holistic perspective like this is needed to describe and explain the emergence of the mining industry and its consequences for communities and environments. Without a holistic approach, it is also difficult to assess the potential and consequences of the mining industry in the future.

A related question is what constitutes a natural resource. The human geographer Gavin Bridge has stressed that this is not something that can be understood as existing in an independent sense (Bridge 2009). Nature consists of various physical and biological phenomena, but if these are to become natural resources, people have to attribute a value to them, and there must be sociotechnical systems to extract and transform them. From this theoretical starting point I shall try here to explain the growth of the mining industry in the Arctic and its consequences. How have minerals in the Arctic been constructed as natural resources? What systems have been built to extract them, and what consequences have these had for humans and environments? How has the legacy of the mining industry's systems been managed when the extraction has ceased?

Early Modern Mining

People in the Arctic extracted minerals from rock long before colonists and mining industrialists arrived there—in North America copper, in Greenland soapstone, quartz, and iron from meteorites (Cooper 2011; Sejersen 2014). It was not until the seventeenth century that people from the south began to take an interest in large-scale extraction of minerals in the Arctic. The mining industry they built up resulted in two important changes. One was the establishment of a new order in which it was mainly powerful players from economic and political centres in the south that extracted the Arctic's natural resources, to generate and use profits outside the northern region. The second was that the Arctic thus became a target for the emerging European colonialism.

An example of this development is Sweden, where the crown in 1635 established a silver mine deep in Sami territory, at Nasafjäll on the border with Norway, which was then part of the kingdom of Denmark. The mine—located high above the tree line—was linked to a smelting plant and a settlement at Silbojokk east of the mountain chain, with shipment from ports on the coast of the Baltic Sea hundreds of kilometres from

there. The miners were brought from the south, while local Sami were forced to handle the transports (Nordin 2012). That this happened at this time and in this place was because the Swedish state needed more finance to wage war in Europe, and according to the dominant economic idea of the time, mercantilism, this was best acquired through precious metals such as silver. At the same time, the state looked at northern Scandinavia through the eyes of an aspiring colonial power. This was a time when European states such as Spain, Portugal, Holland, and England were starting to build colonial empires, from which the crown and trading houses could enrich themselves with precious metals and other commodities. As the archaeologists and cultural heritage researchers Magdalena Naum and Jonas Monié Nordin have pointed out, the Swedish state and the elite of society had similar ambitions, as exemplified by the establishment of the Delaware colony in 1638 and the Swedish Africa Company's trading post at Cabo Corso in West Africa. The attitude of the crown to Nasafjäll is hinted at in the words of the Councillor of the Realm Karl Bonde: "With God's help, this will become the Swedes' Caribbean" (Ekengren *et al.* 2013: 169).

Fig. 1. Remains of the seventeenth-century Kengis iron works, by a rapid by the Torne River. The works and the river itself was a part of large socio-technical system for mining and steel making in the Swedish Arctic. Photo: Dag Avango.

In 1645, a decade after the opening of the mine at Nasafjäll, the state gave private operators rights to begin iron production at Kengis in what is today the municipality of Pajala. They built up a system of mines, blast furnaces, hammer forges, and transport routes that came to cover the entire Torne valley (Moiné Nordin & Ojala 2015). These mining ventures were not the only ones in northern Scandinavia in the early modern period. Mineral resources were also a central component of other countries' colonial interests in the north, such as the Danish colonization of Greenland from 1721 (Stenfoss & Taagholt 2012: 78). What these mining enterprises had in common, however, was that none of them generated much income. In fact, the operations lasted only a few decades.

The colonialists who made their way to the North American Arctic in early modern times were looking for other resources. They mainly wanted furs and whale oil rather

than minerals. In the Eurasian Arctic, likewise, those active in fur hunting played an important role in propelling the Russian colonial expansion in Siberia from the end of the sixteenth century (McCannon 2012: 78–100). All in all, these efforts helped establish a new way of imagining the Arctic—as a region suited to colonial expansion and exploitation of natural resources for markets in the south.

Mining in the Industrial Era

The great expansion of the mining industry in the Arctic began in the mid-nineteenth century. The reason was the rapidly accelerating industrialization in Europe and North America, which created a growing demand for metals (Vikström 2016). Iron was used to make the machinery of the new factories, to build railway locomotives, wagons, and rails, and later a growing amount of consumer goods. In Sweden, the iron and steel industry increased production from about 76,000 to 1,000,000 tonnes between 1830 and 1900 (Isacson & Nisser 2011: 92–96). Electrification led to a greater demand for copper, whose conductivity was utilized in everything from wires to lamps. In order to supply the cities' electric power stations, the factories' steam engines, and the railway engines with raw materials, there was also a rising demand for coal, the main source of energy at this time. The mining industry grew most vigorously in already established mining regions, but when prices were high the mining companies also turned their eyes to deposits in areas located farther from the industrial economy's central areas, including the Arctic. New research on the geology of northern areas, as pursued at universities, academies of sciences, and government organizations, also contributed to this, along with local people's knowledge of where minerals could be found (Avango 2005).

It was not only economic changes that attracted industrialists to establish mines in the Arctic. Sverker Sörlin is one of those who have demonstrated how the north of Sweden was established as a land of the future in the nineteenth century in literature, media and art. A new Sweden would be built using the riches that lay concealed in the northern mountains and forests, not only through resource extraction but also through science and cultural improvement. The craze helped to stimulate economic players to seek their fortune in the Arctic (Sörlin 1988*b*; Sörlin 2002). Global colonialism also contributed to the interest. Since the early modern period, several colonial powers had expanded, especially in continents where the Scandinavian countries lacked the strength to compete with the great empires. The exception was the Arctic (Avango *et al*. 2017).

The development of technology was another factor contributing to the growth of the mining industry, as exemplified by the large iron ore mines in the interior of Norrbotten—Malmberget (established in 1888) and Kiruna (1900). These iron ore deposits had been known since the seventeenth century, but no one had shown any interest in starting mining operations there. One reason was that the ore contained too much phosphorus, which made it unsuitable for the manufacture of steel. From the end of the 1850s, the steel industry developed new technology to increase production capacity. The Thomas process, introduced in 1878, made it possible to produce high-quality steel even from iron ore that was rich in phosphorus. For mining industrialists this made the extraction of Norrbotten's ore financially lucrative (Hansson 1998).

Another obstacle was that the deposits were in the middle of the country, in an area that lacked infrastructure for moving large volumes of ore, equipment and staff to and from the coast. The mining industry solved this with the help of another great innovation of the nineteenth century, the railway. In 1882, the state granted a concession to a British company to lay rails from Luleå on the Gulf of Bothnia to the ore deposits in

Gällivare. It was completed in 1888. That same year, a British mining company was able to start large-scale mining for iron ore at the site where the town of Malmberget was later built (Sörlin 1988*a*).

Another factor contributing to the establishment of the iron ore mines in Norrbotten was that the state played an active role in the project. To ensure that Swedish actors gained control over deposits and infrastructure, the state took over the construction of the railway to the iron ore deposits at Kiirunavaara and Luossavaara and on to Narvik in Norway, from where the ore would be shipped from the ice-free harbour on the Atlantic. At the same time, companies controlled by Swedish capital owners took over the mines. LKAB (Luossavaara-Kiirunavaara Aktiebolag), founded in 1890, established the mines and the town of Kiruna in 1900. LKAB also took over the ore mining in Malmberget. In 1907, the state increased its control by buying up half the shares in the company, thus helping to expand production. In order to acquire a productive and loyal workforce, LKAB provided comparatively good housing and service to its communities in Kiruna and Malmberget, and Kiruna especially would become a model town. To supply railways, mines and communities with sufficient electricity, the state began the industrialization of the Lule River by building the Porjus hydroelectric power station in 1910. Shortly afterwards, Boden fortress was built, partly to defend the system against foreign attackers (Brunnström 1981; Hansson 2015; Sörlin 1988*a*).

Fig. 2. Kiruna, the largest mining town in the Swedish Arctic, built to be an ideal model town. Because of the ongoing mining operations, the municipality and the mining company needs to re-locate or pull down many buildings. The church in the image will be moved to a new location. Photo: Dag Avango.

The historian of technology Staffan Hansson has coined the term *technological megasystem* to describe the huge mining system that state and business built up in Norrbotten (Hansson 1994). The system helped to create a path dependence, which partly explains the dominant position that the mining industry attained and still enjoys in northernmost Sweden. The existence of railways, roads, energy supply and communities with housing and service helped to make it profitable to extract other minerals in the vicinity of the system. One example is the company AB Nautanens Kopparfält, which

established the copper mine and the town of Nautanen in 1903 and connected it to the railway via a cable car to Koskullskulle, near Malmberget. Another is Svappavaara, a village near the ore railway, where LKAB established a new iron ore mine in 1965 when the demand for metals increased during the record post-war years. Svappavaara, like Kiruna, was provided with modernist new housing designed by the star architect Ralph Erskine. In 1968 Boliden established the copper mine of Aitik south of Gällivare, with electricity from new hydroelectric power stations in the Lule River, with housing and services in Gällivare, and with transport capacity on the ore railway for the copper concentrate that Boliden shipped to its smelting plant in Rönnskär near Skellefteå. From the beginning of the twentieth century, mining industries and the state established systems for mineral extraction also in the Finnish and Norwegian Arctic, although these differ in several ways from the megasystem in Norrbotten (Avango *et al*. 2019). Base metals are still mined throughout northern Fennoscandinavia.

The Swedish state is not alone in having turned the Arctic area into a resource landscape for the nation. A similar development can be seen across much of the Arctic, and today it is a dominant feature in mineral rich areas in the region. One reason for starting mines in the Arctic has been the demand for rare minerals. An example is cryolite, which various Danish mining companies extracted at Ivittuut in southwestern Greenland from 1857. Initially, cryolite was used to produce soda that could be used to manufacture soap, glass, and alum for tanning and for the pharmaceutical industry. From around 1900 the mineral became more interesting for aluminium production, partly because it contains aluminium, partly because it could be used to extract aluminium from bauxite. When the aluminium industry introduced synthetic materials that could replace cryolite, demand fell and in 1987 the mining company ended its operations at Ivittuut (Vikström & Högselius 2017).

The mining industry also expanded in other parts of the Arctic in the second half of the nineteenth century. In the North American Arctic, more specifically Alaska, Russian actors found gold as early as the beginning of the century. With the gold rush in the Klondike, Yukon, at the end of the nineteenth century, mineral extraction was pursued on a larger scale. Here too, the context was colonial, with thousands of gold-prospecting settlers and later mining companies establishing themselves in areas inhabited by indigenous peoples. The really large expansion came only after the end of the Second World War, with the extraction of nickel, zinc, lead, gold, precious stones, and uranium (Keeling & Sandlos [eds.] 2015). In the Russian Arctic, the mining industry was established first in the European part of the country at the end of the nineteenth century, later expanding eastwards from the 1930s, partly within the framework of the Soviet prison camp system (Avango *et al*. 2014).

As is evident from the Swedish example, national and geopolitical interests have contributed to the establishment of mining in the Arctic. Another illustrative example comes from the archipelago of Svalbard, which was uninhabited when it was discovered in 1596 and which until 1920 had the status of a no-man's land. Coal could be found there, at that time the main raw material for energy, with a steadily growing demand. From the early twentieth century, companies established mines and communities there to mine these deposits and sell coal on the energy markets of northern Europe. Now states were also beginning to take an interest in the archipelago. Norway was first, as political actors in 1906 began to express the idea that Norway should take administrative responsibility for the archipelago. Their justification for this was that the lack of a state power led to intractable conflicts between rival mining companies and between workers and

companies. The Swedish and Russian governments were firmly opposed to Norwegian sovereignty of Spitsbergen. However, they did agree that law and order was needed there and therefore advocated shared Norwegian-Swedish-Russian governance. The interested states negotiated the issue in 1910, 1912, and 1914 without reaching agreement. The main reason was national prestige. For Norway, which had just gained independence after the dissolution of the union with Sweden in 1905, the Spitsbergen issue became part of the nation-building project. For the Swedish government it was a way of maintaining Swedish leadership in foreign policy issues in Scandinavia, while the Russians wanted to defend what they considered to be their historical rights. With the outbreak of the First World War in 1914, national access to coal became another increasingly important motive for the involvement of states. To strengthen their negotiation positions, all states supported mining companies from their own countries, because their land claims and facilities could be said to represent what was called effective occupation, which, according to international law at the time, legitimized political influence. Against this backdrop, and because of the high prices of coal during the First World War, companies from a number of countries chose to establish mining communities in Svalbard (Avango 2005; Avango *et al*. 2010; Berg 1995; Berg 2004; Lajus 2004).

The geopolitical interests of states also contributed to the survival of the Spitsbergen mining industry through the twentieth century. In 1920, the Spitsbergen Treaty was signed, giving Norway sovereignty over the archipelago but simultaneously guaranteeing companies from signatory states the right to extract natural resources there on the same terms as Norwegian actors. Most companies, however, abandoned their mining sites when coal prices fell after the war. Only Norwegian and Soviet mining companies stayed on. The Norwegian companies, which were working in a market economy, incurred losses which were covered by the Norwegian state because the mines were seen as a prerequisite for maintaining Norwegian settlement and thus the legitimacy of the treaty. The Soviet mines did not have to make a profit because they were intended to cover energy needs in north-western Russia as part of a plan economy. However, there is great deal to suggest that the Soviet Union also maintained its mining communities during the Cold War for geopolitical reasons, for purposes of surveillance and influence in the archipelago (Avango *et al*. 2014; Berg 2011).

The expansion of the mining industry in the Arctic since the mid-nineteenth century is therefore due to the fact that a growing number of actors have attributed values to mineral deposits in the rock. Economic values have been most important—values that have been mainly utilized by actors from the south. Geopolitical and strategic values have also played a role, as have affective values conjured up by storytelling and art. The major sociotechnical systems established by industry then opened up opportunities for others to build new industries. In other words, the systems have tended to strengthen the use of the Arctic as a region for natural resource extraction, but at the same time, as Dieter Müller has shown, other industries such as tourism have been able to establish themselves there (Müller *et al*. 2019).

Imprints on Society and the Environment

The mining industry has often sparked debate, not least its operations in the Arctic. The reason is that mines, for better or worse, always have consequences for humans and environments. The material imprint of the operations is a tangible one. Open pits are perhaps the most visible: wide and deep abysses that can hardly fail to make an impression on anyone who sees them. The imprint of underground mines is different. Few people

notice the openings of LKAB's mines in Malmberget and Kiruna, but the operations undermine entire communities, forcing the company to demolish buildings or to move and build new in other places. In Malmberget this has been going on since the 1950s and will result in the disappearance of the entire town. In Kiruna, the town is being moved to a new site, a project that has received a lot of attention in Sweden and abroad (Sjöholm 2013).

Fig. 3. Open pit mine for iron ore extraction at Schefferville, Quebec, Canada. Photo: Dag Avango.

The imprint of mining also includes waste—in the form of the rock that is separated from the ore and the sand that is a residual product of enrichment, the process by which the metal content of the ore is concentrated. In Sweden, where almost all mining is conducted north or just south of the Arctic Circle, waste rock and sand accounted for 77 per cent of the total waste from all industry in the country in 2016, 58 and 49 million tonnes respectively (Naturvårdsverket 2018). Waste rock tips and sand tailings can leach environmental toxins such as cadmium and lead where companies mine sulphide ore. Other imprints include the infrastructure of the mining industry—roads, railways, and dammed rivers—as well as the towns that were built so that the mines' staff would have somewhere to live.

One effect of the mining industry in the Arctic is the emergence of ghost towns. These often arise because the industry is particularly sensitive to changes in the world market and mining in the Arctic tends to be more expensive than elsewhere. Mining projects that are viable when demand and prices are high can find it difficult to carry on when the market declines. Besides, no ore deposits last forever.

Disused mines in the Arctic have been handled differently depending on context. For a long time, it was common for mining companies to abandon their facilities after closure. One example is the coal mining community of Qullissat (1924), which in the 1960s was one of Greenland's biggest towns, with 1,400 inhabitants. In 1972, the Danish state closed the mine, evacuated the residents and simply left behind hundreds of houses,

Fig. 4. Remains of a *Folkets hus*, a meeting hall at the abandoned mining community Laver, Norrbotten, Arctic Sweden. The county administrative board of this region have attempted to turn this ghost town into a heritage site by placing signboards narrating its history. Photo: Dag Avango.

mining infrastructures and traces of life and work (Jørgensen 2017; Sejersen 2014: 44–46). In Svalbard there are similar remains of several mining communities abandoned at different times: Pyramiden (1934–1998), Grumant City/Coles Bay (1920s–1960s), Advent City (1903–1908), Hiorthamna (1917–1921), and Sveagruvan, a mine which alternately opened and closed between 1917 and 2015 (Avango 2004; Avango 2005). Abandoned mining communities can also be found in northern Sweden. Nautanen is an example of this, closed by the company AB Nautanens Kopparfält just five years after its opening in 1903 due to financial difficulties. The company evacuated the population and sold the buildings. The last resident moved away from there in 1935 (Ollikainen 2002). The remains of the town were left in the forest in the form of house foundations and traces of production. There are many similar examples from all across the Arctic area.

Not all abandoned mines have fallen into oblivion. In the mining community of Laisvall in Älvsbyn municipality, Norrbotten, Boliden mined lead ore between 1943 and 2001. After the closure, many people moved away from there, but today new actors have started using the buildings as holiday accommodation and for small businesses (Lundqvist 2016; Söderberg 2008: 49–62). This is a relatively common occurrence in closed-down mining communities in the Arctic which, inspired by the sociologist Michel Callon, can be summed up in the word *re-economization* (Çalışkan & Callon 2010). By this I mean processes by which actors attribute new values to things such as abandoned houses and infrastructures and put these material things to use for other activities than they were originally intended for. Similar examples can be found in Svalbard, at Longyearbyen, where tourist companies start hotels in former miners' dwellings. Research can be another form of re-economization, as for example in the former mining community of Ny Ålesund in Svalbard, which has been transformed into a base for scientific research stations. Today the entire mining industry of Svalbard is closing down, and both mining companies and state actors are trying to re-economize the settlements with the aid of research and tourism.

A related form of reuse has been to define mines as cultural heritage. In Norrbotten alone, to take one example, the Swedish National Heritage Board has identified a total of 78 national interests for cultural heritage management. As many as 23 of these are sites associated with mining (Riksantikvarieämbetet 1997). In addition, there are remnants

Fig. 5. Cruise ship tourists by the remains of the open pit mine for cryolite extraction at Ivittuut, Greenland. In several parts of the Arctic, former mining sites are being re-economized as visitor sites for tourists. Photo: Dag Avango.

of mining that the state has defined as historic monuments and they are therefore protected under the Heritage Conservation Act. Another example is Svalbard, where the Norwegian authorities protect all remnants of human activity from the time up to 1946, which in practice means that a large share of the mining industry's abandoned towns and prospecting camps are protected as cultural heritage (Marstrander 1999). This phenomenon is less common in the North American Arctic but it does occur, for example, the remains of the gold rush in the Klondike, Yukon (Cook 2013; White 2000).

These examples are what heritage researchers such as Rodney Harrison call official cultural heritage: historical remains that have been given the status of cultural heritage because state authorities and heritage institutions have chosen to define them as such and thus to protect them by legislation, on the advice of antiquarian experts. Another type of cultural heritage process can be called unofficial (Harrison 2013). This is seen when historical remains are preserved because other actors define them as cultural heritage and worthy of protection, even though the site does not enjoy protection by law. At Rankin Inlet in Canada, some of the Inuit who previously worked in the mines have come to regard the historical remains as their cultural heritage (Cater & Keeling 2013). The Qullissat mining community in western Greenland has also come to be regarded by former inhabitants as cultural heritage. Since the 1980s, people have revisited the remains of the town, which gives an anchorage for memories of childhood and working life. Because Qullissat has been a subject of narratives about the actions of the Danish colonial power in Greenland, it has also become a resource for actors who want to mobilize support for Greenland's independence. Although the Greenland authorities do not protect Qullissat as cultural heritage, the former inhabitants do so by carefully renovating former dwellings. Other examples can be found in Svalbard, where mining companies choose to preserve older mines and mining communities even though Norwegian environmental law does not require it. The reasons for this include both economic and geopolitical considerations (Avango & Roberts 2017; Jørgensen 2017; Sørensen 2013).

In contrast, newer mines that are closed down in the Arctic are rarely subject to cultural heritage processes. A major reason is that environmental restoration has become the norm because of the environmental and mining legislation of several Arctic states (Darpö 2001; SGU 2016). Moreover, many mining companies undertake voluntarily to remediate their mining areas. For these reasons, visual traces of newer mining projects may become increasingly uncommon. One example is the Polaris zinc and lead mine, which the Canadian mining giant Cominco operated between 1982 and 2002 on Little Cornwallis Island in the northernmost part of the Canadian Arctic. After the closure, the company removed buildings and other traces of the operations. No attempts were made to attribute any cultural heritage values to the site where Polaris was located. The historian Heather Green has explained this in terms of the lack of material reference points for memories, but she has also stressed the fact that Cominco recruited almost all its labour from other areas, which meant that few people at the place had any cause to relate to the mine as cultural heritage (Green 2015). Another example is the mine of the Norwegian mining company Store Norske at Lunckefjell in Svalbard, which was ready to commence operations in 2015 but never started production due to falling coal prices. The Norwegian Government decided to close the mine completely just two years later. There was no thought of preserving anything from this mine for posterity. Instead the environment was to be restored at a cost that was then estimated at 700 million Norwegian kroner. By 2018, the cost had risen to 2.5 billion (Avango & Brugmans 2018). It remains to be seen whether the environment here will be restored.

There are several cases in the Arctic where the desire for environmental restoration has conflicted with ambitions to preserve. One example is, again, Nautanen. The National Heritage Board added the mine to the list of historic monuments in the early 1980s. A decade or so later, it was clear that waste rock tips and sand tailings were leaching about 200 kilos of copper a year into the water system—in the last century alone. One result of this is that the river downstream no longer has any fish. The municipality of Gällivare has partially rehabilitated the area in cooperation with the Boliden mining company, which transported away parts of the old waste rock piles. However, the municipality is aware that more rehabilitation is needed, but has been unable to do this because of disagreements with the landowner, the state-owned forestry company Sveaskog. This case reflects the growing importance of environmental issues in society, but also a diminishing commitment to the care of the industrial cultural heritage (Avango & Geijerstam 2015; Geijerstam & Houltz 2013).

Meanwhile, a third possible future for abandoned mining communities has appeared. At Nautanen in 2009 the Swedish Mining Inspectorate granted Boliden a permit to investigate the possibility of opening a new mine. In the following years, the company took 75 test corings in the area and estimated in 2016 that there are 9.6 million tonnes of ore with a relatively rich copper content, along with gold, silver, and the heavy metal molybdenum (Boliden 2016). If Boliden applies for and is granted an exploitation concession, the company plans to build a new underground mine, to transport the ore to Aitik for crushing and enrichment, and from there take the copper concentrate to its smelting plant at Rönnskär. What until now has been a ghost town will then once again become a component in the enormous mining system in northernmost Sweden. The cultural heritage researcher Camilla Winqvist, who is studying this re-economization, has concluded that "abandoned mining communities" are never really abandoned. From a narrow socio-economic perspective, the underground mineral deposits, whose emergence Joakim Feldman has described, are a form of latent infrastructure.

A New Arctic Mining Boom?

Boliden's plans at Nautanen are part of a global mining boom that began at the start of the twenty-first century and is continuing despite periods of slowdown. The driving force is a sharp increase in demand for metals, and the rapid economic growth in China is often singled out as a major incentive (SGU 2012; SGU 2013; SGU 2014; SGU 2018). This new mining boom has already led to major investments in prospecting and new mines. Many of these have been established in the Arctic, including mines extracting iron, gold, earth metals and precious stones in Greenland, gold and coal in Svalbard (Nilsson & Jürisoo 2015; Secher *et al*. 2008; Vikström & Högselius 2017). An example from Sweden is the Tapuli mine that the mining company Northland Resources started in Pajala municipality in 2012. The deposit had been known for over a century (at least since 1918) but no one had deemed it rich enough to justify mining until metal prices started to rise. Northland Resources went bankrupt after a couple of years, but in June 2018 Kaunis Iron resumed operations in the mine (Anselm & Haikola 2018). The mining boom has also manifested itself in the fact that established mining companies have increased production in existing mines. An example of this is LKAB's decision in the early 2000s to open new levels and new areas for mining in Kiruna and Malmberget, resulting in extensive transformations of society there.

The mining boom and its consequences have grown to become one of our hottest societal issues. Due to stricter laws and regulations in Sweden, as well as local opposition, several planned Arctic mining ventures are awaiting government decisions. Examples are Laver in Älvsbyn municipality, where Boliden wants to start a large open pit for copper extraction, and the Kallak/Gállok project in Jokkmokk municipality, which the mining company Beowulf has been planning for a number of years. Both projects have raised concerns in the Sami communities whose reindeer grazing lands the mines are to be established in, and among residents of the area who fear that their local environment, income or lifestyle is threatened by the mines (Harnesk *et al*. 2018; Lawrence & Kløcker-Larsen 2017). Other residents pin their hopes on a better future as a result of the new mining projects, particularly in the form of new jobs, direct and indirect. Many inhabitants of Pajala were in favour of the Tapuli mine when it was started, which can be understood in the light of the fact that the municipality has lost nearly half of its inhabitants since the 1970s.

In fact, there are also actors who advocate an expansion of the mining industry based on environmental arguments. Whether the transition to renewable energy production takes place in the form of wind and solar power or through the manufacture of electric cars, it will require increased extraction of minerals such as lithium, neodymium, dysprosium, nickel and also copper. The mining industry, which has been particularly anxious to define this need, believes that the licensing of new mines must be simplified for this reason. Could this development lead to further new mines in the Arctic as well? If so, it is a huge and urgent challenge to ensure that the mining industry of the future does not place an additional burden on environments and people that are already under severe pressure from climate change. There is much to suggest that the future of the mining industry in the Arctic will not only be determined by developments in the world mineral markets, but also by the ability of the mining industry and government agencies to reach agreements with the people who are affected in different ways by mining.

NOTES

[1] This article is a revised and translated version of the chapter "Avtryck i landskapet. Gruvdriftens långa liv i Arktis," in Gustafsson Reinius (ed.) (2020), pp. 130–149.

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