Polarforschung 86 (1), 15–26, 2016

Historical Perspectives – The European Commercial Exploitation of Arctic Mineral Resources After 1500 AD

by Frigga Kruse[1]

Abstract: This paper focuses on the commercial exploitation of Arctic mineral resources by European newcomers to the region. Minerals in demand were extracted in the North and transported to European markets for financial gain. This practice is bound up in the wider colonial history of the North and its discovery and utilisation by individuals, companies, and nation states intent on making profits and claiming territory. The general processes at work are illustrated using four case studies: Frobisher's "black ore" from Baffin Island; the company-controlled extraction of Greenland cryolite; the "resource frontier frenzy" at Nome; and the race for coal in the no man's land of Spitsbergen. Such mineral-based processes set the scene for the emergence of the modern Arctic as a resource frontier region, which is currently seeing renewed interest from cooperations and nation states.

Zusammenfassung: Dieser Artikel konzentriert sich auf die kommerzielle Ausbeutung von arktischen Bodenschätzen durch europäische Neuankömmlinge in der Region. Auf Nachfrage wurden Minerale und Erze im Hohen Norden abgebaut und für finanzielle Bereicherung auf den europäischen Markt transportiert. Diese Praxis ist ein Teil der breiteren Kolonialgeschichte des Nordens und seiner Entdeckung und Nutzung durch Privatpersonen, Unternehmen oder Nationalstaaten, die beabsichtigten, Profit zu schlagen und neue Territorien zu beanspruchen. Die allgemeinen Prozesse, die hierbei vonstattengingen, werden anhand von vier Fallstudien dargestellt: Frobishers „schwarzes Erz" von der Baffininsel; die durch ein Unternehmen gesteuerte Extraktion von grönländischem Kryolith; die „Ressourcengrenzgebietraserei" in Nome; und der Wettlauf um Steinkohle im Niemandsland von Spitzbergen. Diese grundstoffbasierten Prozesse setzen die Entstehung der modernen Arktis als „Ressourcengrenzgebiet" in Szene, welche derzeit erneut Interesse von Kooperationen und Nationalstatten auf sich zieht.

INTRODUCTION

Humans have been living in the Arctic for more than 30,000 years (Pavel et al. 2001, Pitulko et al. 2004). For many millennia, their use of Arctic minerals and rocks was primarily for tool-making as an essential part of their subsistence strategies, though some long-range exchange networks also emerged, leading to the movement of certain highly-prized materials like chert. Though these resources no doubt had social and symbolic value, and could be exchanged and displayed, at no stage were these resources being extracted and transported for commercial profit, that is, to create wealth. Therefore, the arrival of European explorers and traders into the margins of the Arctic world around 500 years ago marks a new phase in the human uses of Arctic mineral resources.

With little prior knowledge of the Arctic, the early European expeditions were driven by a range of factors. In fact, many were driven by motivations other than to mine Arctic minerals; the explorers wanted, for example, to discover new sea routes to the Orient, which would deliver lucrative trade opportunities. Their first encounters with – and reactions to – local mineral resources were therefore opportunistic and speculative, commonly leading to mistakes and false hopes. Over time, these relationships changed as knowledge of the Arctic grew and external demands for mineral resources increased from the sixteenth through to the twentieth century. This paper aims to give a broad-brush overview of the European commercial exploitation of Arctic mineral resources over the last five centuries. These provide an important historical context to modern debates about the Arctic as a "new" resource frontier, with exciting commercial opportunities opening up due to the melting sea ice and new seaways.

The historical overview plots substantial changes in commercial exploitation of the Arctic. These transformations are illustrated by four case studies. Each has been chosen on the grounds of geographical spread (Fig. 1) as well as different historical contexts in order to illustrate similarities and differences through space and time.

1) Frobisher's voyages to Arctic Canada in the late six-teenth century took place in an age of discovery and trade. Although unprofitable, his *Meta Incognita* (unknown shore) in south Baffin Island quickly acquired the tell-tale characteristics of a resource frontier region, albeit a short-lived one.

2) Against the backdrop of the Industrial Revolution, the 130-year story of the Ivigtut cryolite mine in Greenland exemplifies the successful application of Arctic science to global technology. Since the mine's closure, the company town has become a downward transitional area, whose venture into geo-tourism has not paid off.

3) Gold lay at the heart of what may be termed "resource frontier frenzies" such as the rush to Nome, Alaska, at the turn of the twentieth century. Such frenzies appear to occur out of any context, but Nome had its roots in the Californian stampede of 1849. When the hype died down, chaos gave way to order as the former boomtown was incorporated; gold mining here continues to this day.

4) In the case of Spitsbergen in the European High Arctic, a no man's land prior to 1925, the so-called "coal rush" provided rising nations with an impetus for colonial aspirations, potentially upsetting the European balance of power. The length and persistence of coal extraction in the archipelago is an exception to the general pattern of Arctic mining.

doi:10.2312/polarforschung.86.1.15

[1] University of Groningen, Arctic Centre, Aweg 30, 9718CW Groningen, The Netherlands; <f.kruse@rug.nl>

Manuscript received 17 December 2014; accepted 12 September 2016.

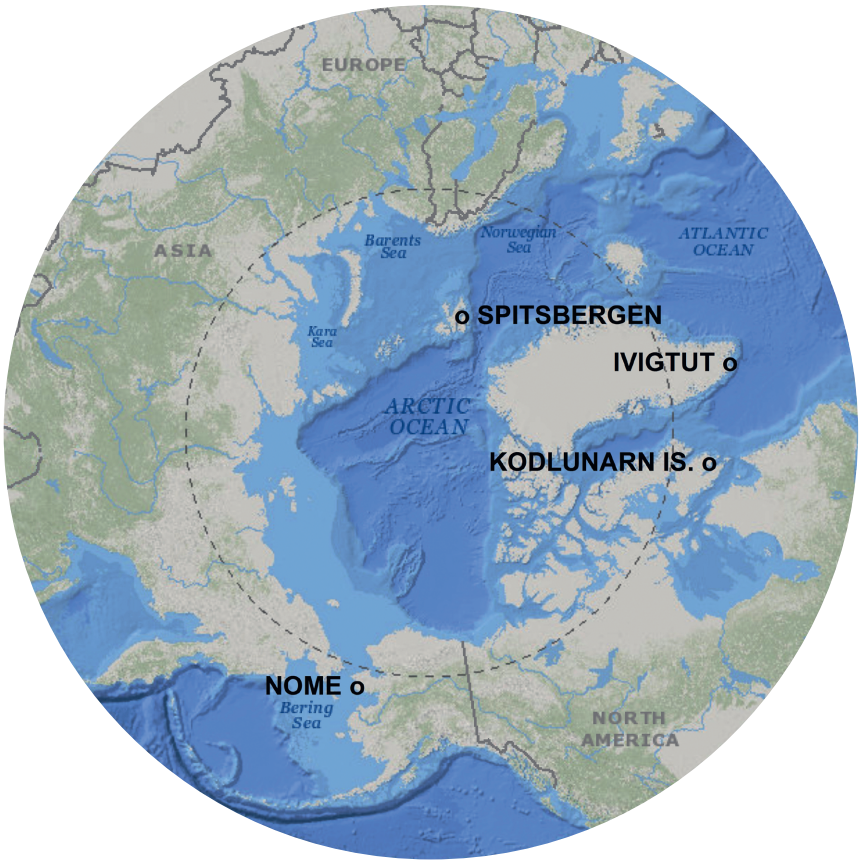

Fig. 1: The Arctic Ocean basemap indicates the locations of the four case studies of Kodlunarn Island, Ivigtut, Nome, and Spitsbergen, which were chosen on the grounds of geographical and temporal spread. Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and others; adapted by the author.

Abb. 1: Die Basiskarte des Arktischen Ozeans zeigt die Lage der vier Fallstudien Kodlunarn Island, Ivigtut, Nome und Spitzbergen, die aufgrund der geografischen und zeitlichen Verbreitung ausgewählt wurden. Quellen: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org u.a.; vom Autor angepasst.

These historical perspectives are important. The current attention on Arctic mineral resources and the realisation that many important lessons can be learned from the past calls for fresh approaches at the Arctic research frontier. The history of Arctic mining and its economic, political, and environmental consequences being a new and timely research direction and industrial archaeology being an innovative technique, there is much to be done.

CASE STUDIES

Case study 1: The Frobisher expeditions to Baffin Island (1576, 1577, 1578)

Sir Martin Frobisher (1535?-1594) was an English privateer, explorer, and naval commander, who undertook three voyages to the Canadian Arctic in 1576, 1577, and 1578 (Holland 1994, McDermott 2004a). Early Modern Europe had reared its head with Columbus' arrival in the New World in 1492, and the subsequent era of discovery witnessed the Western European search for new trading routes. Portugal and Spain led the way; Russia conquered the whole of Siberia, while France, England, and the Netherlands sought to imitate the Iberian accomplishments. To avoid conflict in the widespread Portuguese and Spanish colonies, a commercial sea route north of the Americas was considered for the first time, and the Italian John Cabot (under English commission) initiated the search for this elusive passage to Cathay (China) in 1497. Only between 1903 and 1906 did the Norwegian Roald Amundsen successfully navigate the Northwest Passage, and a single-season transit was not achieved until 1944.

Martin Frobisher was typical of this period. He met with the London mercer, merchant adventurer, and traveller Michael Lok (ca. 1532-1622) in 1574, and together they organised an expedition with the primary objective to unveil said north-west passage to the Orient (McDermott 2004b). In June 1576, two small barks and a pinnace, carrying a total of 34 men, left the Thames. After a storm, only one bark was able to continue the journey, which brought Frobisher to *Meta Incognita* in the south of Baffin Island. This expedition is remembered for sighting the southern tip of Greenland, the discovery of Frobisher Bay, making contact with the Inuit (Ehrenstein 1998), and the formal attempt to claim the newly discovered territory for Queen Elizabeth I.

Central to this paper, however, is a small piece of rock, which Frobisher's men collected on Little Hall Island at the mouth of Frobisher Bay (62°31' N, 64°10' W). Commonly referred to as "black ore", the enthusiastic Lok had this rock assayed until someone confirmed the presence of gold in it (Donald 1950, Hogarth & Loop 1986, McDermott 2004a). This alleged discovery of gold quickly attracted support for the follow-up expeditions in 1577 and 1578. In 1577, the unpromising Little Hall Island was quickly dismissed in favour of Countess of Warwick's Island, now Kodlunarn Island (62°49' N, 65°25' W), where about 160 tons of ore were mined. Back in England, the assays were inconclusive. Nonetheless, the momentous wave created by the prospect of gold swept another 15 ships, conveying about 400 men, to Kodlunarn Island and surrounds in 1578, where circa 1370 tons of ore disappeared into their hulls. Once again, the assays found nothing of value. By now, confidence in the enterprise had waned. Despite £ 25,000 of investments (ca. £ 4 million in today's money) being irretriev-

ably lost, McDermott (2004a) emphasizes that the enterprise was not a spectacular failure; rather it disintegrated as its backers dissociated themselves from it, leaving Lok bankrupted and Frobisher disgraced until he regained royal favour in the West Indies raid of 1585.

Frobisher's unprofitable mines lay forgotten for almost three centuries. Their modern story begins with Charles Francis Hall's Inuit-inspired visit to Kodlunarn Island in 1861. In 1964, a re-evaluation of Frobisher's achievements and legacies led to the island being formally recognised as a National Historic Site of Canada. The Canadian Register (2009) states that, "*the heritage value […] lies in its association with the mining attempts of Martin Frobisher as illustrated by the site and the archaeological evidence it retains to confirm Frobisher's 16th-century presence and activities. Evidence also survives in the oral traditions of the Inuit people who have preserved an account of this first European attempt to exploit the natural resources of the Arctic*."

Yet, said archaeological evidence was not entirely appreciated until the international and interdisciplinary Meta Incognita Project could address this shortcoming in the 1990s (Symons 1999a). Some readers may wonder what archaeological investigation can add to an historical event that was reasonably well documented in its time. To begin with, the European material culture is undeniable proof that Frobisher's Arctic expeditions had, in fact, taken place; the material remains thus verify the documentary record. Besides, the material remains encountered, subject to four centuries of physical erosion and human disturbance, were better preserved than the documents would have believe. The project's aims, therefore, were to protect this non-renewable resource and to qualify the historical environment, thereby aiding conservation, research, and communication.

The Meta Incognita Project gave rise to a number of commendable publications (Alsford 1993, Fitzhugh & Olin 1993, Hogarth et al. 1994, Symons 1999b), but a brief summary of the archaeology of Kodlunarn Island and surrounds must suffice here. The small, mostly barren rock situated 500 m off the northeast shore of Frobisher Bay formed the principal base of Frobisher's mining activities. The archaeological fieldwork in the early 1990s entailed mostly non-intrusive methods in addition to very limited excavation.

The main features were two mining trenches, an area of former industrial activity, and the foundations of the so-called Frobisher House. The Ship's Trench, thought to be the first European mine in North America, was cut into the island's northern coast. Although Inuit oral traditions hint at ship building or repair, rock thought to be a mineral ore had probably been exposed at this location, and a vein had been followed in a south-easterly direction, resulting in a trough measuring 25 by 5 m. In 1578, unused supplies were buried in it, some of which were recovered in a small excavation. The Reservoir Trench (Fig. 2), its name suggesting the unlikely function of a freshwater store, lay 100 m to the southeast yet in line with the Ship's Trench, supporting the notion of a vein being targeted and exploited. This trench had similar dimensions, being only one to two meters deep. Both trenches were therefore very shallow surface workings. Tool marks indicated that the extraction of extremely hard rock was accomplished by pick-and-hammer method; an inventory of mining tools taken by Frobisher showed that plug-and-feather techniques were intended, too. Aforementioned industrial area comprised flat, sloping ground between the Reservoir Trench and the east coast of the island. Over an 80 m spread, coal, slag, and fragments of charcoal and industrial ceramics were found and interpreted as the remains of activities associated with mining such as tool repair and smelting ore for assay. It is uncertain if this area included any buildings; closer comparison with historical sources may yet resolve this. The Frobisher House, formerly Fenton's Watchtower, once stood on a 37 m hill, the highest point of the island. Its remains consisted of a shallow irregular pit and a scatter of large boulders. Its foundation was relatively well preserved, showing some roughly-hewn stones and the use of lime mortar. The house being neither very big nor high, documentary sources completed the picture of stone-and-wood walls with a wooden roof. Lesser archaeological features were a pair of standing stones that could be grave markers and two large areas of scattered stones, explanations of which range from former cairns protecting buried supplies to the remnants of Inuit tent rings. In addition to the

Fig. 2: The inconspicuous Reservoir Trench on Kodlunarn Island in Frobisher Bay has attained Canadian cultural heritage status as part of the earliest European mine in North America and the Arctic. © William Fitzhugh, Arctic Studies Centre, Smithsonian Institute.

Abb. 2: Der unscheinbare „Reservoir Trench" auf Kodlunarn Island in der Frobisherbucht erreichte als Teil der ersten europäischen Mine in Nordamerika und der Arktis den Status eines kanadischen Kulturerbes. © William Fitzhugh, Arctic Studies Centre, Smithsonian Institute.

material culture on Kodlunarn Island, an off-island survey revealed an impressive 75 sites also thought to be associated with Frobisher. In a timely move away from simply focussing on specific mining sites, an entire archaeological landscape of Arctic mineral exploration was thus revealed and tentatively addresses the question of what distinguishes prospecting and outright mining. What fills the gap between no activity at all and mineral extraction? When does a test pit become a small mine?

Frobisher's Arctic material legacy not being enough, it deserves mention that the "black ore" was destined for Dartford in England, where prototype smelting works had been purpose-built along the River Darent (Dartford Town Archive 2014). The ore being worthless, it was subsequently used in construction: some of it can still be viewed in the western wall around Henry VIII's Manor House in Dartford. Nonetheless, the establishment of unique smelting works directly led to a long tradition of specialised industry along the Darent. One wonders if in this way, any dire environmental consequences that often overshadow Arctic mineral extraction were unwittingly diverted to the home country.

Geologically speaking, this abridged account of Frobisher's expeditions raises a number of issues and leads to new questions. In the first instance, "geology" was simply something that was in the way; Frobisher, after all, was looking for a convenient sea passage, not impeding landmasses. He most certainly had no prior geological training besides the notion that precious metals could be found in the ground. In this regard, Castells (2009) highlights the significance of Frobisher's alleged gold from the Arctic, where it was not thought to exist, as a bone of contention between natural philosophy and the emerging scientific process. It serves as an instructive example in a bygone age when new knowledge challenged the traditional doctrines of science. While Frobisher's men were probably inexperienced miners, their efforts nonetheless contributed directly to the progress of smelting technology, while the overly optimistic assays have been blamed on the failings of contemporary metallurgy and the doubtful competence of the assayers rather than intentional fraud (Hogarth & Loop 1986, Castells 2009). Historical searches for gold, however, should not be dismissed too easily: the search continues with, for instance, Commander Resources Ltd (2006) and the Baffin Island Gold Project.

What else does the claim of Frobisher's being the first European mines in North America and the Arctic entail? In the context of this paper, *Meta Incognita* may be viewed as the archetypal resource frontier region: it ticks all the boxes (Friedemann 1966, Sugden 1982). The notion of a developing Arctic resource frontier region quickly puts Frobisher's voyages into a new light. As Symons (1999a) proposes, they prophesied "*the future synergy of maritime navigation, expanding intellectual horizons, colonial ambitions, and industrial enterprise*."

Since the Frobisher expeditions, the Arctic could be seen as a region of opportunity and with the hope of striking it rich. These motivations remained in place over the following centuries, but they were expressed in different ways and had different outcomes.

Case study 2:
The cryolite mine at Ivigtut, Greenland (1854-1987)

Between the late eighteenth century and the early nineteenth century, the Industrial Revolution brought about rapid and drastic changes in European agriculture, manufacture, and transport, which had lasting socioeconomic and cultural effects. Against the backdrop of this process, which continued as industrialisation, the scientific discoveries and commercial products of the cryolite mine at Ivigtut (presently Ivittuut, 61°12' N, 48°10' W) in Arsuk Fjord in southwestern Greenland directly led to technological improvements on a global scale, despite both mine and company town now being abandoned.

The prologue of Greenland's European history had quite literally been carved in stone by Norse settlers between the late tenth century and the mid-fifteenth century; in fact, Ivigtut lies within the so-called Middle Settlement comprising 41 known archaeological sites (Edwards et al. 2013). Following their demise and subsequent absence, Frobisher sighted Greenland again in 1576, and several expeditions followed suit until the noteworthy arrival of the Dano-Norwegian clergyman Hans Egede in 1721. As part of the Danish colonisation of the Americas, Egede and other colonists were under royal orders to search for exploitable natural resources of any kind (Secher 2003, Government of Greenland 2014). At the time, whaling formed the staple European activity, and from 1776, the state-owned Royal Greenland Trading Company (Dan. *Den Kongelige Grønlandske Handel*, KGH) monopolised all trade (Strøm Tejsen 1977, Kragh 1995). Although Egede had reported the occurrence of graphite and the KGH occasionally brought curiosity minerals back to Denmark, systematic exploration and mining were not initiated until the mid-1800s (Secher 2003), from when on Holland (1994) registers regular Danish geological expeditions to Greenland.

Mining had already arrived in Greenland in the form of German coal extraction in Disko Bay (1780), when the mineral cryolite first caught the attention of Europeans. The year of "discovery" is commonly cited as 1799, although some discrepancies exist (Kragh 1995, Ralph & Chau 2014a). Besides, the mineral was not at all new to the Greenlanders, who are said to have used it as fishing weights, for example (Elbo 1948, Kragh 1995). Nonetheless, the colourless to white mineral, which may occasionally appear reddish, brownish, or even black and usually occurs in massive coarsely granular rock, was not fully analysed until 1823, and even then, the small amounts shipped from an undisclosed locality made it seem rare and without immediate industrial use (Kragh 1995). Thus, cryolite had to wait its turn until its industrial use in chemical manufacture was investigated in 1847, and by 1849, the Danish chemist Julius Thomsen (1826-1909) had produced small amounts of sodium carbonate or soda in the lab. At the time, the limited domestic production of soda from kelp could not meet the growing demand of local soap and glass manufacturers. If cryolite proved a suitable raw material, Thomsen would be able to intercept the import of foreign soda and exploit the market niche. The deposit at Ivigtut, which occurred as a pegmatitic body in a granite stock intruded into gneiss (Ralph & Chau 2014b), had been shown to be fairly large and accessible by sea, when Thomsen was granted the patent to manufacture cryolite soda in 1853.

Organised extraction in Greenland was as of yet lacking, and Thomsen depended on the monopoly-bearing KGH, who only shipped 90 tons of the raw material between 1854 and 1856. This bottleneck, however, was overcome when Thomsen and his business partners obtained the right to extract cryolite themselves.

By now, cryolite knew two uses: while Thomsen wanted to make soda, a dominant partner was primarily interested in the production of aluminium, then an expensive metal with great future potential (KRAGH 1995). Trial shipments were therefore sent to France, and in 1856, French representatives visited Ivigtut. One disillusioned mineralogist reported that "*conditions for extraction and shipping were unsatisfactory. The ice fields, the hard climate, the lack of organization of the extraction, and the limited amount of cryolite above water level – all this made him conclude that cryolite would remain a costly mineral unsuited for industry at a larger scale*." (KRAGH 1995, 294). By 1858, it was indeed clear that cryolite aluminium would not be a money-spinner, and ca. 1,500 kg produced in 1859 were so dear that they could barely find a market. The French works were closed in 1864.

Meanwhile, the modest production of cryolite soda had begun in Southern Jutland, from where it was moved to the Kryolithfabriken Øresund in Copenhagen in 1859. That year, "Øresund" consumed 1,500 tons of cryolite to make roughly 2,200 tons of soda. After some economic difficulties, an independent firm was formed in 1865 to handle extraction and sale while Øresund took care of processing and soda production. In addition, an important contract was signed with the Pennsylvania Salt Manufacturing Company of Philadelphia (Pennsalt) for 6,000 tons of cryolite per year, after which Pennsalt monopolised the Americas. The 1860s were good years with several cooperating European firms and a substantial output: for the period between 1865 and 1869, KRAGH (1995) estimates an average of 14,000 tons of soda per year compared with Germany's 6,000 tons and France's 45,000 tons. During the 1870s, however, the quality of cryolite decreased and the price of soda was down. By 1884, the European works had stopped production, and Øresund focused on other cryolite products such as enamels, aluminium, and fluorspar. In 1894, soda production ceased in Copenhagen, Pennsalt following suit in 1900.

Despite the end of the original main product – cryolite soda – the economic importance of cryolite increased dramatically with the invention of the Hall-Héroult process in 1886 (KRAGH 1995). Between 1887 and 1987, cryolite from Ivigtut (Fig. 3) would be used as a flux in the production of metallic aluminium, becoming indispensable to modern industry (SECHER 2002, GOVERNMENT OF GREENLAND 2014). This importance undeniably found expression during World War II. Once Germany had occupied Denmark in April 1940 and the Denmark-Greenland connection was severed until May 1945, the resident Greenland Administration took over the mine and exported cryolite partly to Pennsalt, partly to Canada (ELBO 1948). The US soon built a naval base in Arsuk Fjord to prevent a German takeover (RASMUSSEN 2005). As of 1941, regular US Army units were stationed at Ivigtut's twin town Grønnedal (presently Kangilinnguit), the only Greenlandic settlements to be connected by road. The soldiers were not allowed inside the mine, however, where the miners themselves took care of security. ELBO (1948) states that the very high cryolite production during the conflict was partly due to the US storing large amounts in case Ivigtut should be cut off from America.

The English geologist Elbo visited the site after the war and provided an image of over 80 buildings – shacks, storehouses, barracks, machine-shops, a hospital – clustered around the open-pit mine, which lay about 60 m from the shore (ELBO 1948). The mine was about 190 m long, between 45 and 100 metres wide, and roughly 60 metres deep. The machinery was up-to-date, the granitic rock being air-blasted in winter and the cryolite shot down in summer. Excavators loaded the mineral into waggons, which were transported by elevator to be loaded directly into the ships. The granite was further used to enlarge the quay while a reinforced concrete dam would allow extraction closer to the water. The summer workforce of around 175 men shrank to 120 in winter. Prior to 1945, mainly Danes and some Norwegians had been employed; recently, there were supposedly also Greenlanders for general duties. Their living quarters were comfortable with many amenities. The company town also comprised a wireless station, a telephone exchange, and two fire stations.

During the war, synthetic cryolite had increasingly been used, lowering the market price of the naturally-occurring mineral

Fig. 3: In 1898, the Ivigtut cryolite mine was a hub of activity due to its global importance in the production of metallic aluminium. © The IMM Archive.

Abb. 3: Im Jahre 1898 war Ivigtuts Kryolithmine ein Zentrum der Aktivität aufgrund seiner globalen Bedeutung bei der Herstellung von metallischem Aluminium. © Das IMM Archiv.

(Rasmussen 2005). Coupled with the diminishing quality of the deposit, mining at Ivigtut was halted in 1962 (Kragh 1995). Cryolite production continued for a while yet with former dumps being dug out, the low-grade mineral being extracted, and the pier made of waste rock being removed (Rasmussen 2005, Ralph & Chau 2014b). In 1987, all activities were terminated, and the Greenland Home Rule authorities obtained the facilities. The Ivigtut Cryolite Mine had produced approximately 3.7 million tons with an average content of 58 % (Secher 2002). It was claimed to have been very profitable and to have brought significant socioeconomic benefits to the region (Elbo 1948, Strøm Tejsen 1977, Government of Greenland 2014). Nonetheless, it had a 130-year history of being a resource frontier region: after mine closure, what could Ivigtut, now Ivittuut, do to keep from becoming a downward transitional area?!

Downward transition of a former resource frontier region is characterised by low productivity, declining resources, low living standards, high out-migration, and social demoralisation among others (Sugden 1982). To prevent this from happening, a region must achieve increased autonomy and self-reliant economic growth in good time. After the mine closure in 1987, Ivittuut essentially survived as a side effect of Island Command Greenland being based at Grønnedal (Kangilinnguit). As of 2003, the town sought diversification and alternative income in opening the Ivittuut Mine and Mineral Museum (IMM 2014). *(*Dan. *Ivituut Mine- og Mineralmuseum)*. Its extensive website, in Danish and Kalaallisut, offered a glimpse into its professional and informative exhibits and gave an impression of the experiences that awaited the visitor on a tour around the former mine and company town. The commendable venture into geotourism was supported by EuroGeoSurveys, a non-profit organisation that represents 33 National Geological Surveys in Europe, which recognises that "geological heritage provides added economic growth value to tourism" (EuroGeoSurveys 2014). Furthermore, "*mining heritage represents a record of part of our cultural and technological history. This will allow present and future generations to learn from personal experience how much mining owes to human commitment and endeavour.*" (EuroGeoSurveys 2014) This rings particularly true for the Arctic. However, when Island Command Greenland was reorganised into Arctic Command in 2012 and its headquarters were moved to the Greenlandic capital of Nuuk, the local municipality closed the twin towns of Ivittuut and Kangilinnguit, depriving them of all community services. Consequently, the Ivittuut Museum abruptly had to shut its doors and relocate away from the site. It had not yet generated much revenue, but this was due to a lack of infrastructure rather than a lack of interest; "*in fact, the interest from cruise ships is enormous*" (Secher pers. com. 2014) Thus, diversification came too late to stop the downward spiral, and governmental policy made matters worse. So what is to happen to the ghost town? According to Greenlandic regulations, it should be *cleaned up* and brought back to its *natural state* [author's italics]. Unsurprisingly, there is a growing concern among cultural heritage specialists that the unique historical fingerprint of the Ivigtut cryolite mine will be irreversibly destroyed.

While Frobisher's was an ill-informed, small-scale adventure that ended in failure, this case study has shown that Arctic mines, despite location and climate, can be long-term and profitable. Ivigtut benefitted from scientific breakthroughs rekindling demand in time for a new lease on life. Still, it could not be spared the fate that awaits many mines and mining communities worldwide.

Case study 3:
The gold rush in Nome, Alaska (1898-1901)

Gold lay at the heart of what may be termed resource frontier frenzies such as the celebrated stampede at Klondike, Yukon, and the less well-known rush to Nome, Alaska, at the turn of the twentieth century. Such resource frontier frenzies appear to occur suddenly and out of any context, but they have their roots in the Californian gold rush of 1849. When the media-fuelled hype died down and the chaos was quenched, a town was established. Having instigated Alaska's evolution from unpopular purchase ("Seward's Folly") to statehood, gold and other mineral resources continue to be mined in Nome (64°29' N, 165°24' W) today.

The human fascination in gold reaches far back: the earliest and largest amount of gold artefacts in the world has been found at the Varna Chalcolithic Necropolis in Bulgaria, dating from the middle of the fifth millennium BC (Kostov 2010). Native American Indians, on the other hand, had little interest in the precious metal, and European discoveries in the United States were only made as recently as 1799. Within half a century, between 1849 and 1851, the archetypal Californian gold rush occurred. California forms the point of departure for subsequent resource frontier frenzies, and the concept of adventurism as a type of risk behaviour and social action provides an insight into who actually took part and why. Hamilton (1978, 1467) defines adventurism as "*the act of taking great risks whose outcomes are not calculable in advance [as well as] actions undertaken for sizable social, political, and economic gains that might occur if the venture is successful*." It applies to the Arctic, too, that adventurism was a temporary mobility strategy to substantially alter one's social standing in the home country. Although unpredictable, mining – especially the search for gold – offered the fastest way to wealth and social status. It is unsurprising, therefore, that following the Californian stampede, Holland (1994) records an increasing number of geological expeditions into the Yukon and Alaska. In 1741, Russian sailors had been the first Europeans to land on Alaskan shores, and Russian gold-prospecting expeditions were conducted here in 1849-51 and in 1852. Significantly, a member of the Western Union Telegraph Expedition found gold on the Seward Peninsula in 1866 (Carlson 1946). Yet, the US purchase of Alaska (1867), the first Alaskan gold rush in the Juneau Mining District (1881), and the Klondike gold rush (1897-9) had to pass, before Daniel B. Libby decided to act on his find. The gold discovery in Anvil Creek on the southern shores of the peninsula on August 5, 1898 was not the result of a sudden lucky strike; rather it was the outcome of four separate and gruelling prospecting trips partly aided by natives.

At the time of the decisive discovery, Alaska was not a legal US territory; it was a district with a governor and other officers but without legislature. Thus, it was entirely dependent on US Congress for all legislation (McKee 1902). In September 1898, the original discoverers began staking claims in Anvil

Creek. Realising they had made a mistake according to US mining laws, they quickly restaked the claims as part of their founding the Cape Nome Mining District, an area of 625 square miles (CARLSON 1946). In the mining district, local laws now governed the size of placer claims, the staking of claims by power of attorney, the time in which a claim needed to be recorded, and the use of water, the latter for practical mining reasons as opposed to environmental concern for the natural water courses. A district recorder was elected for a period of two years, and the fee for recording was set at two dollars and fifty cents. Work now began in earnest, and the first riches were retrieved. By November, however, all available water had frozen, and the mining season had effectively ended. Returning to the Swedish mission in nearby Golovin Bay, the discoverers could not keep the news of the rich strike to themselves: in the usual wildfire fashion, word spread, and before the year was over, the rush on Nome had begun.

Of interest to this paper is how the discovery of an Arctic mineral resource such as gold increases anthropogenic pressure on the land and leads to territorial claiming, settlement, law and order, and ultimately government. In December 1898, the first month of the stampede, about 300 claims had been staked and recorded, while more had been located (CARLSON 1946). The right to claim by power of attorney was stretched beyond all reason, and although the local law required that minerals be found before a claim was made, men acted on the notion that any ground could contain gold and gobbled up the territory. By May 1899, claims had been made as far as 40 miles west of Nome. When the Cape Nome Mining District was fully staked in July, other mining districts were founded. A white city of tents (Fig. 4) that expanded for several miles on both sides of the Snake River bore witness to the phenomenal growth of the settlement (CARLSON 1947a). Due to a lack of building materials on the tundra, the construction of houses was difficult. Any buildings initially belonged to the mercantile companies. In early July, a town-site committee was set up in an attempt to bring order into the chaos of claim-jumping and town-plot-jumping. A few days later, disgruntled miners challenged the organisation of the Cape Nome Mining District, and while a small military detachment could disband the conspiracy, the situation remained critical. It was never officially resolved because on July 11, 1899, the unexpected discovery of gold in the beach sands and the ease with which it could be extracted sufficiently evened the odds (CARLSON 1947a). The stampede to the beach sands was rapid, massive, and temporary. Although the steady mining on the creeks, of which Anvil and Glacier creeks were the richest, was far more productive, big employers like the Pioneer Mining Co. lost many workers to the beaches in August and September. By December 1899, roughly 4500 claims, unevenly divided into tundra claims, beach claims, quartz and lode claims, and placer claims, had produced an output of some $ 2.5 million (CARLSON 1946).

After its first season, the settlement had gained some stability. The mining camp was underway to becoming a civilised frontier town. CARLSON (1947b) has identified several factors that contributed to this development. Firstly, the discovery of gold in the beaches calmed a charged situation, and despite on-going claim-jumping, the military was able to keep violent outbreaks at bay. Federal justice was implemented in Alaska, and on his epic 5000 mile circuit through the district, Judge Johnson validated claims made by power of attorney while leaving the question of claims held by so-called aliens to the US Government. In addition, a consent government was elected in Nome, although it had no legal incorporation and lacked the power to raise taxes. Religious services commenced, and newly established newspapers mellowed the expression of conflicting opinions. Poor living conditions and the lack of fresh water were tackled by issuing health ordinances and plans for draining and sewage disposal. In many ways, Nome was a typical boomtown in a resource frontier region, but would it be sustainable once mining was no longer an option?

In 1901, Nome was incorporated. US law encouraged migrants to settle in such towns, and once population and development warranted, the frontier would gain full statehood. Alaskan statehood was granted in 1959. Nicknamed

Fig. 4: A white city of tents mushroomed during the gold rush in the Cape Nome Mining district in Alaska. Source: Alaska State Library, William E. Hunt Photo Collection, P155-1-27; reproduced with permission.

Abb. 4: Während des Goldrausches im Cape Nome Bergbaubezirk wuchsen weiße Zelte wie Pilze aus dem Boden. Quelle: Alaska State Library, William E. Hunt Photo Collection, P155-1-27; Druck mit Erlaubnis.

"the Last Frontier", mining for gold and other economic minerals is on-going. Regarding "Nome's new gold rush" (Alaska Dispatch News 2012), the State's Department of Natural Resources (DNR 2014) recently reported, "*With the current high price of gold and increased interest in offshore mining, there have been several incidents of friction between the miners of the East Nome Beach Public Mining Area. Local police have been called on three occasions*." The DNR has since proposed stipulations to manage the Nome Beach Recreational Mining Areas. It hopes that permits for recreational gold mining will adequately enforce civilised conduct.

The biggest losers during the Nome gold rush were probably the Alaskan natives as pressure on their land increased, game animals landed in miners' cooking pots, fishing streams were destroyed, and disease and drinking spread. This aside, the progression from the discovery of gold to the establishment of a stable Arctic community was seemingly a linear one. It took place despite negligible American governmental presence at the northern frontier. Compared to, for instance, the strict laws in Northern Canada, "*[t]he American version stressed local autonomy and the right of settlers to establish their own system of government and frame their own regulations. In the territories of the United States, federal government authority was asserted differently and was likely to the challenged … [F]ew regulations were imposed from outside to check the triumphs of the most efficient producers of the speedy reorganisation of industry to maximise profits*." (Zaslow 1971 in Coates 1978). At least there was a federal government, unlike in other Arctic regions.

The mining history of Nome highlights the need for law and order at the mining frontier and illustrates the role of natural resources and mineral wealth in the establishment of federal government and statehood. At the same time, Spitsbergen in the European Arctic was one of the world's last no man's lands coveted by many rising nations. Its case demonstrates Arctic mineral resource development and settlement long unchecked by any regulations.

Case study 4:
The "coal rush" on Spitsbergen (1899-1927)

In 1596, the first documentation of Spitsbergen (presently Svalbard, 78°13' N, 15°39' E) by the Dutch navigator Willem Barents set in motion its transformation from a pristine wilderness into a considerably impacted resource frontier region. The uninhabited archipelago in the European High Arctic was attractive for two reasons: it comprised an unknown quantity of natural resources, and it was a *terra incognita* (unknown land) unoccupied, ungoverned – and therefore unrestricted – by any nation state. Seafaring nations soon hunted walruses and whales followed by phases of trapping, scientific expeditions, tourism, and mining. It is therefore short-sighted to say that Spitsbergen is still a pristine wilderness today. What makes it so fascinating to study is that the archipelago was one of the last remaining no man's lands and that both archaeological and historical sources survive with which to reconstruct not only the exploitation of its natural resources but also the emergence of peripheral Arctic Spitsbergen on the world's political stage.

Mineral resources, of which coal was the most pertinent, played a key role in the latter process. Although coal seams had been reported by an Englishman in 1610, a Norwegian sailing captain sent a first commercial shipment to Norway, a country lacking native coal reserves, in 1899. At the time, the nation states of Europe clung to a precarious balance of power whilst cultivating their armed forces and alliances; irrespective of minor skirmishes among the globe-embracing empires that heralded a major conflict, an initial wave of entrepreneurial excitement saw the establishment of Norwegian, British, and American companies on Spitsbergen. These were followed by Swedish, Russian, and Dutch firms. The scale of this "coal rush", however, did not come close to the aforementioned gold rushes: Hoel (1966a, 1966b, 1967) describes the involvement of about twenty small companies. Thorough historical research could probably reveal the names of many if not all of the men, who came in their hundreds, not thousands. Since the individual extraction of a bulk commodity like coal is highly impractical, most miners reached the islands "by invitation only", that is to say, they were contracted in countries like Britain, Norway, or Sweden and transported into the Arctic aboard a company vessel. Nonetheless, the "coal rush" generated a flurry of activity never before witnessed on Spitsbergen, and soon, prospecting camps and company towns sprung up in the different bays.

Although some partnerships were formed, companies of any nationality were by and large guilty of wholesale claiming and reckless claim-jumping. The increasing number of claim disputes, with their potential for international violence, were brought to the attention of the governments concerned. They were undoubtedly a factor in the simultaneously erupting conflict over the sovereignty of the archipelago. Temporarily put on hold by World War I, the so-called Spitsbergen Question was dealt with during the Paris Peace Conference, the resultant Spitsbergen Treaty being signed in 1920. It decided sovereignty in favour of Norway, but it made allowances for the multi-national character of the developing mining industry. The name of Svalbard was adopted at the treaty's ratification in 1925. The "coal rush", however, was only over in 1927, when the independent Danish Commission finally settled all claim disputes.

Addressing Spitsbergen's unsettled legal status and the multinational character of its mining industry, recent interdisciplinary research has concentrated on the mining history and industrial archaeology of the Swedish, American, and British enterprises (Avango 2005, DePasqual 2009, Hartnell 2009, Kruse 2013). A publication on the Dutch venture is forthcoming. Focusing on the British example, four companies were shown to have been active on the archipelago (Kruse 2013). In addition, two fraudulent companies, one company under Russian management, and another firm formed after World War II were outside the scope of that study, while a last one founded to underwrite shares only received tangential mention.

In essence, there was no British model of exploitation and occupation for Spitsbergen (Kruse 2013). The Spitzbergen Coal & Trading Co. (1904-18) was a private coal mining company motivated by distinctly economic goals. It had no political interests besides securing its claim beyond all doubt and would have been satisfied with a Norwegian takeover of

the island group on the condition of reasonable mining laws and taxes. Overspending and incompetence were mainly to blame for its termination, although the directors listed difficulties with the Scandinavian workers and the great distance from Sheffield as reasons for wanting to sell. The commercial objectives of the private Spitzbergen Mining & Exploration Syndicate (1906-11) were divided between mining coal and prospecting for gold. From the start, its directors were disconnected, it lacked in-house expertise, and there was a discord between shareholders preferring one resource over the other. Under the circumstances, the syndicate failed to implement a functional operational strategy and could not deliver the products its stakeholders were expecting. Internal strive was the most likely cause for the syndicate being unceremoniously crossed off the company register. This disappearance benefitted the Northern Exploration Co. (NEC, 1910-1934), who without much ado took over the claims. It must be stressed that the NEC was a private *exploration* company aiming at the discovery of economic minerals and the involvement of subsidiary mining companies to extract them. It had not achieved this by the outbreak of World War I and was practically bankrupt.

War, however, reshuffled the cards, and the NEC, having gone public, used the politically-charged rhetoric of Arctic annexation being essential to British post-war reconstruction to win support for its Spitsbergen venture (Fig. 5). Despite its large capital, it lacked the necessary mining expertise; funds were spent generously on claims, assets, and transport before economic minerals could be proven. Having reached its exploratory limits, the company's conversion to active mining in order to recover some of the original outlay came too late. Large debts forced it to sell to the Norwegian Government. Similarly, the Scottish Spitsbergen Syndicate (SSS, 1909-1953) started out as a private *exploration* company, had nothing to show for itself at the outbreak of war, and became a public company when the conflict had ended. Although the SSS did engage in company propaganda and financial business, it did not go to the same extremes as the NEC. Instead, it prospected according to the professional standards of the time and provided the products expected of a respectable exploration company. Remaining debt-free assured its longevity, but it also failed to attract subsidiary mining companies. The Scots put this down to several factors: the status of Spitsbergen was undecided; the British had long been accused of land-grabbing

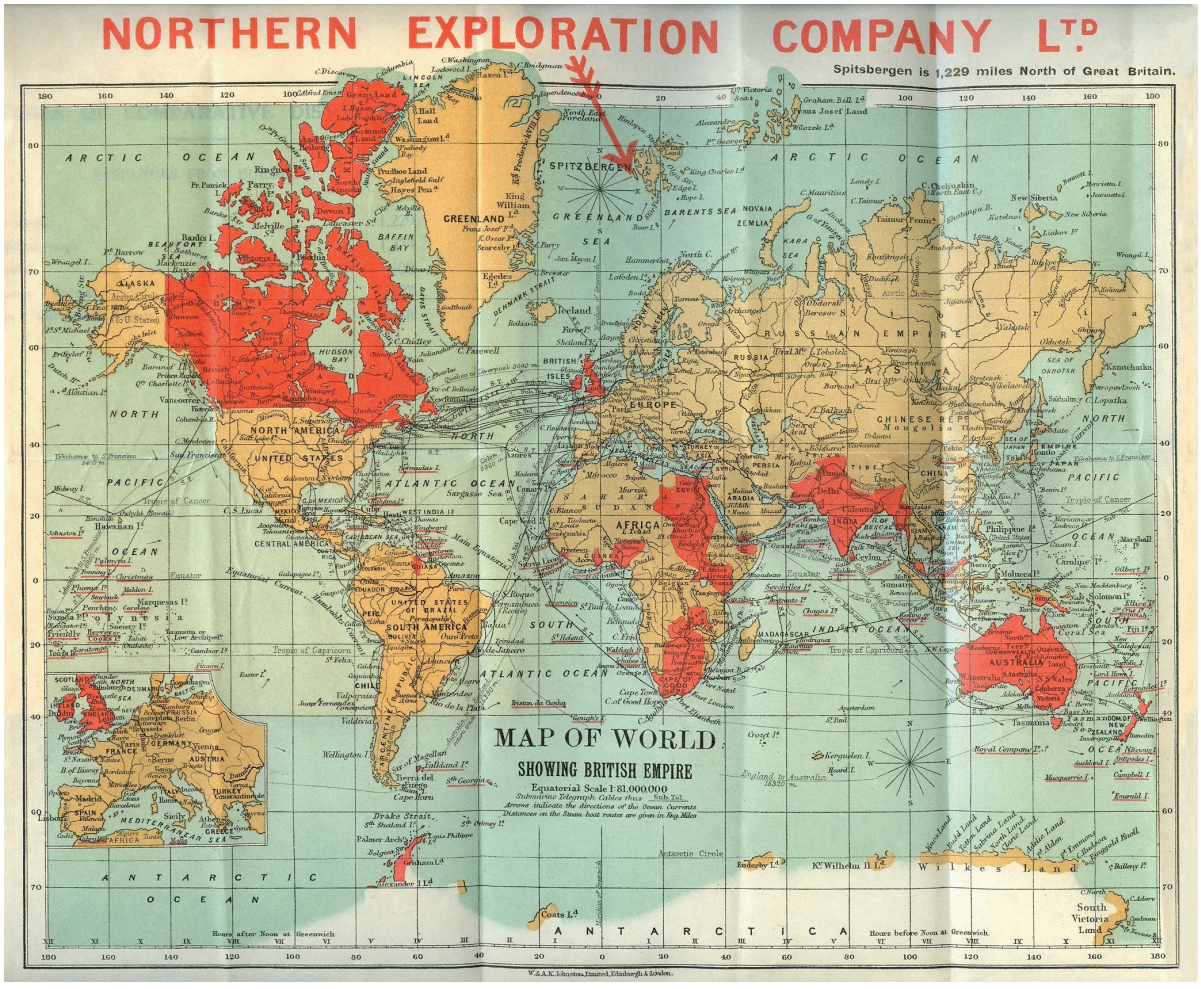

Fig. 5: Produced by the Northern Exploration Company in the closing stages of the First World War, this world map indicates the firm's ambitious political goal of integrating Spitsbergen into the global British Empire, which would stabilise the emerging Arctic mining industry as well as increase the firm's importance in the region. Source: Coal and iron in Spitsbergen (1918) Pam (*32): 622.333, Scott Polar Research Institute Library, Cambridge.

Abb. 5: Produziert von der Northern Exploration Company gegen Ende des Ersten Weltkriegs, zeigt diese Weltkarte das ehrgeizige politische Ziel der Firma, Spitzbergen in das globale britische Empire zu integrieren, wodurch der arktische Bergbau stabilisiert sowie die Bedeutung der Firma in der Region gesteigert würde. Quelle: Coal and iron in Spitsbergen (1918) Pam (*32); 622.333, Scott Polar Research Institute, Bibliothek, Cambridge.

and were now taking a step back; Spitsbergen's reputation had been damaged by dubious gold-diggers like the NEC; and the mineral resources were not thought to be lucrative during the Depression. After World War II, it was a lucky circumstance that the syndicate was eventually bought by Scottish Spitsbergen Development, itself short-lived and unprofitable. Despite the companies' best efforts to change the legal status of Spitsbergen in their favour, at no point was the British Government officially interested in annexing the Arctic archipelago. It also never subsidised the struggling British firms, while government subsidies kept the coal mines of Norway and Russia in pre-carious business until this day.

What transpires from this British example is that there were too few active companies to speak of a British model on Spitsbergen. As in the Frobisher case, the British material remains and archaeological landscape of exploration were thoroughly investigated, but on the whole, the latter remains poorly understood and deserving of greater attention. All four companies were founded for primary economic reasons at a time of buoyant European markets. The two pre-war mining companies had only minor political motives, while the two post-war exploration companies used the changed (geo)political context as a promotional tool. Neither were successful. It remains unknown which pivotal objections prevented subsidiary mining companies to come forward.

The value of this in-depth British micro-level case study will be revealed when its parent project draws to conclusion. The *Large-scale Historical Exploitation of Polar Areas* (LASHIPA) project investigates the histories of different exploitative industries at both poles over the last four centuries (Hacquebord 2012). A synthesis with the other dimensions of this thoroughly international endeavour will help to overcome the relatively narrow and unrepresentative focus with which polar resource frontier regions like Spitsbergen have hitherto been regarded.

DISCUSSION

The Arctic had already been settled for thousands of years when Europeans arrived on the scene around 500 years ago. The newcomers were primarily driven by the search for new sea routes and colonial ambitions. Their expeditions broadened their intellectual horizons, and they built up a corpus of Arctic knowledge, which paved the way for industrial enterprises such as mineral exploration and mining. The general processes at work ranged from the early opportunistic and speculative voyages of enterprising individuals through to the involvement of trade organisations and companies through to the multifaceted aspirations of rising nation states not only at the national northern frontier but also in the Arctic no man's land. The aim of this paper has been to outline these general processes on the basis of four case studies that span circumpolar space and time to make room for comparison and evaluation.

Each case study offers a rich account of historical events that have bearing on the present and hold lessons for the near future. Frobisher's expeditions have been called an individual effort, but both planning and execution depended as much on a network of influential supporters in his native England as they did on his ability to command the activities in Frobisher Bay. To use to the terminology of an analytical framework from the social sciences called the Actor-Network Theory (Law & Hassard 1978, Law & Callon 1992): as a *network builder*, Frobisher positioned himself at the *obligatory point of passage* between his *global network* in the home country and the *local network* in Canada. For his venture to be a success, he had to ascertain the flow of resources between these networks. Much needed investments, however, dried up as soon as the local network failed to deliver the gold that all stakeholders hoped for. Without gold or any other tangible results, Frobisher's actor-network crumbled. In addition, this case study demonstrates how historical sources are complemented by archaeological evidence to provide a comprehensive image of past events. While Arctic mining history has hitherto focused mainly on the European core, timely archaeological fieldwork emerges as the key with which to unlock the industrial experiences of the periphery. The Meta Incognita Project is to be applauded for the move away from the single site of Kodlunarn Island to include the archaeological landscape of prospecting and mining in Frobisher Bay. Only through this re-evaluation did Frobisher's long-forgotten mines come to be a crucial landmark in the emergence of the Arctic as a region of opportunity.

Like Frobisher, Julius Thomsen was a visionary, a pioneer, and the promoter of an original idea, but we lose sight of this network builder and his initial business partners when the Kryolithfabriken Øresund becomes the dominant actor in the actor-network of the long-lived Ivigtut cryolite mine. If the mine were to undergo in-depth historical-archaeological study, which has not happened to date on the basis of its development being seemingly well-known, the Actor-Network Theory would be an appropriate analytical tool despite its inability to deal with weak and partial connections. Furthermore, the core-periphery model, which was used to identify Ivigtut as a resource frontier region, can be used to outline and explain its demise to a downward transitional area. Yet, former Arctic mines and company towns do not have to disappear if their function changes in time. As with Kodlunarn Island above, heritage specialists have recognised the geological, technological, and cultural heritage potential of Ivigtut (Ivittuut) – and rightly so. It is an unfortunate oversight, therefore, that the site does not feature among the protected cultural heritage sites of Greenland (Nunatta Katersugaasivia 2011). The very recent closure of the mine must not be the reason why the material record of this 130-year-old human experience in the Arctic should be lost.

How, if at all, do micro-level studies such as Kodlunarn Island or Ivigtut compare to resource frontier frenzies such as the Nome gold rush? In its entirety, the stampede may appear atypical with little opportunity for comparative work. It would have to be broken down into its many components, giving rise to individuals and companies, which may yet lend themselves to the Actor-Network Theory and the core-periphery model. Although some work has already been done in that direction, a discussion of this exercise is outside the scope of this article. Importantly, Nome highlights the influence of governmental legislation on the national mining frontier. Although countless quarrels arose within Nome's mining districts, the sovereignty of Alaska was not challenged from outside the US. Backed by federal law, investments were fairly well protected, and the

transformation from mining camp to civilised frontier town could swiftly be achieved.

In stark contrast to governed Alaska, let alone the strict laws of the Canadian North, the unsettled legal status of Spitsbergen was subject of a lengthy international dispute. From the first commercial shipment of coal, it took near enough three decades before the Arctic no man's land could be brought under Norwegian control and before all claim disputes were arbitrated. During this time, any investments on the archipelago were at risk. The case study gave an impression of how four British companies dealt with the unstable situation. Ongoing research will show how other nationalities fared under the circumstances. Together, these micro-studies will give rise to the most complete historical image of an Arctic mining landscape to date.

At the time of writing, Ken Coates of the University of Saskatchewan carried out a timely assessment of the history and historiography of non-renewable resource development in the Canadian Arctic. The four case studies presented here support his observation of "*a long and complicated history of resource development, albeit one marked more by hope and promise than by practical results*." (Coates pers. com. 2014) He bemoans the fact that Canadian historians have paid too little attention to the topic. His review of the scholarly literature reveals several key themes, only some of which could be touched on in this article. As such, mining history is on the whole an underrepresented historical and archaeological discipline. It has been "pro-development and celebratory" in the past, paying homage to the leaders in economic development on regional and national level. What Coates (pers. com. 2014) refers to as "southern-focused scholarship", "policy-orientated work", and "Ottawa-centred" in the Canadian context translates into the one-sided emphasis on core regions such as England, Denmark, and the US criticised in this paper. He therefore welcomes the contemporary move towards the critical evaluation of resource development that incorporates north-centred approaches and considers both newcomer populations and indigenous communities on equal terms.

Broadly speaking, this fresh historical direction recognises that "*studying resource peripheries can provide new insights into the global economy that cannot be derived from the experiences of cores*." (HAYTER al. 2003, 17). Such insights additionally lead to a better understanding of long-term environmental effects and changing Arctic ecosystems. In fact, "*for resource peripheries around the globe, environmental, cultural, and geopolitical factors are intersecting with industrial dynamics in unique ways*." (HAYTER et al. 2003, 21) Historians are particularly apt at generating historical knowledge in order to define and clarify public policy issues. Why then, wonders Coates (pers. com. 2014), have historians not come forward in the commonly controversial debates surrounding modern Arctic resource development, and why have governments and industry shown so little interest in the historical context? After all, "*historical understanding is central to a society's abilities to confront the present and make constructive choices about the future*." (Coates pers. com. 2014)

CONCLUSION

The history of European commercial exploitation of Arctic mineral resources after 1500 AD is long, complex – and far from over. Unfortunately, it is underrepresented in the study of Arctic resource development as a whole. The monumental tasks that face Arctic mining historians and industrial archaeologists alike are therefore two-fold: to critically evaluate the underlying circumpolar processes and to provide the much-needed historical context to modern debates on Arctic resource extraction. As a starting point, this paper dealt with four case studies. They are descriptive rather than analytical as they offer a broad overview of mining across Arctic space and time. In summary, Frobisher exposed the Arctic as a region of commercial opportunity some four hundred years ago; the evolving uses of cryolite pinpoint global demand as the main driver behind Arctic mining; the Nome gold rush emphasized the importance of legislature in the orderly settlement of the northern mining frontier; and nowhere else depicts the transformation from polar wilderness to Arctic industry better than Spitsbergen. Although few in number, these case studies hint at numerous intricacies in the historical development of Arctic mineral exploitation.

As a prologue to the present and the near future, timely lessons to be learned from this are that the mineral resources of the Arctic have been over-promoted to investors from outside the region, who grossly underestimate the harmfulness of Arctic climate and northern logistics to commercial viability. The reality is likely to disappoint all but a lucky few. High grading dominates Arctic mining as the wealth produced flows out of the region to southern stakeholders, closely followed by a transient workforce who on the whole will not stay and develop the North. Government policy has favoured national economic benefits not regional returns, largely ignoring indigenous peoples. More recently, natives and locals alike are insisting on bigger and better returns, raising the question if labour-saving technologies can ethically be used in areas of high unemployment. Lastly, who will be left to contemplate and remediate any long-term detrimental environmental impacts when the culprits are long gone? The reader cannot but agree with Coates (pers. com. 2014) that "*if the Arctic is to better understand the likely implications for the North from expanded resource development, it follows that a greater appreciation for historical patterns and processes could and should be invaluable*." Historians and archaeologists working at the Arctic research frontier must be relied on not only to create such an appreciation but to also share it widely and purposefully.

ACKNOWLEDGMENTS

This scientific review article was initiated by the International Arctic Science Committee (IASC): Action Group in Geosciences and Louwrens Hacquebord of the Arctic Centre of the University of Groningen with the aim of providing a much-needed historical perspective on currently emerging questions in Arctic geosciences. The author is grateful for the discussions of pressing matters with Karsten Secher of the Geological Survey of Denmark and Ken Coates of the University of Saskatchewan. Special thanks to William Fitzhugh of the Arctic Studies Centre of the Smithsonian Institute and Vincent

Lafond of the Canadian Museum of History for their valuable input as well as the use of their photographs. Additional thanks to the two anonymous reviewers for their kind and constructive comments on the manuscript.

References

Alaska Dispatch News (2012): Nome's new gold rush. <http://www.adn.com/alaska-news/slideshow/photos-nomes-new-gold-rush/2012/09/18/> (3 October 2014).

Alsford, S. (ed) (1993): The Meta Incognita Project: contributions to field studies.- Hull: Canadian Museum of Civilization.

Avango, D. (2005): Sveagruvan – Svensk gruvhantering mellan industry, diplomati och geovetenskap.- Stockholm: Jernkantoret, 1-440.

Canadian Register (2009): In: Parks Canada, Canada's historic places: Kodlunarn Island National Historic Site of Canada. <http://www.historicplaces.ca/en/rep-reg/place-lieu.aspx?id=11908> (26 September 2014)

Carlson, L.H. (1946): The discovery of gold at Nome, Alaska.- Pacific Historical Review 15 (3): 259-278.

Carlson, L.H. (1947a): The first mining season at Nome, Alaska – 1899.- Pacific Historical Review 16 (2): 163-175.

Carlson, L.H. (1947b): Nome: from mining camp to civilized community.- The Pacific Northwest Quarterly 38 (3): 233-242.

Castells, J.V. (2009): Frozen assets: science, natural philosophy, and the quest for arctic gold.- Unpubl. MA Thesis, University of South Florida, 1-49.

Coates, K. (1987): Controlling the periphery: the territorial administration of the Yukon and Alaska, 1867-1959.- The Pacific Northwest Quarterly 78 (4): 145-151.

Commander Resources Ltd. (2006): Baffin Island Au, Nunavut. <http://www.commanderresources.com/s/BaffinIsland.asp> (26 September 2014).

Dartford Town Archive (2014): Sir Martin Frobisher's smelting works in Dartford. <http://www.dartfordarchive.org.uk/early_modern/industry_sm.shtml> (2 October 2014).

DePasqual, S. (2009): Winning coal at 78° north: mining, contingency and the Chaîne Opératoire in Old Longyear City.- Unpubl MSc Thesis. Michigan Technological University, 1-184.

Donald, M.B. (1950): Burchard Kranich (c. 1515-1578), miner and queen's physician, Cornish mining stamps, antimony, and Frobisher's gold.- Annals of Science 6 (3): 308-322.

Edwards, K.J., Cook, G.T., Nyegaard, G. & Schofield, J.E. (2013): Towards a first chronology for the middle settlement of Norse Greenland: ^{14}C and related studies of animal bone and environmental material.- Radiocarbon 55 (1): 1-17.

Ehrenstein, R.M. (1998): Mining, colonialism and the culture contact. European miners and the indigenous population in the sixteenth-century Arctic.- In: Social approaches to an industrial past: the archaeology and anthropology of mining. London: Routledge, 109-120.

Elbo, J.G. (1948): Cryolite and the mine at Ivigtut, West Greenland.- Polar Record 5 (35-6): 185-188.

EuroGeoSurveys (2014): Sustaining and promoting the mining heritage of Europe, <http://www.euromines.org/sites/default/files/10_Nikolaos_Arvantidis_web.pdf> (3 October 2014).

Fitzhugh, W.W. & Olin, J.S. (1993): Archaeology of the Frobisher voyages.- Washington: Smithsonian Institute, 1-271.

Friedmann, J. (1966): Regional development policy: a case study of Venezuela.- Cambridge, Mass., M.I.T. Press, 1-279.

Government of Greenland (2014): Mining history, <http://www.govmin.gl/minerals/mining-history> (26 Sepember. 2014).

Hacquebord, L. (ed) (2012): LASHIPA. History of large scale exploitation in polar areas.- Groningen. Barkhuis, 1-172.

Hamilton, G.G. (1978): The structural sources of adventurism: the case of the California gold rush.- Amer. J. Sociology 83 (6): 1466-1490.

Hartnell, C.C. (2009): Arctic network builders: the Arctic Coal Company's operations on Spitsbergen and its relationship with the environment.- Unpubl. PhD Thesis. Michigan Technological University, 1-322.

Hayter, R., Barnes, T.J. & Bradshaw, M.J. (2003): Relocating resource peripheries to the core of economic geography's theorizing: rationale and agenda.- Area 35 (1): 15-23.

Hoel, A. (1966a): Svalbard: Svalbards historie 1596-1965, Part 1.- Oslo: Sverre Kildahls Boktrykkeri.

Hoel, A. (1966b): Svalbard: Svalbards historie 1596-1965, Part 2.- Oslo: Sverre Kildahls Boktrykkeri.

Hoel, A. (1967): Svalbard: Svalbards historie 1596-1965, Part 3.- Oslo: Sverre Kildahls Boktrykkeri.

Hogarth, D.D. & Loop, J. (1986): Precious metals in Martin Frobisher's "black ores" from Frobisher Bay, Northwest Territories.- Canadian Mineralogist 24: 259-263.

Hogarth, D.D., Boreham, P.W. & Mitchell, J.G. (1994): Martin Frobisher's northwest venture, 1576-1581: mines, minerals and metallurgy.- Hull. Canadian Museum of History.

Holland, C. (1994): Arctic Exploration and Development.- New York. Garland Publishing, 1-704.

IMM (2014): Ivittuut Mine- og Mineralmuseum. <www.imm.gl> 3 October 2014.

Kostov, R.I. (2010): Gem minerals and materials from the Neolithic and Chalcolithic periods in Bulgaria and their impact on the history of gemmology.- Scientific Annals, School of Geology, Aristotle Univ. Thessaloniki Proc. of the XIX CBGA Congress, Thessaloniki, Greece, Special.

Kragh, H. (1995): From curiosity to industry: the early history of cryolite soda manufacture.- Annals of Science 52 (3): 285-301.

Kruse, F. (2013): Frozen assets. British mining, exploration, and geopolitics on Spitsbergen, 1904-53.- Eelde. Barkhuis, 1-463.

Law, J. & Hassard, J. (eds) (1987): Actor network theory and after.- Oxford & Keele. Blackwell & Sociological Review, 1-256.

Law, J. & Callon, M. (1992): The life and death of an aircraft: a network analysis of technical change.- In: W.E. BIJKER & J. LAW (eds): Shaping technology/building society, studies in sociotechnical change.- London. MIT Press: 21-52.

McDermott, J. (2004a): Frobisher, Sir Martin (1535?-1594)', Oxford Dictionary of National Biography.- <http://www.oxforddnb.com/view/article/10191?docPos=1> (2 October 2014).

McDermott, J. (2004b): Lok, Michael (c.1532-1620x22)', Oxford Dictionary of National Biography.- <http://www.oxforddnb.com/view/article/16950?docPos=2> (2 October 2014).

McKee, L. (1902): The land of Nome.- New York. Grafton Press, 1-276.

Nunatta Katersugaasivia (2011): Cultural heritage Greenland – Ruins and buildings. <http://www.kulturi.org/en/index.html> (3 October 2014).

Pavel, P., Svendsen, J.I. & Indrelid, S. (2001): Human presence in the European Arctic nearly 40,000 years ago.- Nature 413: 64-67.

Pitulko, V.V., Nikolsky, P.A., Girya, E. Yu., Basilyan, A.E., Tumskoy, V.E., Koulakov, S.A., Astakhov, S.N., Pavlova, E.Yu. & Anisimov, M.A. (2004): The Yana RHS site: humans in the Arctic before the last glacial maximum.- Science 303 (5654): 52-56.

Ralph, J. & Chau, I. (2014a): Cryolite. <http://www.mindat.org/min-1161.html> (21 November 2014).

Ralph, J. & Chau, I. (2014b): Ivigtut cryolite deposit. <http://www.mindat.org/loc-1958.html> (21 November 2014).

Rasmussen (2005): Ivittuut.- In: M. NUTTALL (ed) (2005): Encyclopedia of the Arctic.- New York. Routledge:1030-1031.

Secher, K. (2002): Early mining activities in South Greenland, Greenland Mineral Resources Fact Sheet No. 2. <http://www.geus.dk/DK/publications/newsletters/minex/Sider/fact_sheets-dk.aspx> (29 September 2014).

Secher, K. (2003): Map of known mineral occurrences in Greenland.- Greenland Mineral Resources Fact Sheet No. 5. <http://www.geus.dk/DK/publications/newsletters/minex/Sider/fact_sheets-dk.aspx> (29. September 2014).

State of Alaska Department of Natural Resources (2014): Nome recreation area stipulations. <http://dnr.alaska.gov/mlw/mining/nome/NomeRecareastipulations.pdf> (24 November 2014).

Strøm Tejsen, A.V. (1977): The history of the Royal Greenland Trade Department.- Polar Record 18 (116): 451-474.

Sugden, D. (1982): Arctic and Antarctic: a modern geographical synthesis.- Oxfor. Blackwell, 1-472.

Symons, T.H.B. (1999a): The Meta Incognita Project, 1990 – 1999. <http://www.historymuseum.ca/cmc/exhibitions/hist/frobisher/frsub16e.shtml> (11 November 2014).

Symons, T.H.B. (1999b): Meta Incognita: a discourse in discovery. Martin Frobisher's Arctic expeditions, 1576-1578 (2 vols.).- Hull. Canadian Museum of History, 1-636.