The Canadian Mining Industry North of the 55th parallel: a maritime traffic generator?

Abstract

Keywords: Arctic, Mining, Canada, Sea Shipping & Transportation, Northwest Passage

Introduction

Melting summer sea ice in the Arctic has been extensively documented and has increasingly been making headlines. This phenomenon, underlined by scientists and the media since the turn of the century, has triggered speculation on the opening of much shorter sea routes linking Europe via the eastern coast of North America to Asia, as well as on increased access to mineral resources in this region. The Arctic is currently undergoing a change of pace many would not have considered possible only a decade or so ago (Molenaar 2014). Closely integrated into the current economics of globalization, the Arctic region of the 21st century shows a growing worldwide economic, political and scientific interest. It also provides options in relation to energy security (Zhang 2011; Blunden 2012; Huebert *and al.* 2012; Johnston 2010; 2012) and visions of new transarctic sea routes (Lasserre, 2011; Pelletier and Lasserre 2012; Farré and *al.* 2014; Heininen 2014). In recent years, the prospect of growing shipping traffic in Arctic waters led to analysis pertaining to the possibilities for expanded activities in the cruise industry (Stewart *and al*. 2007; Grenier and Müller 2011; Lemelin, Dawson and Stewart 2012; Lasserre and Têtu 2013; Dawson, Johnston and Stewart 2014), the fishing industry (Arctic Council 2009), as well as in cargo shipping for western and Asian commercial shipping companies (Lasserre and Pelletier 2011; Campbell, 2012; Lasserre 2014) It seems, however, that less attention has been paid to the prospect of the mining industry becoming a major maritime traffic generator despite all the attention paid to the oil & gas potential of the region. This dimension of a reported "rush" to Arctic riches is also a recurrent theme in Arctic discourse (Lasserre 2010a 2013). In Canada, mining in Arctic and subarctic regions began in 1920, but despite its significant expansion, its scope has nothing in common with the Siberian policy of resource development implemented in the Soviet Union, in a different economic system, it is true (Lasserre 2010b). Moreover, as noted by Heininen (2014) it is important 'to bear in mind that such terms reflect a general desire to regularize particular understandings of spaces, territories and borders, which may well then inform a host of socio-cultural, economic and political projects revolving around how the arctic is defined and understood'. The perspective of an Arctic resource 'boom', rapid climate change, environmental challenges, new options for energy security and increased shipping traffic along the Northern Sea Route and the Northwest Passage are often cited as significant.

In this context, the question that arises is: what is the current picture of the development of the mining industry in the Canadian Arctic (see Haley *and al.* 2011)? More specifically, to what extent is the development of mining projects in the Canadian Arctic likely to trigger an

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expansion of commercial shipping in Canadian waters? Furthermore, this study consolidates existing literature (c.f. Haley *and al.* 2011) and data on marine transportation in northern Canada, expands this through consultations, and provide geographic information systems (GIS) resources and maps.

Assessing the Mining Industry transportation logistics in the Canadian Arctic: Methodology

The core methodology is based on a literature and statistical review of publicly available information on mining activities beyond the 55th parallel of Canada, and mainly on the 2011 Statistics Canada's Report on Maritime Shipping in Canada (Statistics Canada, 2011); from the latter we identified 19 *potential* or *existing* mines. For each one we collected information data on geographic location, we reclassified them according to their stage (exploration and feasibility studies stage, development and construction of the related infrastructures, or if it is an active mine), the type of extracted raw materials, the geographical origin of the investors, their investments' shares in each project and their parent company, if any. We finally processed, confirmed, and updated our sample with the 2014 Mines and Advanced Mine Projects list of the NWT and Nunavut Chamber of Mines (NWT & Nunavut Chamber of Mines 2014), from the 2013 Natural Resource Canada Map of Top 100 Exploration Projects and Deposit Appraisal Projects (Natural Resource Canada 2014) and from the 2012 Map of Yukon Mining and Exploration Projects obtained from mining Yukon – Mining & Exploration Portal (2014 Online). We then included ten additional mining projects in our dataset. Thus, the final sample dataset consists of thirty mining sites.

To determine the potential of these projects to trigger an expansion of commercial shipping activities along the Canadian Arctic Shipping Lanes, the transportation logistics of each project have been documented. This information was solicited from relevant departments and agencies, i.e. from Natural Resources Canada, Statistics Canada and Transport Canada; Nunavut, Nunatsiavut, Yukon and Northwest Territories government's websites; NWT and Nunavut Chamber of Mines; and from Mining Companies websites. The main reference remains the 2011 Statistics Canada's Report on Maritime Shipping in Canada (Statistics Canada 2011 – now discontinued). From this report, the logistic of each mining project has been documented. Two types were identified: a mining project where 'exports of commodities rely on marine shipping logistic' and those that 'exports of commodities do not rely on marine shipping logistic' i.e. they rely on surface transportation mode, or by air. From this step, ten mining projects kept our attention because their logistic of exporting commodities relied on marine shipping logistic through Canadian Arctic Waters. Finally, we produced tables and location information maps with the use of the GIS program ArcGIS 10.2 (ESRI) in order to provide a thematic overview of mining in northern Canada and related mining transportation logistics strategies.

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Area of Study

The geographic scope of northern Canada is defined as a region north of the 55th parallel but extending south to include the entire Labrador Coast on the Labrador Sea and James Bay. The vast region encompasses four provinces, namely the northern areas of Newfoundland and Labrador (Nunatsiavut), Quebec (Nunavik), Ontario and Manitoba and all three Territories which are the Yukon, the Northwest Territories and Nunavut.

Canadian Mining Industry beyond the 55th parallel

Mining History in the Canadian Arctic

Mining in Canada beyond the 55th parallel is not a recent phenomenon and instead, dates back to the late 18th century (Cameron 2011). Indeed, the British Explorer Samuel Hearne had undertaken a travel from Prince of Wales Fort in Hudson Bay, in order to discover the rich copper deposits such as conveyed by the persistent rumors at that time. Since so long, mining exploration and exploitation are, indeed, part of the face of the Canadian arctic and subarctic regions. Mining projects such as Rankin Inlet (1957-1962), Nanisivik (1979-2002), Polaris (1981-2002), Ulu & Lupin (1982-2004) and Jericho (2006-2008) have already been in operation in these northern latitudes (Cater and Kelling 2013; Rodon, 2013).

Between 1957 and 1962, copper and nickel were exploited in Rankin Inlet (Hubardt 1979), located on Baffin Island, but the mine was closed in 2002 because of exhaustion of ore and low world prices (Lasserre 2010). The ore was shipped by sea to the port of Quebec or those of Western Europe (*Ibid.*). Finally, lead and zinc were extracted in 1981 from the Polaris mine located on Little Cornwallis Island (Bowes-Lyon *and al.* 2009; Green 2013). In 2002, the mine was also closed due to the relative depletion of the ore, and the same happened in Nanisivik, because of lower commodity prices at that time (Lasserre, 2010). The ore was concentrated and stored in a plant barge and shipped each year by polar class ship to Europe or to the Port of Quebec. The MV Arctic, owned by Fednav, was used in the High Canadian Arctic for both, the Polaris and Nanisivik mines. The Ulu & Lupin gold deposit owned by Elgin Mining Inc. began operations in 1982 near Lake Contwoyto but since February 2005, due to low gold price, the company ceased production and put the mine "under care and maintenance". The re-opening of the Lupin's mine is a possibility (George 2011), although projections change rapidly and frequently. Finally, the Jericho diamond mine led by Shear Diamonds Ltd. closed in 2008 after two years of production but the company said it is reassessing the viability of reopening the mine (Hall 2012). While few development projects were on the table to upgrade the remaining facilities such as port infrastructure, all these plans are currently on hold. In 2008, Shear Diamonds Ltd. closed its Jericho diamond mine. Finally, port infrastructure exist in Nanisivik (Nunavut); a mining camp has been built in 1975 to support the lead zinc mining and mineral processing operations of the Nanisivik Mine. In production between 1976 and 2002, the Nanisivik mining site was later cleaned up and a few development projects were on the table to upgrade the remaining facilities but all these plans are currently on hold.

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Current Mining Activities in the Canadian Arctic: toward an Increase of Marine Transportation Activities related to these Projects?

There are actually only ten actives mines in the Canadian Arctic i.e. north of the 55th parallel. Only three of them are opting for a logistic that relies on Canadian Arctic shipping routes to export their raw materials. Indeed, so few active mines currently support their export of extracted raw materials through Canada's Arctic waters. However, when in operation, three iron ore projects and four other ones related to basic and industrial metals will base their exports of raw materials on Canadian Arctic shipping routes (Table 1). When all these projects will be at the stage of exploitation, seven mines should base their exports of raw materials on Arctic Shipping lanes.

Table 1 – Number of actives and inactive and unexploited mines which export of raw materials are based on a shipping logistics through the Canadian Arctic waters, on December 2014

* Jericho Diamond mine and Ulu & Lupin's gold mine are both closed; Elgin Mining Inc. closed the mine which is "under care and maintenance" since February 2005 and Shear Diamonds Ltd reassess the viability of reopening the Jericho Diamonds mine.

Mining activities	Exploration & Feasibility Study	Development & Construction of infrastructure	Active mines	Actives mines where exports of raw materials are based on a shipping logistics through the Canadian Arctic Waters	Inactive and unexploited mines where exports of raw materials are based on a shipping logistics through the Canadian Arctic Waters
Iron ore	1	3	0	-	3
Base/ industrial metals (Copper, nickel, zinc)	2	3	5	3	4
Uranium ore	2	1	0	-	0
Precious metals (gold and silver)	3	2	5*	0	0
Total	**8**	**9**	**10**	**3**	**7**

Actives Mines where Exports of Raw Materials are based on a Shipping Logistics through the Canadian Arctic Waters

Falconbridge operated the Raglan's copper and nickel mine in Nunavik, in the far north of Quebec, in 1997, before being acquired by Xstrata in 2006, which then merged with Glencore

in May 2013 to form Glencore Xstrata Plc (Aversano and Ritsatos 2014; Philie 2014). The ores are crushed, grounded and processed into nickel concentrates and copper in Raglan. The nickel concentrate is then trucked in Deception Bay seaport, 100 kilometers to the east. At Deception Bay, it is stored in a dome until undertaking a sea travel of 2600 km on the MV Arctic, a Polar Class 4 vessel, to the port of Quebec during free-ice months, at least six times a year. Then, the concentrate is transferred by train to Glencore's smelter in Sudbury (Ontario). Only after this last trip of 950 kilometers, the nickel concentrate is melted in cast matte, returned to Quebec by train, from where it is finally shipped by boat to the Nikkelyerk refinery in Norway, in the coastal town of Kristiansand, where nickel concentrate is converted into high-quality metal that will be sold worldwide (Lasserre 2010) (Table 2). At Deception Bay, Glencore Xstrata Plc built its own dry bulk terminal in early 1970. Rebuilt in 2007, the new terminal has two docking facilities that can accommodate polar class ocean-going vessels.

The Polar Class selection depends on an analysis of ice statistics, owners experience, ice expertise and financial and economic considerations. The Polar Rules give on general guidance and all Polar classes can find ice that will damage the structure. Class selection is a balance among ice conditions, operational requirements and costs (IIACS 2007). While various Classification Societies have had their respective requirements for Polar Class ships, the International Association of Classification Societies (IACS) harmonized the rules which came into effect in March 2008 (Lasserre 2010; Transport Canada 2010).

In Labrador, the Voisey's Bay nickel-copper-cobalt development project, owned by the Brazilian ValeInco Ltd., initiated ore processing in 2005. The ore concentrate is shipped to the Port of Quebec and six other ports, mainly in Scandinavia and Asia, to Bayuquan Port (China). The ore is loaded in summer and winter on the Fednav's MV Umiak 1, a vessel ranked Polar Class 4 or 5, which can therefore face the ice coast of Labrador (Walsh and Brière 2013). The port/terminal, located 11 kilometers away from the mine's concentrator at Edward's Cove in Anaktalak Bay, includes facilities like a dock, storage building and conveyor system for loading the concentrate.

Located a few kilometers from the Raglan mine, the Nunavik Nickel mine objective in 2012 was to produce 150,000 tons of nickel concentrate to ship in Finland (CPCS 2012). However, 2013 has been a difficult financial year for the owner of the project, Jilin Jien Nickel Industry Co. Ltd., and it seems that the company has transferred its operation to an investment bank based in Toronto. Finally, at the end of 2013, the copper ore was shipped from the new terminal developed by Jilin Jien Nickel, which is located 1.5 km southeast of Glencore Xstrata Plc's facilities. A barge bridge connects the barge to land and supports the conveyor system. The facility is also equipped to receive liquid bulks. In March 2014, Fednav commissioned Fednav's MV Nunavik, sister ship of the *Umiak 1*, built at *JMU's Tsu Shypyard* in Japan, and will be used to export the concentrate produced at the Nunavik Nickel mine at Deception Bay in northern Quebec (Fednav 2014). It also should be contracted to supply the marine carriage capacity for the Baffinland Project (Canadian Sailings 2013).

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Table 2 – Marine Transportation Logistics of actives mines that exports raw materials through the Canadian Arctic Waters, in December 2014

Active mines	Owner	Expected Lifetime	Marine Transportation Logistics (vessels, destinations)
Base/Industrial Metals Mining Activities			
Raglan	Glencore Xstrata PLC (Anglo-Swiss)	1997-2023	- Vessel: *MV Arctic* (Polar Class 4) - Deception Bay to Quebec City, then Sudbury by Train, return to Quebec City and then shipped to Norway
Voisey's Bay	Voisey's Bay Nickel Company Ltd. (Brazil) – Subsidiary of ValeInco Ltd. (Brazil)	2005-2035	- Vessel: *MV Umiak I* (Polar Class 5) and *MV Arctic (*Polar Class 4) - Voisey's Bay to Quebec city (Zinc) and to six ports, mostly of Northern Europe and Bayuquan (China)
Nunavik Nickel	Jilin Jien Nickel Industry Co., Ltd (China) – Subsidiary of Jilin HOROC Nonferrous Metal Group Co., Ltd. (China)	2014-20??	- Vessel: *MV Nunavik* (Polar Class 4) and *MV Arctic (Polar Class 4)* - Deception Bay to Finland (nickel) and to China (copper)

Source: data compiled by the author from various sources

Inactive and Unexploited Mines where Exports of Raw Materials are based on a Shipping Logistics through the Canadian Arctic Waters

The logistics of mining projects – at the stage of exploration or of the construction and development of related infrastructures – related to iron ore, according to the information collected, will all base their exports of raw materials on Canadian Arctic Shipping Routes (Table 3). The commodities are shipped commodities to the Internationals Markets including Chinese ports and the logistics of these mining projects involves logistic and marine transportation activities through the Canadian Arctic waters. The Baffinland Iron ore project, also called Mary River project, is located about 100 kilometers north of Milne Inlet where cargo and supplies are shipped. Once in operation, the ore will be railed south to Steensby Inlet where it will be loaded on the MV Nunavik, a new Polar Class 4 vessel owned by Fednav, and will carry it to the European Market year round (CPCS 2012). On August 31, 2008, Baffinland Iron Mines Corporation announced the arrival in Europe of the first shipment of high grade lump iron ore from its Mary River Project (Conley *and al.* 2012). The MV Federal Franklin departed Milne Inlet on the north coast of Baffin Island with 54,000 tons of high grade ore destined to Europe, discharging first at the port of Vissingen, Nertherlands (Baffinland Iron Ore Corp. 2008). The second shipment of high grade, shipped on the Fednav's MV Federal Hunter with a capacity of 34,500 tons, arrived at the port of Bremen in Germany in September

2008. The third and final trial cargo of high grade fine iron ore were transported on the MV Federal MAAS. It arrived at the port of Vlissingen, Netherlands, on September 21, 2008 with a capacity of 33,000 tons. Due to both demand and price fluctuations for this commodity in 2012, however, the scope of Mary River project, located in the northwest section of Baffin Island, was temporarily reduced in 2013. In line with the world demand for iron ore and corresponding market prices for this commodity in 2012, the construction of the railway to Steensby Inlet was delayed to the end of the current decade. Until then, the ore will be shipped by truck to Milne Inlet where it will be shipped to International markets between mid-July and mid-October. While the mine is actually in a stage of development, first shipment of iron ore is expected to occur during the open water season of 2015 (Baffinland 2014).

When in operation, the Roche Bay Iron mine will exports its products to China and International Markets. Chinese investors Xixing Pipes Group Corp. Ltd. and Shandong Fulun Steel Company Ltd. are both respectively entitled to 14% and 19% of the Roche Bay's iron mine production. This represents approximately 1.5 million tons of iron ore concentrate per year for 10 years (Advanced Explorations Inc. 2013). Iron ore extracted from the Hope Advanced mine also take the road to the port of Qingdao, in China, or to the port of Rotterdam, Netherlands (CPCS 2012). While the exact logistic stay unclear, the vessels used would be large ice-strengthened ore carriers ranging between 180,000 and 240,000 deadweight tons (DWT). Port marine infrastructure design was completed by AMEC International. Iron ore would be shipped year-round from a 330-meter wharf, classified as mooring in Turmel (2013). According to Humphreys (2012), the partner *Dean* and his management team are looking for will likely be a Chinese or other global steel company looking to secure a long term high quality iron ore supply with scale at a low operating cost in order to help satisfy its long term supply requirements and provide leverage in negotiations with the Big 3 (BHP Biliton, Vale, RioTinto). Oceanic's Pre-Feasbility Study was released in October 2012 and, since then, the management team has been evaluating the iron and steel space for potential partners. According to Humphreys (2012) there are 30-50 companies capable of partnering with a project like this, and the company is currently engaged in discussions with 10-12 parties.

Finally, the Otelnuk Lake project, potentially the largest mining project in Canadian History, will rely on the port facilities in Sept-Ïles, Quebec, to ship the ore to the global markets. In the frame of the northern Quebec's development Plan (Plan Nord), the assessment of potential sites (the Otelnuk Lake for example) by the Quebec government to build a deep-water harbor in Kuujjuaq area, which is linked to the construction of a railway from southern Quebec (Turmel 2013), seems to be on hold. Adriana Resources therefore prefer to invest in the construction of a railway connecting the mine to the existing Quebec North Shore and Labrador Railway (QNS & L) network, itself connected to the Port of Sept-Îles, ice-free twelve months a year and able to accommodate Chinamax vessels, the second largest type of bulk-carrier, behind the Valemax carriers (Kavussanos and Alizadeh-M 2011). The iron ore from the Otelnuk Lake mine will then be shipped to International Markets the first fifteen years. Then,

it will be China's turn to be entitled to 60% of the production from that mine (Adriana Resources 2014). Adriana Resources is expected to produce 50 million tons of iron ore concentrate per year over up to 100 years (Cauchon, Caron and Woods 2012).

Table 3 – Marine transportation logistics of inactive and unexploited mines that will exports raw materials through the Canadian Arctic Waters, in December 2014

Mining Project	**Status***	**Owner**	**Expected Lifetime**	**Marine transportation logistic (vessels, destination)**
Iron ore Mining Activities				
Mary River	DEV	Baffinland Iron Mines Corp. (Canada) *ArcelorMittal* (50%) and *Nunavut Iron Ore* (50%).	2017-2038	- Vessel: *MV Nunavik* (Polar Class 4) - Ore railed south to Steensby Inlet projected deep-water port to the European Market (to the Netherlands and Germany in 2008)
Roche Bay	DEV	Roche Bay Plc Holding and Advanced Explorations Inc. (both from Canada); Chinese Investments in Advanced Explorations Inc. from a) Xinxing Ductile Iron Pipes Group Corp. Ltd. (China, b) Shandong Fulun Steel Company Ltd). (China), a subsidiary of Chinese Shandong Jinyang Enterprise Group, and c) China Mining Finance Partners (CMFP) (China).	2017-2032	To China and to International Markets
Hope Advanced	DEV	Oceanic Iron Ore Corp. (Canada)	2017-2040	To China (Qingdao Port) or to Rotterdam
Otelnuk Lake (Linked to southern Port)	EXPL	Adriana Resources (Canada) (40%) – Wuhan Iron and Steel Corp. Ltd. (China) (WISCO) (60%)	2016-2116	Railed south to the Port of Sept-Îles (Qc) and then to International Markets and to China (60% of the production in 15 years)
Base/Industrial Metals Mining Activities				
Izok & High Lake (Izok Corridor) (Two mines)	DEV (x2)	MMG LTd. (China), a subsidiary of *China Minmetals Nonferrous Metals Co. Ltd. (China)*	2017-2029	Shipping season will likely be limited to 100-120 days per year – From Gray's Bay to Belgium (Antwerp) and to Japan.
Hackett River	EXPL	Glencore Xstrata PLC (Anglo-Swiss) and Sabina Gold & Silver (Canada)	2020-2035	Shipped to overseas markets by using the shipping route to the east.
West Raglan	EXPL	True North Nickel (subsidiary of Royal Nickel Corporation) (Canada)	N/A	N/A

* Status: Exploration & Feasibility Study (EXPL); Development and construction of the infrastructure (DEV)
Source: data compiled by the author from various sources

Mining Projects related to basic industrial metals – Izok and High Lake, Hackett River and West Raglan, also all rely on the Canadian Arctic navigable waterways to export their productions.

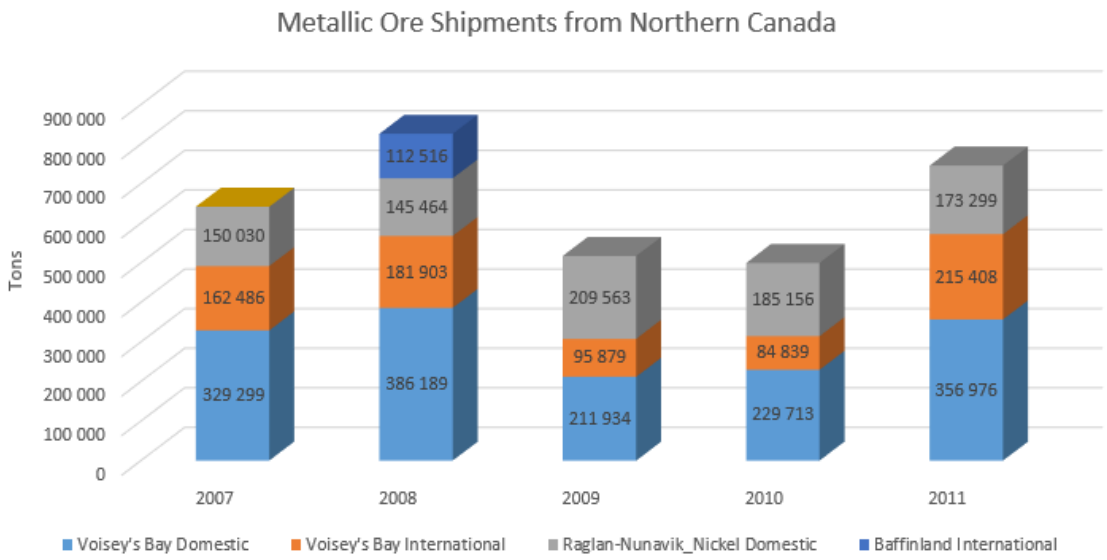
Proposed by *Minmetals Resources Ltd. (MMG Ltd.)*, the Izok Corridor (which comprise Izok and High Lake mines) production would be carried by land to Grays Bay where port infrastructure is to be constructed. As mentioned above, *MMG Ltd.* wishes to begin site preparation activities in 2014 with mine operations beginning 2017. The planned port facility would be capable of loading 50,000 DWT bulkers. This would represent 40 calls of port from Coronation Gulf' Gray's Bay's Port per year to which a certain amount of dry cargo and diesel deliveries would be added. The ore will then be shipped to the port of Antwerp (Belgium) and to Japan, according to MMG Ltd. (MMG Ltd. 2014). This represents about twenty yearly one-way transits more than with the Roche Bay Iron ore project and the 172,000 DWT bulk carriers needed, plus an unknown amount of tankers bringing fuel to power the site and various ships bringing in supplies for operations.

In collaboration with *Sabina Gold and Silver Corporation*, *Glencore-Xstrata plc* has also invested in the Hackett River Zinc and Gold Project. Glencore Xstrata Plc contemplates the idea of building a deep water port in Bathurst Inlet (approximately 80 km to the east of Hackett River and 70 km to the north of Back River) and an all-weather road connecting the port to existing ice roads which service both Ekati and Diavik mines from Yellowknife, NWT (Nunatsiaq News 2013). Significant infrastructure as contemplated within the BIPR project necessary for the shipping of concentrates from the proposed Hackett River project could also be utilized to support operations at the Company's proposed Back River gold project. According to *Glencore Xstrata plc*, the port could offer year-round accessibility and have the potential to accommodate other users. These other users could notably provide fuel distribution to communities because the port project includes a 220 million-liter tank farm. All these facilities are part of the Bathurst Inlet Port and Road (BIPR) project (Xstrata – Sabina Gold and Silver Corp. 2012). The proposed port facility, 35 km to the south of the community of Bathurst Inlet, would include the construction of a dock, 18 large fuel storage tanks, a 211 km road to Contwoyto Lake, a 1,200-metre airstrip and two camps for about 200 workers (George 2013). This lack of infrastructure is the issue most often stated by stakeholders consulted. Except in Nunavik where the Government of Quebec recently completed a marine infrastructure program and Nunastiavut where docks are available – but not always in good condition- nearly all communities of northern Canada lack basic infrastructure. Turmel et al. (2013) and the ongoing PhD thesis work of Laframboise (Laval University) on mining logistics and Arctic shipping provide examples of the difficulties related to the development of infrastructure in northern Canada.

Metallic ore flows in northern Canada essentially originate from Voisey's Bay on the Labrador coast and Deception Bay in Nunavik (Raglan and Nunavik Nickel mines); the logistic of gold and diamonds mining activities rely most of the time on air transportation. For example,

in Yukon, mines beyond the 55th parallel rely on surface transportation modes, by truck through all-seasons weather road, or by rail to the West Coast Ports. Voisey's Bay shipments are either exported or sent to Quebec City. Deception Bay shipments are exclusively composed of domestic flows of ores to Quebec City. Occasionally, ore can be shipped from other sites. This is notably the case for samples of iron ore from the Baffinland mining project sent to the Netherlands and Germany in 2008 (figure 1).

Figure 1 - Metallic Ore Shipments from Northern Canada, metric tons.



Source: CPCS (2012).

In 2011, a little over 38% of 2 million tons were carried in northern Canada and was composed of metallic ores (figure 1). Metallic ores carried in northern Canadian waters were exclusively outbound flows, that is, originating within the North, but destined elsewhere. Of the 754,700 tons loaded in the area in 2011, a little over 48% (366,000 tons) was zinc ores, followed by copper ores (28.5%- 215,400 tons) and nickel ores (23% - 173,300 tons). Nickel and zinc ores were sent to Canadian destinations while copper was exported. Cargo handled on the Labrador coast in 2011 totalled 662,545 tons. Metallic ores represented 86% of this amount. These flows were exclusively loaded in Voisey's Bay. All of the zinc ores (357 000 metric tons) were shipped to the Port of Québec while copper ores (215,400 tons) were destined to six ports, mostly of northern Europe and the Far East. A total of 402,400 tons of cargo was handled in Nunavik in 2011. Metallic ores (nickel concentrates) shipped from Deception Bay to Québec City represented the largest share of this traffic, totalling 173,300 tons. 2009 to 2011 for Labrador in the following figure are composed of zinc and copper ores. In 2011, the 49% increase in metallic ore shipments out of northern Canada is explained by a sharp increase in copper and zinc concentrates loadings in Voisey's Bay.

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While Metallic ore flows can be very volatile and are subject to international market demand drivers and resulting commodity prices, regulatory measures can also have an impact on cargo flows. For example, shipment of nickel concentrates from Voisey's Bay were strictly governed by the Nickel-in-Concentrate Exemption Order, 2009 of Newfoundland and Labrador. Under this order, a maximum amount of 440 000 tons of nickel concentrates was allowed to be shipped out of Newfoundland and Labrador until the completion of the hydrometallurgical facility in Long Harbour. As of the end of 2008, Statistics Canada data reveals that 588 400 tons had already been shipped. This order partially explains the sharp drop in metallic ore shipments from Labrador in 2009.

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Discussion

Our results shows that mining in the Canadian Arctic North of the 55th parallel and the consequent metallic flows were the result of only three active mines, namely Raglan, Nunavik Nickel and Voisey's Bay. The Iron ore Marry River project also export raw materials through Arctic waters, but only in 2008. These three actives mines, excluding Marry River, are all based on Arctic Sea lanes through the Hudson Strait and the east-coast of Labrador, to export their raw materials. In this context, we can highlight the fact that the number of actives mines beyond the 55th parallel of Canada remains very modest compared to the thirty mining sites we have identified beyond the 55th parallel and according to the even more potential deposits identified by Natural Resources Canada. In short, we cannot talk about an intense mining activity in the Canadian Arctic and therefore the Canadian Mining Industry North of the 55th parallel do not generate an increase of maritime traffic related to the exploitation of these resources; the metallic ore shipment flows through Canadian Arctic waters in recent years do not exceed one million ton exported annually.

However, the Canadian Mining expertise developed in the Nordic region of Canada for many years by companies such as Baffinland Iron Mines Corp. and Glencore Xstrata Plc, as well as the expertise and the operability developed by the Canadian Shipping Company Fednav Ltd. in northern latitudes constitute one of many valuable assets for the development of the Canadian Arctic's mining potential. Growth in transportation demand, particularly relating to resource development project, is obviously another opportunity for the northern Canadian marine transportation sector. This growth in demand for marine shipping may encourage new shipping lines to enter the market and increase competition in transportation services.

This will be particularly true when all new iron ore projects, both at the stage of exploration or the development of related infrastructures - Marry River, Roche Bay and Hope Advance - as well as those related to base and industrial metals - Izok and High Lake, Hackett river and West Raglan – will start production. The traffic through the Canadian Arctic waters to export the ores to the International Markets, while it remains difficult to quantify precisely, should increase. All other mining projects, including gold and diamonds projects, will based their exports of raw materials on land transport logistic by truck or by rail, or by air, which is the most common transportation system of precious metals mining activities. Moreover, the Nunavut Impact Review Board is currently reviewing proposals of the Bathurst Inlet Port and Road (BIPR) project run by Glencore Xstrata Plc and Sabina Gold and Silver Corp, including the Hope Bay belt, Contwoyto Lake region, and the Back and Hackett River regions. This proposal to develop a port and road network in the Bathurst Inlet area are oriented around linking future Nunavut's mines with existing road and mine infrastructure in the NWT, as well as with an increasingly ice-free shipping route through the Northwest Passage. While both companies recognize that infrastructure is needed for all development in Nunavut and not just for these mineral projects, the BIPR initiative, once completed, would move infrastructure development forward for other parties in the area.

However, and nevertheless, the uncertainties related to the development of the projects, and ever more for the logistics surrounding their implementation, challenge their future realization. The viability of Northern mineral developments is related to a wide variety of conditions, including access to capital and direct foreign investment for the development and construction of the infrastructures; international market conditions and shifting demand which largely determines commodity prices and the profitability of a project; the prospect of alternative mineral sources (competitiveness); harsh environmental conditions and high operating costs in northern latitudes; as well as several conditions including regulatory and permitting processes and the requirement for negotiation with indigenous land-claim organizations. While it is beyond the scope of this paper, it is important to keep in mind that mining in the North increases risks and hazards posed by maritime transportation, both at the regional and local scale. Concerns raised by local communities and the impact of increased shipping on marine life, the prospects of groundings and collisions, pollution of the marine environment from ballast water and fuels are also important constraint to mining in the Canadian Arctic. Then, it appears that the long-term viability and benefit of such investments remain an open question, symbolized best, perhaps, by the mothballed

port at Nanisivik. In this context it remains very expensive to develop mining sites in the Canadian North.

In this early 21st century, despite all these uncertainties, demand for minerals in some countries of the world is growing faster than ever. It cannot be denied that this international demand, driven mainly by China and India for iron ore and base metals, has an impact on market prices and this result in an increased interest for northern resources. In this context, as our results shows, all the active mines beyond the 55th parallel in the Canadian North - Raglan, Nunavik Nickel and Voisey's Bay -, with the exception of the *Agnico Eagle*'s Meadowbank gold mine, are all exploited and driven by foreign investments, mainly BRIC's countries, namely Brazil, Russia, India and China, as well as the multinationals *Glencore-Xstrata plc* and *Rio Tinto Alcan*. However, the Canadian North, for similar mineral concentration and ownership structure, can have much higher implementation and shipping costs than southern projects in Brazil, Australia, Chile or southern Canada. Northern Canadian mining projects are thus considered to be much more exposed to commodity price variations. As market prices fluctuate, prospective deposits change hands and government/partners tie-in conditions, shipping plans can drastically change more than once during the 10 to 15 years (and sometimes more) between the time carriers are initially approached and the time when a first shipment is loaded. In some cases, project cargo can be shipped on-site one summer, repatriated two years later because the project lacks funding, and then sent back the next open season after the deposit is taken over by another proponent. In this context, it is excessively complex to make assumptions on potential trends. In summary, there is effectively a trend indicating that northern resources become increasingly interesting but the term to which each project will result in ore or concentrate shipments is often speculative. It highlights the fact that in the global climate change context that increases the accessibility of northern mining deposits and despite all what has been written about the interest of the Northwest Passage (NWP) and its profitability for mining operations, its profitability remains difficult to assess and highly speculative. While industrial mining demand should also generate demand for additional vessels, the limited northern marine infrastructure, environmental realities, as well as institutional capacity constraints including insufficient information, planning challenges, as well as regulatory barriers all increased the cost of doing business in the North.

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ness of northern Canadian resources can thus be ameliorated through improved accessibility. In a context of limited funding, the potential savings generated by multi-project infrastructure development in strategic locations should be carefully examined in order to determine if/how/to what level a hub for each region could reduce mining resupply costs.

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