An inventory of abandoned mining exploration sites in Nunavik, Canada[1]

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This article presents, for the first time in the literature, an inventory of abandoned mining exploration sites in Nunavik, namely the sites containing materials representing a danger to the environment and human health, to lay the foundations for a priority cleanup operation. In this article, the historical context of mining exploration in Canada first provides a backdrop for the research problem. The methodology section then examines the various techniques tested during a pilot project aimed at determining the feasibility of the project at the lowest cost. The final section presents an inventory of abandoned sites and begins an initial discussion of the potential impacts associated with these sites and some of the priority actions envisioned to mitigate these impacts.

Cet article dresse, pour la première fois dans la littérature, un inventaire des sites abandonnés d'exploration minière au Nunavik, c'est-à-dire des sites qui contiennent des produits qui peuvent représenter un danger pour l'environnement et la santé humaine afin de jeter les bases d'une opération prioritaire de nettoyage. Nous traitons en premier lieu du contexte historique de l'exploration minière au Canada formant la toile de fond du problème de recherche. La section méthodologique examine différentes techniques qui ont été testées au cours d'un projet-pilote qui avait pour but de déterminer la faisabilité du projet au moindre coût. La dernière section présente un inventaire des sites abandonnés et amorce une discussion initiale concernant les impacts potentiels associés à ces sites et quelques actions prioritaires qui mitigeraient ces impacts.

1 This project was carried out with funding obtained from the EJLB Foundation (http://www.ejlb.qc.ca), in the context of research activities associated with the Chaire Louis-Edmond-Hamelin de recherche nordique en sciences sociales de l'Université Laval (Université Laval's Louis-Edmond-Hamelin Chair for Northern Research in Social Sciences) (http://www.chaireconditionautochtone.fss.ulaval.ca/Fr/LaChaire/leh.html).

Historical Context

Since Arctic expeditions at the turn of the seventeenth century, development of mineralogical knowledge of the territory coincided with exploration of the Canadian North. Over the following decades, explorers searching for the Northwest Passage continued to add to the mineralogical description of the territories that they were exploring. However, prior to the 1870s and 1880s, the discovery of important mineral deposits in Canada occurred merely by chance, since their discoverers were not looking for them but were instead concentrating on other goals such as the fur trade or spreading the gospel to Native people. It was only in the early twentieth century, when gold became a highly prized metal, that the mining industry began to systematically explore Crown lands. Fluctuations in gold prices subsequently influenced the intensity of mining exploration from 1920 to 1939, until nonprecious base metals became the focus of growing world demand and revitalised exploration activities (Nassichuk 1987; Cranstone 2002). Several factors have influenced exploration decisions, including increased exploration costs, assurance of the potential of discovering metals in certain regions and variations in metal prices (Dubuc 1979). Added to these factors today are the fiscal aspect and the high costs of development work.

In Canada, the mining industry has long been regulated by the 'free-entry' system, which has contributed to the development of an attitude closely linked to the idea of the 'right to explore' Crown lands; mineral resources such as iron, coal, gold and nickel were at that time considered as being a public good (McPherson 2003). At the turn of the 1950s, mining companies were filled with hope. '[B]elief in the yet undiscovered mineral wealth in the Canadian frontier was a powerful magnet. The laws of the provinces and territories provided a legal framework for exploration that was open, straightforward, democratic, and encouraging' (McPherson 2003). Rooted in the spirit of the 'free-entry' system, the regulatory framework allowed mining companies to go anywhere, in secret if necessary, to explore Crown lands (McPherson 2003). The general view at that time was that access to, and exploration and development of, mineral resources would lead to a better world and result in the eradication of poverty. The most optimistic projections thus encouraged governments, together with the mining industry, to re-engineer policies based on a future devoted to technological development, production and mass consumption (*The Northern Miner*, 7 March 1968, quoted in McPherson 2003). During the 1950s, major mining exploration projects were carried out in northern Québec, in the territory north of the 55th parallel. The discovery of large deposits in the Ungava Trough and Labrador Trough led to intensive exploration works. From 1940 to 1960, more than twenty companies were actively involved in the search for deposits in the Labrador Trough (Paquette 2000). A few large companies established facilities there between 1942 and 1953 and obtained extensive exploration leases covering various sections of the Labrador Trough. The works began to slacken off in the early 1980s.

> Exploration rights to all these lands were held under the new, very liberal regulatory framework adopted by the Union Nationale government in 1945; the leases were issued for a maximum period of 15 years; the surface area involved was, in principle, unlimited and the annual fees set by the state only amounted to about $0.50 per square mile [*Translation*] (Paquette 2000).

Starting in the 1930s, and up to the end of the Second World War, exploration expenses fell, until the Korean War triggered a sharp increase in the demand for, and prices of, metals essential to the war effort, such as nickel, copper, iron, lead, zinc, molybdenum, niobium, tungsten and cobalt. This increase was maintained throughout the 1960s, corresponding to a period of widespread and energetic exploration campaigns (Cumming and Wicklund 1975; Rose *et al.* 1979; Descarreaux 1989; Cranstone 2002).

In northern Québec, the discovery of the Asbestos Hill (asbestos), Raglan (nickel) and Katinniq (nickel) deposits in the Ungava Trough in the 1940s propelled mining exploration in this region. Exploration works were also launched in the Labrador Trough following the deregulation of mining exploration after the start-up of the Schefferville mine. Prior to 1976, mining companies were not legally required to clean up exploration sites. Owing to the high costs of transportation, many companies did not clean up abandoned sites, and left behind a wide variety

of exploration equipment and utilities for workers.[2] A few mining companies had cleaned up exploration sites when they left, but many left everything behind, from prospecting equipment to buildings for workers and workshops. Before the adoption of the 1976 *Environment Quality Act*, others were more selective, in abandoning in the hinterland outmoded equipment (empty drums, broken and outdated equipment) and surpluses. Oil products often formed an important part of these surpluses. In the 1990s, Inuit who went to these territories during hunting expeditions informed the authorities of the presence of oil and chemical products on specific sites, and mentioned the progressive deterioration of storage conditions. In 1997, with the setting up of a cleanup program in the Ungava Bay region, certain sites were cleaned up, giving priority to sites with the greatest potential environmental impact, especially sites containing chemical and oil products (Barret and Lepage 1998). But some of these sites are far from the communities, which makes the cleanup operations much more expensive. Thus, when this study was launched in 1999, very few sites had been cleaned up, and it was recognised that neither the number of abandoned exploration sites nor their potential adverse effects on the environment and on the communities were known.

Problem

Over the years, Inuit and Naskapi hunters have reported a wide range of equipment on the sites, including cans of food, modular laboratories, heavy machinery and equipment for the storage and transportation of oil products. In the mid-1990s, the Inuit population became increasingly concerned about the presence of abandoned chemical and oil wastes: storage conditions had deteriorated and the containers were no longer securely sealed. Hunters noticed various serious environmental problems on a regular basis such as the death of foxes resulting from the consumption of various rotting food products and highly toxic chemical products near streams, lakes and rivers. In the absence of a comprehensive inventory of abandoned sites located within this territory, major environmental impacts are expected to occur, which is causing great concern among the populations using these lands. However, before the actual social and environmental dangers can be determined, an inventory of the sites is needed to be able to then begin the characterisation phase, which will more accurately assess the risks posed by such sites.

Consequently, the aim of the program that we set up in 1999, in collaboration with the municipal corporations in the northern villages, was to obtain the needed information about the scope and nature of the problem of abandoned mining exploration sites (Duhaime and Comtois 2000). The following objectives were then pinpointed together with the municipal corporations: (i) to determine the number of sites that contain abandoned equipment; (ii) to identify their exact location; and (iii) to identify sites that contain toxic substances. From an environmental viewpoint, the scope of the problem is as yet largely unknown. However, from a social, economic and cultural viewpoint, the effects of environmental contamination on hunting and fishing activities would be considerable if the territory affected is extensively used by the local population. The results presented in this study make it possible to list and locate, as accurately as possible, abandoned mining exploration sites, the contents and potential environmental dangers of which still need to be characterised.

Method

Pilot project

No method is known to be both efficient and cost-effective in identifying abandoned mine exploration sites, given the enormous size of the territory, which extends for approximately 500,000 km^2, and represents approximately the surface area of a country such as Spain. An initial examination of the archives of the ministère des Ressources naturelles du Québec (MRN) (Québec Ministry of Natural Resources) proved unsatisfactory, although it did locate two corpuses edited by the MRN that identify the sites of mineral deposits. This has led to the conclusion that there are no valid methods using archival research that are appropriate to the problem of identifying

2 1976 represents a landmark year, as mining exploration has since gradually become subject to stricter regulations in regard to environmental impacts, with the Québec government's adoption in that year of the Environment Quality Act.

potential abandoned mining exploration sites. Other methods were therefore tested. Three survey methods were tested in a pilot project conducted in the Kangiqsujuaq area, within a 50-by-50 km (2,500 km^2) area of the hinterland: (i) interviews with key informants, (ii) aerial surveys and (iii) remote sensing. The Kangiqsujuaq area was chosen because it is well known that this area contains several abandoned mining exploration sites, as the residents of Kangiqsujuaq have reported numerous abandoned sites and a great deal of abandoned equipment. Moreover, its location in the Ungava Trough is relevant since exploration works were concentrated in this area prior to 1976. The 50-by-50 km delimitation is the minimum surface area required for a RADARSAT image.

The interviews with key informants were aimed at mapping sites known to residents of this community. The interviews also made it possible to collect information on knowledge acquired during site cleanups that had been carried out to date. This method resulted in the location of thirty-four sites that were directly related to the abandonment of exploration equipment.[3]

Aerial survey methods were also tested to identify potential abandoned sites. The recognition of sites by aerial survey involved a series of flights aboard a seaplane, following parallel and equidistant flight lines 1 km apart and flying at an altitude of 300 m at the speed of 100 miles/h. Two observers posted at the rear windows were responsible for taking photographs and writing down the site co-ordinates (Figure 1). The two other observers in the front windows, including the pilot, ensured that there was constant observation of the ground below. Upon the initial ground observation of a site, the pilot would slow down and begin the necessary turns to enable the geographical co-ordinates of the site to be pinpointed with the GPS and to allow photographs to be taken. In all, fifty-five recordings of site positions were completed during the aerial surveys.

Remote sensing was also used to identify the most time-effective and cost-effective technique, or combination of techniques, that would make it possible to complete an inventory of all abandoned sites in the entire territory of Nunavik. Testing the potential of remote sensing was made possible by the involvement of the MRN's Service des applications géospatiales (SAG). The test in Nunavik used SPOT PLA (precision of 10 m, 1997) and LANDSAT (precision of 30 m, 1995) optical satellite images, as well as summer and winter RADARSAT (precision of 8 m, 1999) radar satellite images. The test proved that no medium-resolution satellite data could be used to accurately identify any piece of equipment identified during the fieldwork conducted in 1999. Therefore, we concluded that, given the technology available during the pilot project, satellite images are not an effective way to identify sites or to determine the shapes of any equipment, no matter what material it is made of.

In sum, the techniques of interviews with key informants and aerial surveys did allow for the location and enumeration of various pieces of equipment on the territory, although several sites were missed using these two techniques; many sites contain rusted drums that tend to be indistinguishable in the rust-coloured environment of the Arctic tundra. In fact, one had to be quite close to the site to notice the heap of drums. In the project testing zone, a combination of interviews, topographical maps and aerial surveys of the area made it possible to identify forty-seven abandoned mining exploration sites. However,

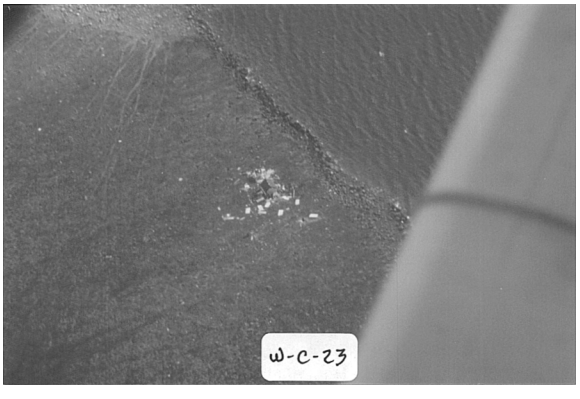

Figure 1
Camp or cabin, with small shed, surrounded by debris along a body of water at about 25 m.
SOURCE: Duhaime and Comtois (2000), photo by Robert Comtois

3 For the purposes of this study, the delimitation of a potential site, as agreed upon with the informants, covers an area containing all pieces of equipment located less than 300 m (1,000 feet) from one another. Pieces of equipment located at a greater distance are considered to be part of a separate site.

although effective, this technique was shelved due to its prohibitive costs.

The inventory

The method chosen combines two techniques that were shown to be effective: the combination of interviews with key informants and use of data from the MRN corpus on mining deposits offers the greatest potential at the least cost for successfully completing the inventory. All of the Inuit and Naskapi municipalities were visited between June and October 2000. Preparatory meetings were aimed at presenting the results of the pilot project carried out in 1999 and at raising the participants' awareness of the presence of various mining exploration sites. This was followed by interviews with key informants, who were asked to indicate and pinpoint abandoned sites that they were aware of on topographical maps with scales of 1 : 50,000 and 1 : 250,000. The recording of equipment observations focused on quantifiable details (quantity, volume, surface area and distance) and descriptions of the types of materials or products and their state of preservation. The descriptive categories are: (i) buildings (structures) and dwellings (housing), (ii) drums, gas tanks and bottles, (iii) scrap (other than barrels: e.g., vehicles), (iv) solid waste and dry equipment, (v) distance from sensitive areas (e.g., lakes, rivers and streams) and (vi) presence of contaminated soils. The key informants frequently issued a warning during the plotting of the potential sites on maps: except in the case of sites near the villages, they mention the frequent presence of snow cover when they made their observations, which limited their ability to accurately describe the items and equipment on the sites. The discovery at the MRN of a corpus which catalogued and mapped mining deposits in Québec—the *Catalogue des gîtes minéraux du Québec* (Avramtchev 1982a, 1982c, 1990a) and the *Carte des gîtes minéraux du Québec* (Avramtchev 1982b, 1982d, 1990b)—offered new hope for the successful completion of the inventory. These two key sources, published in 1982 (Ungava Trough and Hudson Bay regions) and 1990 (Labrador Trough region), together cover all regions of Nunavik. During the pilot project, the geographical coordinates of sites associated with mining deposits, collected from the *Carte des gîtes minéraux du Québec—Région de la Fosse de l'Ungava (*map of mineral deposits in the Ungava Trough), with a scale of 1 : 250,000, were transposed onto maps drawn up during the first phase of the inventory.

Available data on mining deposits discovered in Québec are currently integrated into a computerised geomining information system, called SIGÉOM, which integrates virtually all of the relevant databases. Since the focus of this study is the period prior to 1976, the use of an earlier database, called COGÎTE, was necessary. The data contained in the COGÎTE database are index cards on mining deposits codified in the *Catalogue des gîtes miniers du Québec* and include all types—showings, prospects and deposits—of documentary data. Therefore, the approach of combining the data gathered from the key informants with data found at the MRN allowed us to draw up an inventory of abandoned exploration sites and their location (Duhaime and Comtois 2002).

The 'remains' of an era of mining exploration

The description of potential sites obtained from the key informants suggests some of the typical functions of exploration works, such as: landing and take-off areas for the purpose of aircraft supply, fuel depots, camps and dwellings, drilling sites, equipment depots, vehicle maintenance areas and transportation infrastructures. However, while some information can be gathered regarding the composition of an exploration site, it is impossible to identify the abandoned equipment and products on the sole assumption that there are particular areas devoted to particular functions. The reorganisation of exploration camps and moves across the territory in search of new drilling sites are likely to have spread the equipment and products over a wide area that is beyond a given surface area identified on a map.

The presence of dangerous materials (oil, gas and chemical products) and the variety of equipment observed are probably fairly good indicators of the extent of the work conducted on the sites. For example, gas tanks and chemical products were observed in sites where camps were established for lengthy periods of exploration, i.e., in sites classified as deposits and prospects (Figure 2). However, the informants warned future users about the data that they were providing: the equipment was often observed during the winter,

Figure 2
Drums for the transportation of oil products. In the background, various buildings and workshops.
SOURCE: Duhaime and Comtois (2000), photo by Robert Comtois

under a layer of snow. The enumeration and extent of dispersal of this equipment therefore need to be validated during the summer season. The classification used for the potential sites observed by the informants emphasises the types of equipment, defined in terms of items and products, as well as the variety observed on the sites.

The presentation of the results lists items and products, whether found on their own or combined with other elements, according to the degree of their potential impact on the environment and on human beings. Seven categories were set up for describing the potential sites (Table 1). They are presented in descending order, according to their decreasing degree of potential impact. They include chemical products, gas products, oil products, buildings, dwelling, scrap and solid waste.

Potential abandoned mining exploration sites

In Nunavik, there are 595 potential mining exploration sites that contain equipment, dwellings, vehicles or other items that might have been abandoned during works conducted before 1976. Table 2 presents an overview of the results for the Ungava Trough and Hudson Bay (UTHB) and Labrador Trough and George River (LTGR) regions. The informants identified a total of 379 sites more directly associated with mining exploration conducted before 1976 (Table 2). The Inuit and Naskapi informants also identified a total of sixty-six sites that contain abandoned equipment not related to mining exploration, e.g., Hydro-Québec camp sites or fuel depots, outfitting establishments and mobile sport hunting camps.

Table 3 summarises the distribution of the potential sites according to the number of type of observed equipment or remains, where Category 1 designates sites with only one type of observed equipment or remains, and where Category 6 group designates sites with six types of equipment or remains. Two general findings emerge from the compilation presented in Table 3: (i) more than half (52 percent) of the potential sites are characterised by the presence of a single product or item or piece of equipment, i.e., 196 sites of 379 potential abandoned sites in both the Ungava Trough and Hudson Bay region and the Labrador Trough and George River region; and (ii) the presence of standard drums (45 gallons) for the transportation of oil products was mentioned in 80 percent of the potential sites indicated by the informants. Moreover, the cleanup initiatives undertaken by the municipal corporations have affected only a minimal number, i.e., less than 10 percent, of the potential sites in Nunavik.

Table 1
Items and products observed on potential sites by key informants

Chemical products	Concentrated acids, sprays (aerosol, solvents), drums (brine of calcium chloride), battery acid, calcium chloride, dynamite, heavy metals
Gas products	Tanks, propane
Oil products	Oil cans, diesel fuel, gasoline, oil, kerosene, furnace oil, standard 45-gallon drums
Buildings	Shacks, domes (metal), drilling cabins, garages, laboratories, mobile workshops, sheds (radio station), tripods
Dwellings	Cabins, mobile camp cabins, tent frames
Scrap	Antennas, fasteners (nut, bolt, string), domestic appliances, tracked vehicle workshops, airplanes, boats, cans (food, milk), crushers, bulldozers, cables, trucks, pick-ups, camp equipment, canoes, car body (parts), wagons, loaders (tractor), containers, kitchen appliances, debris, derricks, shelves (drilling post), furnaces, generators, cranes, helicopters, beds, heavy equipment, airplane motors, outboard motors, skidoos, tools, water pumps, drums recycled as bridge, tracked vehicles (Bombardier, Muskeg)
Solid waste	Tent frames (collapsed), wood, boxes for rock samples, bottles, hoses, canvas, camp structures and equipment, rubber, plywood, domestic waste, dump sites, studs, mattresses, building equipment, food, seaplane wharves, Styrofoam, tents, cloth (plastic-coated), sleighs (akutik)

Table 2
Potential abandoned sites in Nunavik by field of activity and region

Field of activity and source of information	Ungava Trough and Hudson Bay	Labrador Trough and George River	Total (*n*)
Potential abandoned mining exploration sites			
Identified by key informants	176	203	379
Identified from MRN data	28	188	216
Subtotal	204	391	595
Potential abandoned sites from other industries			
Identified by key informants	22	44	66
Total	226	435	661

Table 3
Potential abandoned mining exploration sites by category and region

Potential abandoned sites according to key informants	Ungava Trough and Hudson Bay	Labrador Trough and George River	Total (*n*)
Category 1: one type of observed equipment	97	99	196
Chemical products	8	–	
Standard oil drums	72	59	
Buildings and dwellings	8	21	
Scrap	9	19	
Category 2: two types of observed equipment	40	56	96
Chemical products and gas tanks	1	–	
Standard drums and gas tanks	4	5	
Standard drums and buildings and dwellings	6	26	
Standard drums and scrap	29	25	
Category 3: three types of observed equipment	12	17	29
Standard drums, gas tanks and buildings or dwellings	2	2	
Gas tanks, dwellings and solid waste	1	3	
Standard drums, dwellings and scrap	9	12	
Category 4: four types of observed equipment	7	14	21
Standard drums, gas tanks, buildings or dwellings and scrap	2	5	
Standard drums, gas tanks, dwellings and solid waste	1	3	
Standard drums, buildings, dwellings and scrap	1	3	
Standard drums, dwellings (cabin), dwellings (tent frame or mobile home) and scrap	1	1	
Standard drums, dwellings, scrap and solid waste	1	1	
Standard drums, buildings, scrap and solid waste	1	1	
Category 5: five types of observed equipment	3		3
Chemical products, gas tanks, standard drums, buildings (shed) and scrap	1	–	
Standard drums, gas tanks, buildings, dwellings and scrap	2	–	
Category 6: six types of observed equipment	2	1	3
Chemical products, gas tanks, standard drums, dwellings, buildings and scrap		1	
Chemical products, gas tanks, standard drums, dwellings, buildings and solid waste	1		
Chemical products, gas tanks, standard drums, buildings, scrap and solid waste	1		
Sites affected by a cleanup	18	13	31
Subtotal	176	203	379
Potential abandoned sites according to MRN data			
Categories unspecified	28	188	216
Total	204	391	595

Potential sites by category

A total of 196 sites are thought to contain one type of item or equipment (Category 1). However, the exact number of pieces of equipment in each site is still impossible to determine. Of this total, 131 sites contain only standard drums, while twelve sites contain oil product residues, the quantities of which need to be validated on site. There are eight sites containing chemical products, all located in the Ungava Trough and Hudson Bay region. In four sites, informants also reported the presence of drums containing, or that had contained, brine of calcium chloride. Informants from Ivujivik also noted the presence of a site containing a number of batteries. Other sites contain buildings and dwellings, especially in the Labrador Trough and George River region. One-fourth (96 of 379) of the potential abandoned sites in Nunavik contain at least two types of observed equipment (Category 2). The most common combination observed is oil drums with scrap items, or oil drums combined with the waste associated with dwellings for workers (56 percent). Another commonly observed type of site is the combination of buildings and dwellings with standard drums (Figure 2). It is important to note that in the Ungava Trough and Hudson Bay region, one site indicated by the informants contains a combination of chemical products and gas tanks. However, without the snow cover present during the observations made by the informants, many of the sites in this category might have been placed in other categories with more types of observed equipment.

There are twenty-nine potential sites with a combination of three types of equipment (Category 3). All of these sites contain buildings, whether associated with the exploration work itself or in the form of dwellings for workers. Almost all of the sites (twenty-eight) contain standard drums. There are twenty-one sites where four different types of equipment and items were observed (Category 4). All of these sites contain buildings and dwellings, as well as at least one standard drum, while twenty of the twenty-one sites contain scrap. More than half of the sites were reported to contain gas tanks, while the scrap was reported to be in various forms: oil furnaces, debris, tractors, buckets and antennas. Three sites containing five different types of equipment were recorded in Category 5, representing <1 percent of all potential sites in Nunavik. All of these sites are located in the Labrador Trough and George River region and contain gas tanks, standard drums, buildings (a shed) and scrap. According to an informant, one site may contain dynamite, which was classified as a chemical product (Figure 3). Another site was reported to contain a combination of chemical products, gas tanks, standard drums, buildings (a shed) and scrap (drilling waste and a tractor). The Kativik Regional Government was informed as soon as the existence of this site was known. Three potential sites were reported to contain six different types of equipment (Category 6). These sites were all said to contain chemical products, gas tanks, standard drums and buildings (sheds). One site also contains dwellings in the form of cabins and scrap in the form of a tractor and several drilling pieces. Another potential site contains solid waste in the form of plywood, while a third contains scrap associated with drilling equipment as well as plywood.

There are presently thirty-one sites where a cleanup has been completed or is in progress under the supervision of the responsible authorities. Eight Nunavik villages took part in projects launched in the mid-1990s to clean up mining exploration sites. In 2000, the informants from

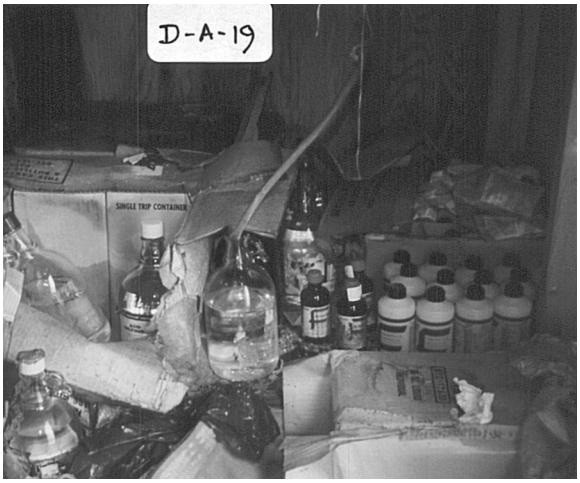

Figure 3
Chemical compounds found in one site, including toxic concentrated acids. The cabin in which they were contained had no padlock or any other safety devices.
SOURCE: Duhaime and Comtois (2000), photo by Robert Comtois

four villages provided an assessment of the projects in their villages, which together represented 69 percent of the overall cleanup efforts. The cleanup initiatives are associated mostly with sites in Categories 1–5, which represent the large majority of the total number of sites.

Potential sites documented using the COGÎTE database

Some 216 sites with exploration work dating from before 1976 were documented by using the COGÎTE database. Of these sites, eighty-one were 'deposits', i.e., they were the focus of works that allowed the tonnage to be evaluated. Some 135 sites were the focus of works that allowed some dimensional parameters to be evaluated, but did not allow for an evaluation of the tonnage. These sites were selected on the basis of the results from the 1999 pilot project. By cross-checking these sites with the sites indicated by the informants, we could expect some abandoned equipment to be present near the locations indicated in the mining deposit index cards. Using the COGÎTE database, three types of documentation were examined: (i) mining company annual reports; (ii) the cards included with the annual reports, mainly concerning drilling locations; and (iii) reports by MRN geologists. Unfortunately, the annual reports rarely include a description of the equipment used for the exploration work, the cards included with the annual reports do not contain any comments about sites likely to contain abandoned equipment and the reports by the MRN geologists are rarely accompanied by maps, and when there are maps, they are generally large-scale. In short, other than the geographical co-ordinates of the location of the sites provided by the index cards and their validation during the 1999 pilot project, the potential of the corpus on mining deposits is limited in terms of providing information about sites most likely to contain abandoned exploration equipment. However, a characterisation of the potential sites could provide indications that would make it easier to trace the history of the works.

Figure 4 shows the spatial distribution of the abandoned mining exploration sites identified by the key informants and the *Catalogue des gîtes miniers du Québec*. The map was produced using MapInfo software and National Topographic System (NTS) Numbering.

Discussion

Assessment and prioritisation of potential abandoned sites

The sites identified by the informants show a considerable variety in the quantity and complexity of abandoned equipment and materials. The overall results show that there are few sites with dangerous products, while there are many sites with no dangerous products or a few dangerous products; there are few sites with a large quantity of equipment, whereas there are numerous sites with only a few equipment items left behind on the site. Authorities' action could then be oriented toward those few sites containing such dangerous products and evaluate the opportunity to clean up the other problematic sites according to clearly identified criteria, among others the potential danger for the environment and the human health and the distance between the sites and the communities.

The use of various techniques made it possible to compare and validate the results obtained from each of these techniques. To date, the technique of remote sensing cannot provide sufficiently detailed information on the location of exploration sites in the hinterland. On the other hand, the aerial surveys were found to be useful: the collection of both geographical co-ordinates and photographs of sites with equipment provided the 'field truths' that allowed the other corpuses of data to be evaluated, including the data on mineral deposits. It appears that nearly all of the sites with multiple records were identified by the key informants and the aerial surveys. Moreover, a comparison of the results in the category of sites identified by the aerial surveys alone indicated that ten of the thirteen sites contain a small quantity of equipment, and of the three remaining sites, there is one site with fifty oil drums that was not identified by the key informants. Moreover, in the sixteen sites identified by the key informants alone, it is noteworthy that the potential contents—including camps, a helicopter, a tracked vehicle and gas tanks—were not identified by observers during the aerial surveys.

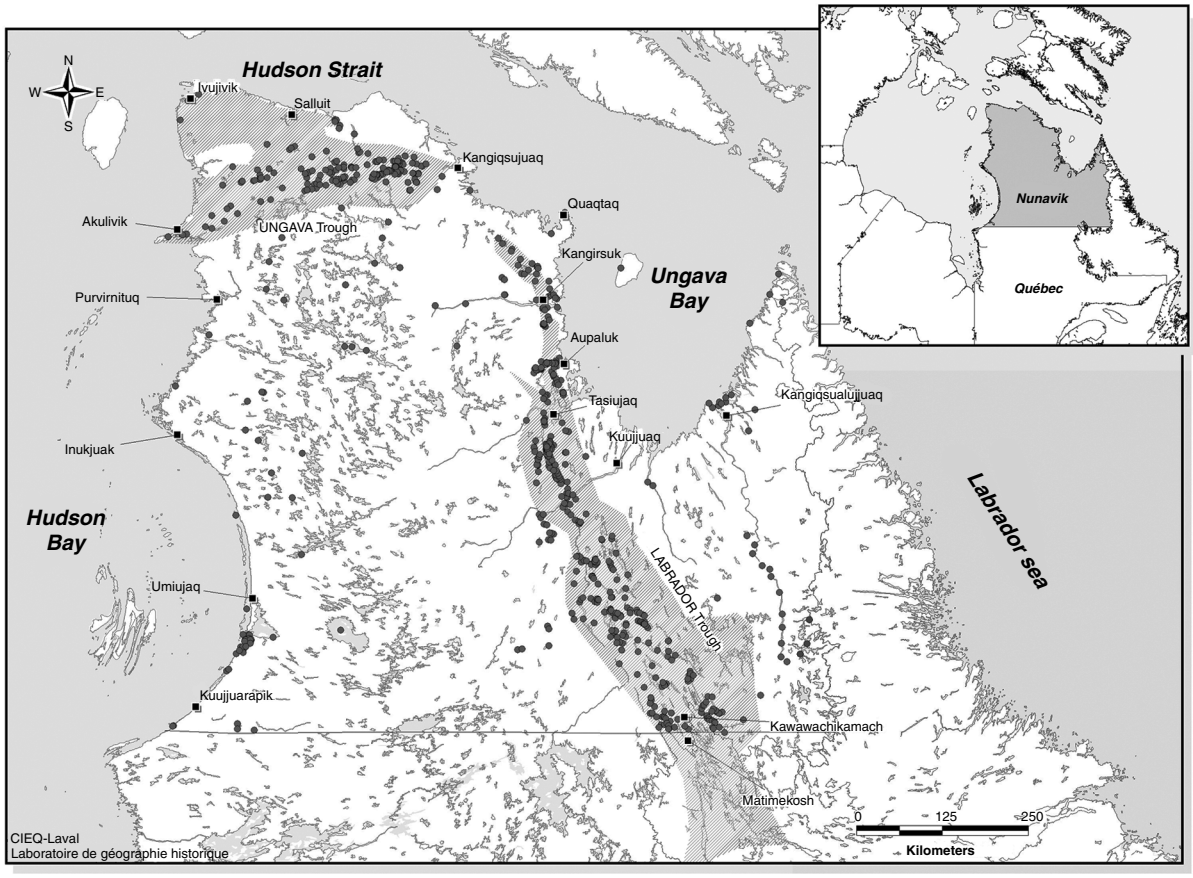

Figure 4
Location of potential abandoned mining exploration sites in Nunavik

All of the sites where the key informants mentioned the presence of chemical products and large numbers of oil drums were also identified by the aerial surveys. Access to the documentary data on mineral deposits classified as 'prospects' and 'deposits' gives us a complementary technique that can be used to carry out a large-scale inventory at a reasonable cost. In the Labrador Trough, the number of mining deposits classified as 'deposits' that were found and the large number of standard oil drums identified by the informants in many potential sites give us some indication of a significant potential presence of other dangerous products such as gas and chemical products.

For the moment, in Nunavik, the number of potential sites containing chemical products is low, with less than ten such sites reported. However, the large number of potential sites with oil drums is worrying, insofar as very few data are available on the exact number of drums per site, the presence of residues and the volume of such residues. Moreover, the data on the number of indicated potential sites associated with other industries (sixty-six) are still fragmentary: these sites have quite often been indicated because their size was more impressive than the size of the nearby mining exploration sites, or because of their rarity. The research upon which this paper is based has increased our knowledge about the sites observed by the local population, but the total number of abandoned sites (all industries included) is still unknown. When the

characterisation phase is completed, giving us more information about the number of sites and the quantity of debris abandoned on the territory, the responsible authorities should be better able to take the appropriate measures.

The project aimed at the characterisation of a sample of potential abandoned sites throughout Nunavik began in 2001. The Kativik Regional Government and Makivik Corporation are jointly supervising the conducting of this phase of the project, which is funded by Environment Canada's Northern Ecosystem Initiative and Québec's ministère des Ressources naturelles. Several fieldwork sojourns were planned over the two-year period from 2001 to 2003. Two main geographical areas were delimited for this purpose, one corresponding to the Ungava region, and another area located in the southern part of Nunavik, extending from Hudson Bay to the Labrador border. An initial characterisation phase was conducted by the Kativik Regional Government and Makivik Corporation from 2001 to 2003. The preliminary findings were presented at the 7th International Symposium on Mining in the Arctic that took place in Iqaluit in March 2003 (Nelson 2003). This critical phase will serve as a descriptive platform that can be used to support various cleanup initiatives. These projects will be carried out in order of priority, based on the severity of the potential environmental impacts and the use of these lands by the Inuit. The characterisation phase resulted in the identification of 275 abandoned sites, 25 of which represent a major environmental risk, 95 a moderate risk and the rest a minor risk (Nelson 2003).

In conclusion, it is essential to extend our thinking beyond the boundaries of Nunavik and to include the problem of abandoned mining exploration sites in Nunavik in the context of the growing concern about cleaning up abandoned mining sites in the Canadian North. The Department of Indian and Northern Affairs Canada (INAC) plays a central role in the 2002 report of the Commissioner of the Environment and Sustainable Development in terms of the urgent actions that must be taken in regard to the cleanup of sites that are considered priorities, such as the Colomac, Giant and Mount Nansen mines in the Northwest Territories, and Faro in the Yukon (Commissioner of the Environment and Sustainable Development 2002). Other sites are not prioritised and are less documented even though the state of the surrounding environment is deplorable (Dufour and Tremblay 2000). Environmental groups responded to the publication of this report by demanding that strong and immediate action be taken by the federal government to clean up abandoned sites across Canada (MiningWatch Canada 2002). Anticipating the publication of the report of the Commissioner of the Environment and Sustainable Development, INAC announced its policies in August 2002 in regard to mining sites in Nunavut and the Northwest Territories. However, these polices are in no way '. . . legally binding, do not cover the exploration phase of mining, do not cover abandoned mines and ministerial discretion governs their application to current mines. The policy does not in any way meet the serious needs for prevention and clean up of abandoned mines in Northern Canada' (MiningWatch Canada 2002). The problem is likely to remain unresolved unless a national policy is developed that is legally binding on polluters. And in Nunavik, the sites that have been identified which date from before 1976 do not fall under any jurisdiction and thus make it difficult, if not impossible, to establish companies' accountability.

Although the legal context for mining exploration and exploitation has significantly changed over the last few decades, especially since the 1970s, this inventory suggests that a lot remains to be done to redress negligence from the past, and to harmonise, in the future, economic development with social and environment stakes. Northern Canada is experiencing massive large-scale mining projects currently underway and major infrastructures investment is planned (Myers 2001). In such a situation, these findings should contribute to raise awareness to ask for corporate practices that are environmentally and socially sensitive.

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