Heritage and Change in the Arctic:

Resources for the Present, and the Future

Edited by

Robert C. Thomsen and Lill Rastad Bjørst

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From Cryolite to Critical Metals: The Scramble for Greenland's Minerals

Hanna Vikström & Per Högselius

World demand for minerals is growing. New skyscrapers, aircraft and railways are being built, and so are wind turbines, solar cells, computers and LED lamps – all of them crucially dependent on an ever-broader range of raw materials.[1] Historically, base metals such as iron and copper have been the main resources sought. The search for new deposits of these ores continues, but manufacturers have increasingly also found uses for many other metals. Demand is soaring for elements such as tantalum, indium and the rare earths, many of which have become essential in high-tech digital products, renewable energy technology and a range of other modern appliances.

In recent years industrial and political actors have expressed growing concerns regarding the future supply of minerals, fearing resource

1 We would like to thank the editorial team and our colleagues Peder Roberts and Dag Avango for their valuable comments on several earlier drafts of this chapter. Thanks also to the participants at the *Heritage and Change in the Arctic* conference, held in Nuuk, 2013, for their comments on an early version of the chapter, and to Espen Storli and the participants at a higher seminar held at KTH Royal Institute of Technology in 2015, where another draft of this chapter was discussed.

scarcity. Historically, actors who perceive a shortage of a particular resource – be it mineral or agricultural – have often turned to exploiting regions perceived as 'empty' and 'unpopulated'. Demand for silver and gold, for example, motivated Spain and Portugal to colonize South America in order to gain access to its metals starting at the end of the fifteenth century. Similarly, increased demand for food resulted in an expanding wheat frontier across the great prairies in the United States from the 1870s onwards. In the interwar era, Japan secured coal, iron ore and magnesium by turning to Manchuria and North China (Barbier 2011, 244, 379, 503).

In a similar way, the Arctic has gained worldwide attention as a promising region for natural resource extraction. In the twenty-first century, the main argument in the public debate for exploiting the resources of the region has been framed in relation to global warming and the melting of glaciers and sea ice. This is evident both in the case of potential offshore oil and gas riches in the Arctic Ocean and in adjacent onshore territories (see further Avango and Högselius 2012 and Avango et al. 2015).

Greenland has figured prominently in these discourses. "Never before", wrote the geologist Minik Rosing in his introduction to a recent report on the future of mining in Greenland, "has more column space, more air time, and more gigabytes been devoted to discussing how the assets buried in Greenland's underground should be managed" (Rosing 2014, 6). Extensive news coverage has depicted Greenland as a promising future supplier of various natural resources, framed against the omnipresent mantra that previously hidden mineral treasures will become exposed as Greenland's glaciers melt. *The Guardian*, for example, noted that "as rising temperatures expose more land for exploration, prospectors are rushing to the far north in the hope of carving out a new mineral frontier" (*Guardian*, 4 March 2011). Such statements were almost identical to the phrasings of mining companies like NunaMinerals, whose CEO Ole Christensen observed that "retreating glaciers offer the promise of finding more minerals" (Northern Miner 2013). Similarly, Greenland's Prime Minster Aleqa Hammond argued in 2014 that "climate change means that now an area equivalent to Germany is ice-free, and this area is increasing every year". This, she further specified, inevitably meant that "rare earth elements, gold, uranium, iron, copper, zinc and nickel are becoming available in quantities and qualities which are unique internationally" (Hammond 2014). A common line of argument was that the Arctic earlier had been "largely off-limits because much of the land was considered unworkable, buried under hundreds of meters of snow and ice, and with nothing in the way of traditional infrastructure". Now, however, "global warming has changed that picture" (*Guardian*, 4 March 2011).

In this paper we argue that this line of thinking is misleading. We intend to show that the changing climate in the Arctic has only limited explanatory power when it comes to recent investments in Greenland's mining sector. To do so we scrutinize the historical and global context in which actors' interests in the island's mineral riches have emerged and evolved. Our point of departure is that the current interest in Greenland's minerals has not appeared overnight, and that there is thus a need to view ongoing developments in their historical context. Only by tracing the historical origins of today's resource interests may we get an idea of the extent to which current developments are unique and what role climate change has played in changing the investment climate for mining. Our main research question is a very simple one: Why have actors, from the nineteenth century to today, invested in and supported the exploitation of Greenland's minerals, and is there a major rupture in the history of Greenlandic mining related to the onset of the climate change debate? Our argument is that by answering these questions we may also better grasp the wider topic of heritage and change in the Arctic.

The empirical part of the paper is divided into two sections, each concerned primarily with mapping the contours of mining in Greenland with an eye to the reasons why mining has been deemed interesting (or not) at different points in time. The first section explores mining development in Greenland before the climate debate came to the forefront in the late 1980s. The second deals with the development of Greenlandic mining from the 1990s onwards, in the era of the debate about global warming and rapid growth in demand for metals. In a final section we seek to identify and understand the main factors that have been dominant in shaping Greenland as a mining country – and the extent to which these factors differ between the two time periods.

Theoretical and methodological approach

From a theoretical point of view, the narrative about the melting ice as the main 'driver' of mining in Greenland is a prime case of what archaeologists, geographers, anthropologists and historians have labelled 'environmental determinism'. According to Frenkel (1992), environmental determinism as a concept was introduced in the late nineteenth and early twentieth century. It invoked climatic conditions to explain collective human characteristics, down to the level of behaviour and cultural habits. Moreover, it has been used to justify imperialism. While the concept has been heavily critiqued, in actual practice it has continued to serve as a way to explain cultural, social and economic phenomena.[2]

In this article we argue that in order to understand how and why a mining project comes about, the point of departure of the analysis must be the perspective of those actors who invest in or support the projects in question. While it may be true that they are likely to take the environment into account in their decision-making, it is never the only thing that needs to be considered.

Mining companies' decisions to invest in specific countries and sites are usually based on careful consideration of a range of global and local specificities. Important global factors include *technological trends*

2 One example of this is Barbier, who states that Canada's harsh climate explains why its resources were not as heavily exploited as the USA's in the early twentieth century (2011, 405).

(in the form of innovations that require minerals, innovations that enable extraction and purification of minerals, or, conversely, innovations that make old mineral-dependent or mineral-processing technologies obsolete), world-wide *economic trends* (since these strongly influence the demand for many minerals) and more generally the trend in terms of the *world market price* of the mineral in question (Vikström, forthcoming).

If the global trends are considered favourable, then the local setting is likely to shape mining companies' decisions in terms of whether and where to invest. The mining industry's perception of the importance of various local factors in decisions concerning exploration and mining has been studied through surveys conducted by academics and by think tanks such as the Fraser Institute. In the following we build on such earlier insights.

To begin with, *geological and environmental conditions* are likely to play a role. It only makes sense for mining companies to invest in places where sufficiently large and sufficiently rich ore deposits exist, and where unusual topographical or environmental features do not result in unacceptably high extraction costs. Whether or not it is possible to extract the resources from a certain deposit depends on local *regulations and policies,* for example, in the form of taxes and fees for extraction, environmental laws, labour regulations and the possibilities to access geological databases (Jackson 2014). Additionally, the existence or lack of *infrastructure* in the region of interest may influence corporate investment decisions. Historically, new mineral deposits have often been discovered in areas devoid of modern human-made infrastructure (see e.g. Vikström, forthcoming, and Vikström et al., forthcoming). In such situations a high market price is needed to compensate for the often substantial costs that arise from the need to construct new roads, railways, harbours, electric power systems and the like (cf. Högselius et al. 2016, chapters 4-5). Another important local factor that needs to be taken into account is the degree of *political stability.* While wars and other forms of political unrest have often both fuelled and been fuelled by natural resource extraction (Le

Billon 2001), investing in politically stable territories clearly poses fewer problems for international mining companies.

Importantly, the perceived relative importance of the above factors may vary. A company may or may not, for example, consider an environmental aspect like the melting of glaciers to be important in relation to other factors in its decision-making process. The actual relative weight attached to different factors in shaping corporate decisions can thus not merely be inferred from general economic, political or environmental conditions.

Moreover, it is important to be aware that actors other than the mining companies themselves may play a role in shaping decisions on whether or not to initiate the exploration or extraction of minerals. For example, local governments may support mining projects in attempts to promote increased political autonomy and increased job opportunities (e.g., Müller 2015). Conversely, central governments may support resource extraction in peripheral or colonial areas as part of their attempts to claim and bind these lands more firmly to the centre (e.g. Avango et al. 2014). Governments in countries that are dependent on imported minerals, for their part, may support and even subsidize foreign extractive projects as part of their efforts to cope with domestic resource scarcity (e.g. Högselius 2013). In other words, a mining project may become a brick in a larger (geo-)political game, in which much more than corporate profits are at stake.

To analyse the recent exploitation of Greenland's minerals, we use as our main source the *Mining Journal* (referred to in the following as MJ). Since the nineteenth century, it has been the world's leading journal dealing with developments in the mining industry. MJ publishes articles and reports on worldwide developments in mining, ranging from corporate investments and trends in raw materials supply to technological developments. The choice of this journal as our core empirical source reflects our aim to understand mining in Greenland primarily from the perspective of the actors who plan and execute the projects. Analysis of articles in the MJ provides insight into how actors in the mining industry present their activities within wider commercial, political and environmental contexts and what factors are characterized as relevant (or even decisive). Following our argument that actors other than the extractive companies themselves may play a role in shaping mining decisions, we have also included political actors in our analysis, such as the EU, the government of Greenland and the Geological Survey of Denmark and Greenland (GEUS). For this purpose we have consulted a number of official government reports, company websites and other sources. We have also made use of secondary academic literature on Greenland's mining developments in the past and present.

Mining in Greenland before the climate change debate

The first mine to open in Greenland during the modern period was a small-scale coal mine at Disko Island (see figure 1). This mine was in operation from the 1780s until 1833, supplying local needs. The first attempt to extract metals came in 1852, when a British consortium tried to extract copper from a deposit in Josva, located close to Qaqortoq in southwest Greenland. According to Steenfos and Taagholt (2012, 72), the mining company found it difficult to access the copper ore, and closed the operation after only two years. Copper's importance increased with the electrification of Western society, as the metal was a crucial component of electrical wires. This motivated another company, Grønlandsk Minedrifts Aktieselskab A/S (Greenlandic Mining Ltd.), to put the mine back into operation in 1905. This exemplifies how technology-driven changes in demand, as discussed above, often motivate decisions to commence mining. In 1914, however, the Josva mine's owners decided to shut it down again. According to the Geological Survey of Greenland and Denmark (2002) this was due to the low concentration of copper in the ore, the small size of the deposit and failures in smelting operations. Steenfos and Taagholt (2012, 72f.), for their part, place more weight on transport problems, as shipping was considered too risky due to the loose ice.

Fig. 1: Selected mining sites in Greenland, 1780-1990

Greenland has a unique geology; in addition to base metals, it contains numerous deposits of rare minerals. From the second half of the nineteenth century one of these – cryolite – became the basis for a large-scale mining site at Ivittuut that was central to Greenland's economy for many years. In 1852 the chemist Julius Thomsen invented a process by which cryolite could be converted into soda (Kragh 1995). Soda was crucial in Europe's modern chemical industry, which at this time was just experiencing a breakthrough. Two years later the Royal Greenland Trade Company began extracting cryolite from the deposit, shipping it to Copenhagen. In 1859, thanks to the now sta-

ble supplies from Greenland, Thomsen, part owner of Kryolithfabriken Øresund (The Cryolite Factory Øresund), was able to open a soda factory in Copenhagen. The company received a license for the Ivittuut deposit and would continue to mine it for over a century (Kragh 1995, Nuttall 2005, 1030).

Fig. 2: The mining settlement of Qullissat in summer 2015.
Photo by Hanna Vikström[3]

In keeping with the increasing interest in harnessing chemistry for industrial development, in 1886 two chemists working independently of each other came up with a method that used cryolite to purify aluminium, called the Hall-Héroult process. With the rise of aviation

3 Photo taken on fieldwork in Greenland for the project: 'Sustainable Communities and the Legacies of Mining in the Nordic Arctic', sponsored by Nordregio.

in the early twentieth century, aluminium became a strategically important metal, fuelling further growth in the demand for cryolite (Steenfos and Taagholt 2012, 76) – much in the same way as electrification stimulated the extraction of copper. After World War I, the activities at Ivittuut expanded rapidly as Kryolithfabriken Øresund seized the opportunity to profit from global needs (Johansen et al. 2001).

Other mines opened in Greenland during the early twentieth century. In 1924 a new coal mine opened at Qullissat on Disko Island. This mine continued to operate until 1972, producing a total of about 570,000 tons of coal through the years. In this case, however, mining was driven by domestic energy needs in Greenland rather than by an export market (Nuttall 2008, BMP 1999), the aim being to make the island self-sufficient in coal supply (Sejersen 2014, 44f). With over a thousand residents at its peak, Qullissat was one of Greenland's largest settlements.

The Danish government's interest in Greenland's mineral resources increased during the 1930s. This was partly due to Denmark's conflict with Norway over eastern Greenland, through which the Danes were reminded of the potentially strategic importance of what international law referred to as "effective occupation" (Wråkberg, 1999). Although the search for minerals was motivated by a more general desire to map and control Greenlandic territory rather than to exploit it economically, it included a royal Danish decree in 1935 that defined all sub-surface mineral resources in Greenland as Danish state property (Sinding 1992). The Danish state also sponsored expeditions to map resources in eastern Greenland, led by geologist Lauge Koch (BMP 1999, Nielsen and Knudsen 2013). Koch discovered a large deposit of lead and zinc at Mestersvig in northeastern Greenland, which was ultimately opened up for mining.

The strategic value of cryolite made the Ivittuut mine an important issue after the German occupation of Denmark in April 1940. Following occupation, Denmark's ambassador to the United States, Henrik Kauffmann, declared himself no longer bound by the Danish government and negotiated an agreement through which the United States took over the defence and supply of Greenland, to the fury of the government in Copenhagen (Lidegaard 1996). The Americans were particularly interested in the cryolite mine, as they needed the mineral to meet increased military demand for aluminium (Steenfos and Taagholt 2012, 79). Ivittuut was guarded by American troops and the cryolite was shipped to the US and Canada for refining, with the ships bringing supplies to Greenland on their return voyages.[4] The Danish and Greenlandic authorities learned from this experience that mining could play an important role in Greenland's economy (Sejersen 2014, 42).

In 1946 the Danish government initiated further systematic investigations of Greenland's mineral resources. Lauge Koch returned to East Greenland, and the newly established Geological Survey of Greenland began a long-term research program that produced both maps and eventually a comprehensive *Geology of Greenland* (Escher and Watt 1976). Mining activities in Greenland were now shaped by the Cold War context and the onset of the atomic age. The United States followed up its wartime defence activities in Greenland by establishing the Thule air base in 1951-1952. From an American perspective, Greenland was of interest partly because the island was believed to rest on substantial uranium resources, which at the time were perceived to be scarce in the United States. An American explorer, Douglas McMillan, carried out several geological studies, which culminated in the discovery of a uranium deposit close to the capital, Nuuk (Nielsen and Knutsen 2013).

The Danish government also took interest in this development. Denmark was heavily dependent on imported fossil fuels, and from 1955 nuclear power was presented as a way for the country to diversify its energy supply and make it less import-dependent. Greenland's ura-

4 The mine was run by the Greenlandic *landsfogder* together with the mine workers and later the Danish ambassador Henrik Kauffman in Washington (Sejersen 2014, 42f).

nium was regarded as a highly valuable resource in this context (see further Nielsen and Knudsen 2013).[5] The Danish Atomic Energy Commission (AEK) took particular interest in the Ilimaussaq area in southwestern Greenland, which contained several rare minerals, some of which held uranium and thorium (Steenfeldt 1991, Nielsen and Knudsen 2013). Supported by AEK, Øresund A/S – the same company that operated the Ivittuut mine – began exploring Ilimaussaq's uranium resources in 1956 (Nielsen and Knudsen 2013). Two years later a Swedish company, Svenska Diamantborrningsbolaget AB, began to drill in a part of the complex named Kvanefjeld. Uranium was found, but disappointment spread as it turned out that the concentration was not as high as desired. During the period that followed, some ore was produced and shipped to AEK's Risø laboratory in Denmark, whose chemists started to develop methods for extracting uranium from it (Nielsen and Knudsen 2013). According to Nuttall (2013), extraction came to an end in 1962, although it was temporarily revived again from 1978 to 1981, this time producing about 10,000 tonnes.

Another project that materialized during this era was the zinc-lead mine that Lauge Koch had identified at Mestersvig, which commenced operations in 1956 by Nordisk Mineselskab A/S.[6] However, the ore body was small so that declining world-market prices for both zinc and lead prompted the company to close the mine in 1963 (Johansen et al. 2001). In this sense economic considerations rather than geopolitical factors drove the decision-making process. This was true for Ivittuut as well. The owners closed the mine in 1962 as a result of declining cryolite concentrations and, more importantly, the invention of synthetic cryolite (although the shipping of the reserves already extracted continued until 1987) (Lyck 2012).

5 Denmark had almost depleted its lignite, peat and wood resources during the war and wanted to reduce its dependence on imported fossil fuels. In this context uranium became very important (Nielsen and Knudsen 2013).

6 Nordisk Mineselskab A/S (Northern Mining Company Ltd. or "Nordmine") was jointly owned by the Danish State (27.5 %), private Danish enterprises (27.5 %), two Swedish companies – Boliden (15 %) and Stora Kopparberg (15 %) – and Ventures Ltd. of Canada (15 %).

Mining was a significant issue in Greenlandic politics during the 1970s. Greenlandic politicians discussed the exploitation of oil and mineral resources as a possible way to reduce Greenland's dependence on the Danish state and to increase Greenland's political autonomy. They viewed mining as a possibility to diversify the economy, which traditionally was based on hunting and fishing (Brøsted and Gulløv 1977). The legal right to Greenland's mineral resources was a major issue in this context. Greenland wished to obtain control over mining activities in its territory. Denmark's Prime Minister Anker Jørgensen asserted that the soil belonged to Denmark and not to Greenland. The Danish government, long having seen Greenland as an expense rather than a source of income, was eager to harvest some of the profits from mining. Eventually a compromise was reached in which half of the mining revenues were to go to Denmark and the other half to Greenland. The agreement formed part of the historic move to Greenlandic Home Rule in 1979, under which many state functions involving internal issues were shifted from Denmark to Greenland (Nuttall 2012b).

The significance of mining to the Home Rule debates extended beyond the economic sphere. The evacuation of the coal mining settlement of Qullissat in 1972 meant the end of a community rather than simply a mine, producing significant discontent that fed into wider dissatisfaction with the existing political structure (see for e.g. Rosing Olsen 2005, Avango and Roberts, this volume). Some of the displaced workers found employment at the 'Black Angel' lead-zinc mine in Maamorilik, which the Canadian mining company Cominco opened in 1973. Apart from lead and zinc, the mine also contained silver, which was extracted as a by-product, paying for the transport to markets (Lyck 2012). In 1986 the Swedish mining company Boliden AB bought the mine as part of a corporate internationalization strategy that also included new acquisitions in countries such as Angola, Colombia and the Philippines (Lundquist 2013, 239). Boliden eventually closed the mine in 1990. According to the Geological Survey of Greenland and Denmark (2003), the main reason was depletion of the minerals.

By the 1980s companies and state actors alike had lost interest in Greenland's uranium deposits as well. Denmark finally abandoned all plans for nuclear power stations in a 1985 parliamentary resolution and as a result, the country no longer considered Greenland's uranium to be a strategic resource (Vestergaard 2014). Environmental concerns about uranium mining further contributed to weakening the prospects for Greenland as a supplier. As a consequence, in 1988 the Joint Committee on Minerals in Greenland (*Fællesrådet vedrørende Mineralske Råstoffer i Grønland*) decided to introduce a zero-tolerance uranium policy, to prevent uranium prospecting and mining.

Mines	Product	Years of operation	Tons of ore
Josva, Innatsiaq	Copper	1852–54 , 1905–14	2,252
Ivittuut, Arsuk	Cryolite	1854–1987	3,700,000
Qullisat, Disko	Coal	1924–72	570,000
Blyklippen, Mestersvig	Lead, zinc	1956–63	545,000
Kvanefjeld, Narsaq	Uranium	1958–62, 1978–81	11,000
Black Angel, Maarmorilik	Lead, zinc, silver	1973–90	11,300,000

Fig. 3: Selected mines in Greenland in operation before 1990
Source: Steenfos and Taagholt 2012, 71

Greenland's recent minerals boom

New regulatory and political conditions

After the closure of the Black Angel in 1990 there were no longer any active mines in Greenland. Interest in the island's minerals persisted, however, both in the international mining industry and among Greenlandic politicians. The Greenlandic Home Rule government eagerly financed both airborne and marine geophysical surveys and sought to develop a cooperative attitude towards private international companies contemplating investments (BMP 1999). In 1991 the government passed a new mining act covering taxation policy, the tenure, closure, abandonment of sites, and government-investor relations.[7] In 2002 Sweden's Raw Materials Group, which studied the global mineral industry on behalf of various customers, concluded that Greenland's mining legislation was among the most favourable in Europe (MJ 12 April 2002).

Greenland's resources continued to be a hotly debated topic in the political relations between Denmark and Greenland, and in 2004 a Danish-Greenlandic Self-Rule Commission was established. It arrived at the conclusion that the minerals in Greenland belonged to Greenland and not to Denmark (Nuttall 2008). From then on Greenland was free to extract minerals and energy on its territory, but if the earnings exceeded 75 million DKK, the Danish annual block grant (that is, Copenhagen's financial support to the Greenlandic government) would be decreased. Greenland and Denmark would divide the future revenues, and eventually the block grant would be phased out (ibid.). At the same time, in 2004, Greenland's Bureau of Minerals and Petroleum (BMP), which took over responsibility for the administration of the minerals industry from Denmark in 1998, published a strategy for mining activities, stating that mining should – once again – become an important industry in Greenland (Lyck 2012). In 2009 Greenland attained a greater degree of autonomy when self-government was established. In 2010, Greenland took control over sub-surface resources through the Mineral Resources Act, implying that there could be direct negotiations between the Greenlandic authorities and interested companies (Nuttall 2012a).

Greenland's struggle to become a major strategic minerals supplier was further supported by the EU. In 2006, the EU pushed to expand its agreement with the island, increasing, among other things, the amount of loans and grants for mineral exploitation (MJ 7 July 2006).

7 For further details on these issues see Sinding 1992.

The EU at the time had growing concerns regarding its dependence on imported minerals, and eyed Greenland's minerals as one way to reduce its vulnerability in this field. In 2012 the EU recognized Greenland as having strong potential for six of the fourteen materials on the EU's 'critical raw materials' list: niobium, the platinum group metals,[8] the rare earth elements, tantalum, graphite, and fluoride (EU 2012b).[9] The EU argued that the elements on the list were critical due to their high importance to the economy and high supply risk. Some of them were only produced in a few politically and economically unstable countries and were difficult to substitute and recycle (EU 2012a). Greenland was perceived as an ideal supplier because it was a politically stable polity located close to the European Union. In 2012 the European Commission signed a new agreement on cooperation with Greenland on raw materials in order to secure the EU's supply of critical metals (EU 2012b). In particular, the EU was interested in Kvanefjeld's rare minerals, which became part of the EU's EURARE project, the purpose of which was to decrease China's dominance in the production of rare earth elements.[10]

Greenland's Bureau of Minerals and Petroleum (BMP) renewed its strategy in 2009 and again in 2014, taking into account oil, gas and minerals. In its 2014 version, the strategy stated that Greenland's focus in the minerals sector would be on iron ore, copper, zinc, rare earth elements, gold, uranium and gemstones (Government of Greenland 2014). The goal was "to promote prosperity and welfare by creating new income and employment opportunities in the area of mineral resources" (Ibid., 15). The same argument was brought forward by the committee *Greenlandic Mineral Resources to the Benefit of Society* in a report entitled "To the Benefit of Greenland". The report elaborated on "how mineral resources can be used to benefit Greenland and

8 The platinum group metals include the following: ruthenium, rhodium, palladium, osmium, iridium and platinum.

9 Molybdenum was listed as a critical metal in Britain but not in the EU.

10 It may added that from an historical point of view, Greenland's relations with the EU have been problematic. The island used to be part of the EU between 1979 and 1983, joining it together with Denmark. Later on, it decided to leave the EU after a referendum.

Greenlanders as much as possible and thereby also benefit the Kingdom of Denmark" (Rosing 2014, 6).

New trends in prospecting and exploration

From the early 1990s on, many in the mining industry already thought conditions excellent for reviving and further developing a thriving minerals industry in Greenland. The climatic disadvantages of mining in the High Arctic were seen to be compensated for by a range of human-made advantages, not least the excellent legal and policy conditions. Most of Greenland, of course, remained covered by the ice cap. Even in places where 'exposure' (that is, the lack of ice) was close to 100 %, however, the territory was seen to be "vastly underexplored". The "main obstacle" to the development of Greenland's mineral sector was, in the *Mining Journal's* opinion, not the ice cap, but "the fact that no mining operation currently exists". The Journal believed that if one mining project was started up, then other investors would quickly follow (MJ, 31 July 1992).

One of the exploration projects targeted a vast zinc deposit near Citronen Fjord in northern Greenland. Situated at the latitude of 84 degrees north, it was described as "the world's most northerly known base metals deposit" (MJ, 16 February 1996). Citronen was first discovered by GEUS in 1993, and then Platinova, a Canadian mining company, explored it. An advantage of the site was that its proximity to deep tidewater made shipping possible (MJ, 16 February 1996). Since the mine was so far north, in a region devoid of infrastructure (other than natural shipping lanes), the Greenlandic government was prepared to offer more favourable conditions than usual. In 2007 Citronen was acquired by Ironbark Zinc, an Australian company. Ironbark subsequently forged a partnership with China Nonferrous Metal Industries (Downes 2013). One reason behind Ironbark's interest, according to the company itself, was the low sovereignty risk. In addition, the world zinc price was on the rise and there was even a fear of zinc supply shortages in the United States (MJ, 27 June 2014 and 24 July 2014). In its Mineral Strategy 2014-2018, the Greenlandic government described Citronen as one of its priorities. The strategy pointed to Greenland as one of the most favourable places to mine zinc in the world – for the permit holder – hinting at excellent conditions in both geological and regulatory terms (Government of Greenland 2014, 53).

Fig. 4: Some recent exploration projects in Greenland

Another large-scale base metal project that seemed to be taking off targeted a large iron ore deposit at Isukasia, which had been discovered in 1965 by Øresund (MJ, 1 March 1996). As of the late 1980s the Isukasia deposit was seen to have "no commercial value", due to the lack of infrastructure in the area (Lyck and Taagholt, 1987, 57). In 2006, however, London Mining, a UK-based company, received an exploration license for the deposit. In 2013, Greenland awarded London Mining a thirty-year license to operate the mine (MJ, 1 November 2013). The iron ore price had risen spectacularly (see figure 4), prompting the company to conclude that the deposit could become profitable even if the license-holder had to invest in expensive new infrastructure. The Greenlandic government eagerly pushed for more mining to go ahead, arguing that apart from Sweden and Canada, Greenland was the most favourable jurisdiction in which to mine iron ore, again hinting at excellent geological and regulatory conditions (Government of Greenland 2014, 48). When London Mining set out to forge cooperation with Chinese actors, however, fears arose in the population that the mining scheme "could lead to thousands of Chinese arriving in Greenland with a wider agenda of controlling an area of vast potential mineral wealth to feed their own country's industrialization" (*Guardian,* 5 January 2014; Nuttall 2013), thus pointing to both scarcity and geopolitics as factors shaping investment decisions on iron ore mining in Greenland.

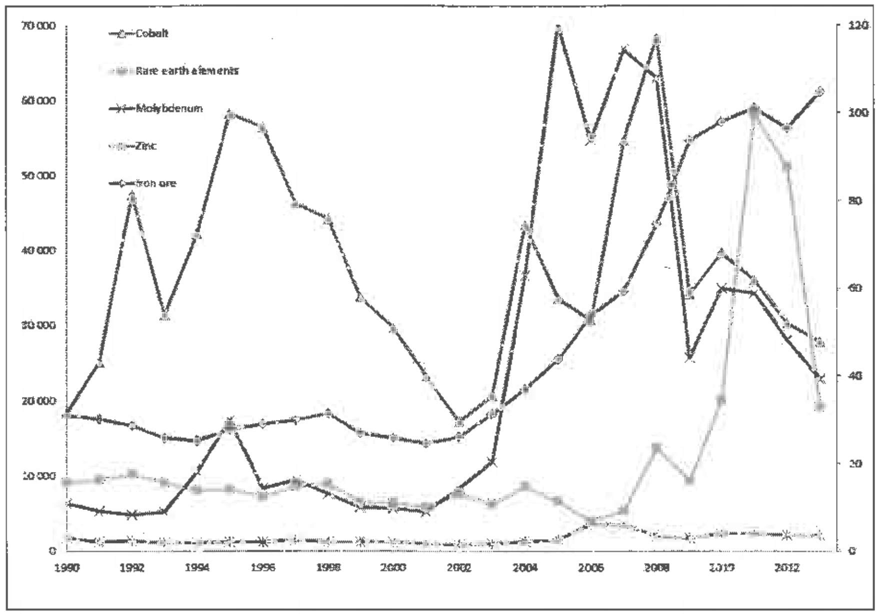

Fig. 5: World metal prices, 1990-2013 (USD/tonne). The iron price is projected on the right, all other metals on the left axis. Source: Based on data in USGS (2016)

Greenland's base metals aside, several actors were increasingly attracted to the island's "critical" or "strategic" metals, including tungsten, molybdenum, zirconium, tantalum, niobium and rare earth elements (EU 2010). Geologists had known about the presence of such deposits on Greenland at least since the 1950s, at which time they attracted the attention of geologists in search of uranium deposits (Nielsen and Knudsen 2013). In the 1980s the Geological Survey of Denmark and Greenland found additional deposits of 'critical' metals. In 1984, for example, the Survey reported findings of tungsten, crucial in steelmaking and a range of other applications (MJ, 14 December 1984), and in 1986 it learnt about deposits containing niobium and tantalum – metals essential in electronics and in aircraft. In the 1990s, the Survey continued to map Greenland's geology extensively and found additional metal deposits in southern Greenland, including tungsten along with rare earths and uranium. Apart from that, the Survey mapped an already known molybdenum deposit at Malmbjerget (MJ, 30 August 1991).

As GEUS completed more mapping work and made the geological conditions clearer, a range of international mining companies began to show a serious interest in various sites. In 1987, for example, three Canadian firms acquired the rights to explore rare earth elements in southwest Greenland. The demand for these minerals was on the rise, one reason being that they were vital in superconductor technology, which was just starting to take off (MJ, 22 May 1987). The interest of the companies – Highwood Resources, Platinova and Calkas A/S – grew rapidly, and in 1992 they started exploring the Illimaussaq intrusion at Kvanefjeld for rare earths and zirconium (MJ, 31 July 1992). As of 1994, Platinova regarded the deposits of zirconium as especially promising. At the time, zirconium – essential in high-temperature applications – was produced mainly in South Africa, whose reserves were about to be depleted (MJ, 3 June 1994). In this context Greenland was framed as an alternative zirconium source and a way of diversifying supply.

The molybdenum site, discovered in the 1960s, also attracted private actors' attention. Believed to be one of the world's largest molybdenum deposits, it formed "a ridge of land between two glaciers" (KGHM International 2013). Molybdenum was mainly known for alloying in steel applications, but it was also used in lubricants. Metal prices rose in 1994, and especially the price of molybdenum, which increased five-fold (MJ, 3 June 1994, see also figure 4). This sparked the interest of Platinova, the Canadian mining company that was already active at Citronen and Kvanefjeld. In 1995, the company acquired an exploration license for Malmbjerget (MJ, 20 January 1995). In 1996, however, the molybdenum market unexpectedly collapsed, so suddenly the deposit was no longer regarded as economically viable (see figure 4) (MJ, 24 May 1996). Only after the turn of the millennium did the molybdenum market revive again, once more spurring interest in the deposit. Quadra Mining, another Canadian company, took over the site in 2007. In October 2011, however, following global recession, the company stated that the molybdenum price was again too low for the project to be profitable. Soon afterwards Quadra Mining was acquired by the Polish mining company KGHM International, which took over responsibility for the project (MJ, 21 October 2011).

Another 'critical' metal was cobalt, crucial in high-temperature and wear-resistant applications and usually found together with nickel and copper. In 1992 Platinova and a partner, Falconbridge, decided to join forces in a search for the three metals in Disko Bay in western Greenland. Three years later Greenland was virtually flooded by foreign mining companies motivated by a spectacular discovery of nickel and cobalt in Labrador, Canada. The geological similarities between Labrador and Greenland produced a belief among mining companies that Greenland might be equally rich in terms of these metals (MJ, 16 February and 1 March 1996). Greenland waited in vain for a nickel-copper-cobalt mining boom, however, as none of the exploratory projects led to the actual opening of new mines, one reason being the "undulating terrain" at promising sites such as Maniitsoq, which reportedly caused technical difficulties in surveying some areas (MJ, 22 November 2013). In 2011, however, another company, North American Nickel, received a license from the Bureau of Minerals and Petroleum of Greenland to explore the Maniitsoq area anew for cobalt and nickel (North American Nickel 2014). This time new mapping technology was available, and the company also carried out drilling in the area. (MJ, 22 Nov 2013).

Greenland showed potential for other mineral resources as well. In 1986 the *Mining Journal* reported that tantalum and niobium, two of the world's "rarest metals", had been discovered at Sarfartoq in western Greenland (MJ, 7 November 1986). In 1998 the Australian company New Millennium Resources started to explore the deposit (MJ, 23 November 2001). Two years later, a British exploration company, Angus & Ross, received a license from the Government of Greenland to explore another tantalum deposit, situated at the Motzfeldt centre, which had been discovered in the 1970s (MJ, 11 February 2000). In 2010 Ram Resources acquired the Motzfeldt deposit from Angus & Ross. The *Mining Journal* believed that the site had the potential to become a world-class tantalum and niobium source that might contribute in a significant way to diversifying the market, since most production at that time took place in Africa and South America (MJ, 1 October 2010). In Africa these metals were referred to as "conflict minerals", as they were mined in parts of the Democratic Republic of Congo, where the profits were used to fuel armed conflict. Greenland was viewed as a (politically speaking) more favourable source of these metals and a possible way of diversifying global supply.

Increasingly, the mining industry's interest turned to the strategic rare earth elements (REEs).[11] These metals were used in various high-tech products, such as mobile phones, wind turbines and hybrid and electrical vehicles. Analysts expressed environmental concerns relating to the mining of these resources, which caused problems for the rare earths industry in many countries. The large American mine at Mountain Pass, California, in particular, had to close in 2002 after radioactive wastewater was found to be leaking out (see e.g. Vikström 2011). This, in combination with declining world market prices for these

11 REEs are a group of seventeen different elements with similar properties; they occur together with the radioactive elements uranium and thorium.

minerals in the years around 2000 (see figure 4), made the American mine unprofitable. It paved the way for China, which subsequently emerged as the world's by far dominant supplier of rare earths (see figure 6 below).

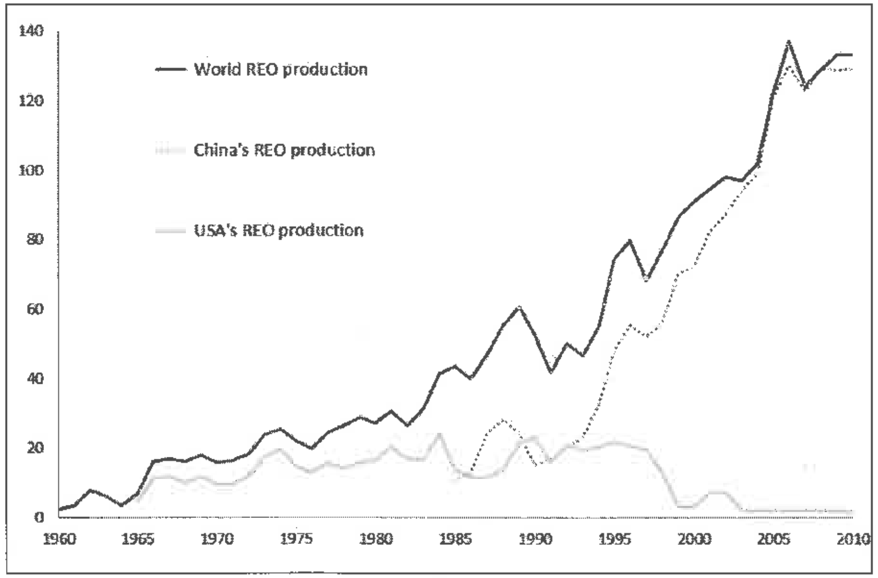

Fig. 6: World production of rare earth oxides (REO), 1960–2010 (million tonnes). Source: Based on data in USGS (2010)

Greenland gradually appeared to offer an interesting alternative to existing sites of rare earths mining. The large Illumassaq area, which had been prospected several times already by both private companies and the Geological Survey's scientists, contained several interesting deposits of rare earth elements. The former uranium mining site of Kvanefjeld was the main focus in Greenland's rare earths hunt. It held a high concentration of heavy rare earth elements, which were much sought-after because they usually occurred only in small concentrations[12] In 2007 Greenland Minerals and Energy, an Australian com-

12 Elsewhere, the elements in question were typically found only in very small concentrations, and the

pany, started exploring Kvanefjeld's minerals (Greenland Minerals and Energy 2013). The initiative coincided with a new, sharp upward trend in rare earth prices (see figure 4). The potential mine received support from a Greenlandic business council and was seen as a way of providing work and strengthening the economy (Nuttall 2008). The mining companies also showed interest in numerous other Greenlandic REE deposits.[13] One problem for the investors and the mining industry was that the REEs could be extracted only if uranium was mined at the same time. Against this background, the Greenlandic parliament started considering repealing the 1988 ban on mining radioactive substances (Nuttall 2008a). In 2010 the government decided to amend the zero-tolerance uranium policy by allowing companies to make environmental and social assessments around the deposits (MJ, 21 Oct 2011). According to Greenland Minerals and Energy, this was an important step in continuing to develop the Kvanefjeld project (MJ 10 September 2010). Later in 2010 the Greenlandic government approved GME's application to evaluate Kvanefjeld (MJ, 17 December 2010). In 2012, the company and the government decided to include uranium in the Kvanefjeld license, eventually paving the way for similar developments in other places (MJ, 4 October 2012 and 20 April 2012). In October 2013 the zero-tolerance uranium policy was formally lifted, as the Greenlandic parliament voted 15 to 14 to end the prohibition on mining (MJ, 1 November 2013).

From around 2014 the global mining industry faced problems again, due mainly to weak demand and decreasing prices, primarily as a consequence of over-production worldwide and a slowdown in China's industrial growth. The effects on Greenland have so far varied from project to project. Regarding Malmbjerget, Greenland's government states that the mine is not in operation "due to the low prices of molybdenum" (Government of Greenland 2016). KGHM, which owns the deposit, intends to keep the license as the market conditions may

most common ones were "light" rare earth elements. In Kvanefjeld the concentration of "heavy" REE were estimated to about 15 %, whereas many other deposits contained concentrations of around 1 %.

13 The focus on both the Motzfeld and Sarfartoq deposits shifted to REEs, and the company mined for REEs at Kringlerne near Kvanefjeld (MJ 16 March 2010, MJ 18 October 2013).

change. Similarly, as a result of globally declining iron ore prices and the Ebola outbreak in Sierra Leone in 2014, which seriously affected the owners of London Mining, the Isukasia iron ore deposit was sold to a Hong-Kong-based company, General Nice Development Limited (Government of Greenland 2016 and Arctic Journal 2015). What will happen to the area is unclear. The same can be said about the zinc prospects at Citronen Fjord.

Other mining projects, however, appear to be proceeding, albeit slowly. The license-holders of the Motzfeldt deposit plan to map and sample the site (Regency Mines 2016). Similarly, In the Maniitsoq area, North American Nickel implemented a program for drilling in a nickel, copper and cobalt deposit to which they held rights (North American Nickel 2016). The Greenland Minerals and Energy company is optimistic about the Kvanefjeld rare earths and uranium deposit, believing it will become a globally important extraction site (Greenland Minerals and Energy 2016a). In January 2016, Greenland Minerals and Energy and the Danish government reached an agreement over legislation regarding future uranium exports from Greenland (Greenland Minerals and Energy 2016b). The dream of Greenland's minerals as a lever of riches, freedom and power lives on.

Discussion: explaining actors' interests in Greenland's minerals

In this chapter we have shown that the interest in Greenland as a mining country has by no means come about overnight. It is but the latest phase of more than two centuries of enthusiasm for exploring, extracting and using Greenland's minerals. The actors involved in this development have taken an interest – and sometimes lost interest – in Greenland for a variety of reasons. Understanding this history, we believe, is essential for grasping the wider topic of heritage and change in the Arctic. In this concluding section we follow up our historical analysis by trying to discern, at a structural level, how the global and local factors discussed in the theoretical section above, can be seen to have shaped actors' decisions to invest in and support mining activities in Greenland.

Firstly, global **technological trends** have clearly shaped actors' enthusiasm for Greenland's minerals during the years. Rapid technological progress in areas such as electronics, superconductivity, new materials and renewable energy technologies have in recent years generated a massive demand for rare earth elements and other "strategic" metals. As these metals are often perceived as scarce, finding new deposits has been crucial for manufacturers, and it is in this context that the scramble for Greenland's rare earths should be understood. Since the 1980s, as we have seen, a range of actors began to take interest in the exploitation of these resources, anticipating price increases and great profits linked to technological breakthroughs. Importantly, such actors often went ahead with substantial investments even before it had become clear that the Arctic was warming up and that Greenland's glaciers were about to melt away.

Similar mineral rushes linked to rapid technological change and price increases have taken place in the past. Greenland's cryolite mine, for example, was started up in connection with the take-off of the modern chemical industry in Europe in the 1850s, and it was further expanded as a result of the rise of the aviation industry (and its demand for aluminium) in the early twentieth century. In the same vein, Greenland's uranium suddenly became interesting through the invention of nuclear weapons and nuclear energy. What these historical examples also show is that a boom can be quickly reversed: in the case of cryolite, the interest in Greenland decreased after the invention of a synthetic substitute; in the case of uranium, the early expectations for a flourishing nuclear age with thousands of nuclear reactors worldwide never materialized – least of all in Denmark, which never built a single large-scale nuclear reactor. Ironically, Greenland might actually become a uranium producer in the twenty-first century, but the uranium will be extracted mainly as a by-product of rare earth elements.

Secondly, global **economic trends** and **changes in world market prices** have played a crucial role. Many decisions to invest in or withdraw from mining projects in Greenland can be better understood by looking at the volatility of world market prices for the involved minerals and metals. For example, the upward trend in early twenty-first-century iron ore prices, which was essentially fuelled by China's industrial growth, appeared to make London Mining's planned iron mine at Isukasia economically feasible. The company's optimism would have surprised an observer in the 1980s, at which time it was believed that such a project could never become profitable. The dramatic rise in rare earth prices, especially from 2007, is even more remarkable, and actors often cite it as a main motivating force when considering investments in Greenland. What the price hikes essentially do is render irrelevant the additional costs that arise from extreme climatic conditions. On the other hand, as we have seen, price hikes can also be followed by unexpected market collapses, leading actors to put projects on hold or to abandon them altogether. This was the case for the molybdenum deposit at Malmbjerget, for example, and earlier for the abandonment of the Mestersvig lead-zinc mine.

Turning to local factors, Greenland as a mining country has clearly been shaped by **politics**. Our story makes clear that since Greenland is closely connected with Denmark, has a democratic political system, and is geographically located in relative proximity to both Western Europe and North America, the world's largest island is much more attractive – from the perspective of Western actors who worry about scarcity and vulnerability in their minerals supply – than many resource-rich regions in Africa, Latin America, or Asia. The EU appears to be the most enthusiastic political actor in this context, as it perceives access to many metals as risky, especially when it comes to rare earth elements from China.

This development is reminiscent of Western interest in Greenland's uranium resources after World War II, which was regarded as – geopolitically speaking – excellently located. Once promising resources had been identified, Denmark and the United States set out to exploit the uranium. There seemed to be no need to wait for glaciers to melt away. From such an historical point of view, it may be argued that the current interest in Greenland's "critical" minerals, notably the rare earths, would have been very strong even if global warming had not been an issue in the twenty-first century.

Regional politics has also shaped Greenland's mining history. As we have seen, many political actors and analysts have long argued that mining holds the key to greater Greenlandic autonomy and perhaps even full political independence. This has, at times, motivated Greenlandic politicians to do everything they can to attract investments in the mining sector. The potentially huge profits from mining in Greenland – as demonstrated by cases such as the cryolite mine at Ivittuut and the Black Angel zinc-lead-silver project – became interlinked with a fierce political debate, not only over Copenhagen's control of revenues from the island's mineral wealth, but also the general political and economic relations between Denmark and Greenland. A first outcome of this debate was the 1978 decision to institute home rule. The debate has continued on a rollercoaster trajectory up to the present, resulting in a new agreement on increased Greenlandic autonomy in 2009. It may be noted that this latter agreement coincided with an upsurge in the global warming debate. However, since the autonomy debate surfaced in the 1970s, it is hardly a recent phenomenon that can be explained by this recent environmental debate.

In our theoretical section we further identified **regulations** and **infrastructure** as two factors on the local level that may encourage or discourage mining companies to contemplate new explorative or exploitative investments. Our empirical evidence clearly confirms the importance of both factors. Especially in the years around 1990, the industry's main obstacles to the launch of new projects in Greenland were mainly related to Greenland's need for new legislation and the closure of depleted mines. It was seen as difficult to start up new mining operations when no other mines were active. The government tried to deal with this problem, as explicated above, by financing airborne and marine geophysical surveys, by developing a generally cooperative attitude, and by issuing new rules and laws that by the early twenty-first century had turned Greenland, in the words of the industry, into one of the most favourable mining countries in Europe.

Lack of infrastructure was cited, for example, as a main reason why, as of the early 1980s, the Isukasia iron ore deposit was seen to have no commercial value. In other cases, however, such as the Citronen zinc project in Greenland's far north, the infrastructure dimension was actually framed as a positive factor in terms of favourable access to deep tidewater. The situation was much the same in important historical projects like the Ivittuut cryolite mine and the Black Angel zinc-lead mine.

Lastly, let us address Greenland's **geological and environmental conditions**. A basic motivation for mining companies to take an interest in Greenland has clearly been the island's geology. Greenland has been considered unusually well-endowed with minerals, from its unique cryolite deposits to its immensely rich finds of rare earths. In terms of climate and other environmental conditions, mining companies have sometimes understood them as difficult and sometimes as favourable. Concerning the much-publicized recent retreat of glaciers, however, our material does not indicate that such environmental processes have in any way been decisive in motivating actors to prospect, explore and exploit Greenland's mineral riches. Put simply, it is very difficult to find examples of mining companies that have actually based their decisions to start up new projects in Greenland on the promises of an ice-free future. Virtually all minerals projects in Greenland that have appeared in media reports – and which have been discussed in this chapter – are situated in areas that have been known to be ice-free for decades or even centuries.

To the extent that receding glaciers do qualify as a factor that helps us understand the rise of Greenland as a paradise for minerals, it is the narrative about them that matters rather than their physical materiality. The Greenlandic government and the mining industry have made ample use of the climate debate to legitimize new projects, attract investors and 'brand' Greenland globally. The argument's most characteristic feature is that it tends to refer to the impact that climate change will have in an unspecified future; it rarely refers to any concrete, already ongoing projects in Greenland as having come about as a result of it.

Why, then, is the discourse about the radical impact of the melting ice such an appealing image among political and industrial actors, in media and public awareness? In our view, the main reason is the lack of historical perspective. Greenland is commonly perceived as a blank spot on the economic world map; few people are aware of the thriving and multifaceted minerals-related activities that have taken place there since long before the onset of the climate debate. Moreover, there is a long history of misconceptions regarding the general relations between environmental change and societal development, as discussed in the theoretical section. While it is possible to argue that the melting ice reveals new, previously unexplored land, by no means does this allow us to draw any conclusions about how actors will respond to this change in the environment. In our case, the impression is clearly that environmental change has so far not produced any significant change in actual mining activities. Rather, the melting of the ice merely confirms a path on which actors have already embarked.

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