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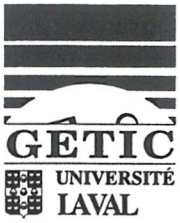

INVENTORY AND CHARACTERISATION OF ABANDONED MINING EXPLORATION SITES IN NUNAVIK: PILOT PROJECT

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EXECUTIVE SUMMARY

Since the 1950s, the territory of Nunavik has been the subject of numerous mining exploration campaigns, especially in the Labrador and Ungava Troughs. At the end of their prospection forays in these regions, many of these companies abandoned on site all types of waste materials: drilling equipment, products for geochemical analysis, heavy equipment, hydrocarbons, etc.

Thanks to the pilot project financed by La Fondation EJLB, it has been established that 47 of these sites exist within an area of 2500 square kilometers, some of which have been found to contain large amounts of waste material or highly toxic concentrated acids. By combining appropriate methods, it has been shown that an inventory of these sites can be done which will then give a reliable picture of the extent of their threat to the environment and to public health.

In fact, the pilot project has shown that an inventory can be done by using the *Catalogue des gîtes minéraux du Québec* (Avramtchev 1982a, 1982c, 1990a) and the *Carte des gîtes minéraux du Québec* (Avramtchev 1982b, 1982d, 1990b), combined with interviews with key informants. The sites of mineral deposits are specified within the *Catalogue*, and the eyewitnesses provide information as to which of these contain abandoned equipment, and other sites unmapped or unknown to outsiders.

In this capacity, the use of remote sensing satellite data had been disappointing so far: the medium definition satellites — data from the 10 m. definition satellites SPOT and RADARSAT which regularly fly over Nunavik — cannot determine the specific geometry of on site material. But now this data could be cross-checked by remote sensing images from IKONOS, a high definition (1-4 m.) satellite which was launched last fall. As for the characterisation of the sites, the pilot project has shown this can only be determined by on site visits, via helicopter.

Finally, the pilot project has made it possible for the people of the area to break the isolation which the region is subject to and to bring on more visibility at the provincial and national levels concerning this problem which confronts all residents of Nunavik. As of the year 2000, with the help of the research team and with the means which were mustered for the pilot project, the people of Nunavik have shown they are willing and able to complete the survey and participate in the characterisation of the abandoned sites of the entire region.

1. INTRODUCTION

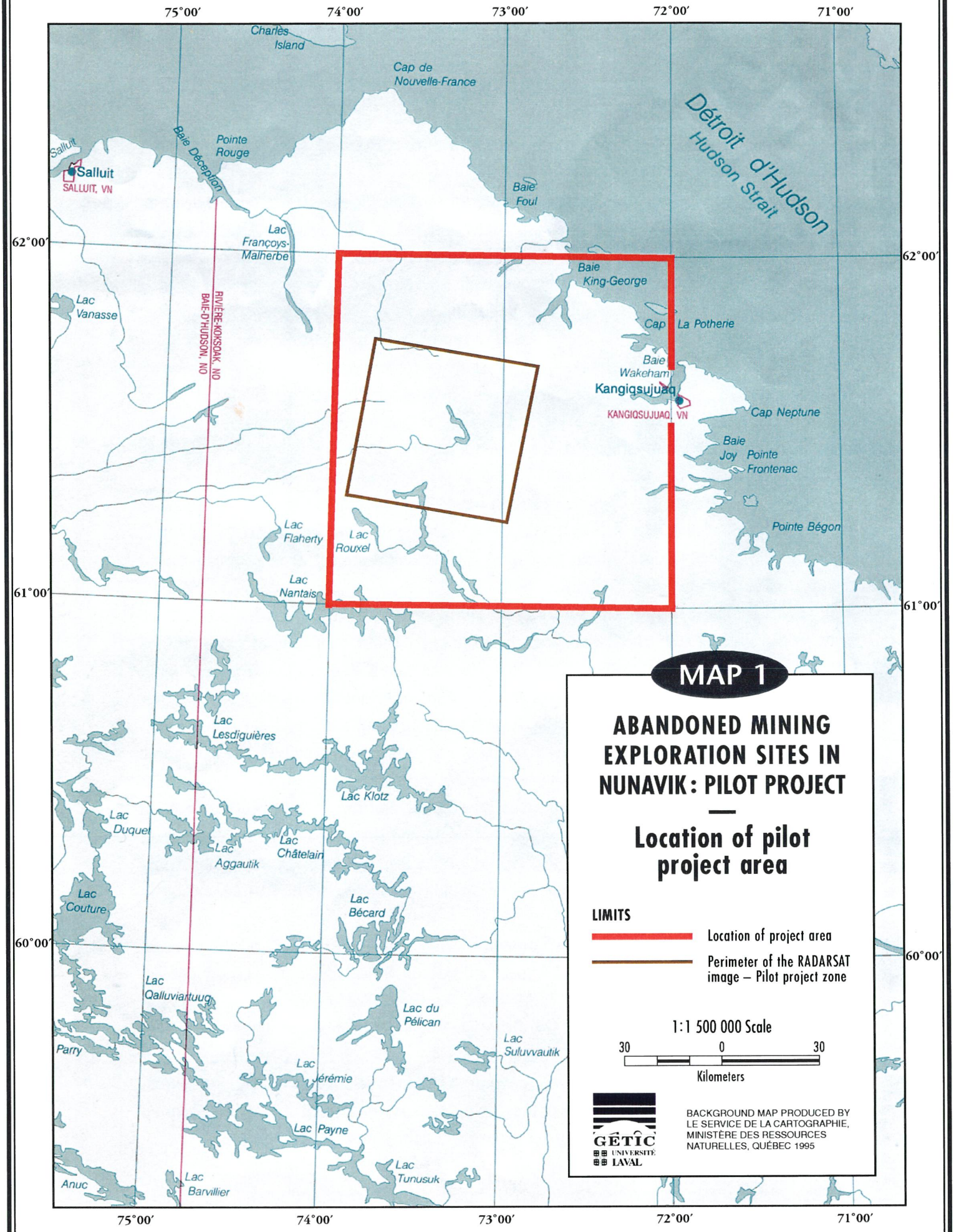
1.1 Problem

Nunavik, the territory of Québec situated north of the 55th parallel, was the site of major prospecting during the 1950s, some of which led to the opening of the Asbestos Hills and Raglan mines. Prior to 1975, mining companies were not required to clean up exploration sites. While some nevertheless made an effort to remove all traces of their operations, many simply up and left, abandoning machinery, equipment, fuel drums, chemical product containers — concentrated hydrochloric, nitric and sulphuric acid — buildings, and various types of waste, with no regard for the environment. The presence of these materials poses a risk to both human and animal health. And since a large part of the Inuit diet still cornes from hunting and fishing, the threat of animal poisoning from these abandoned sites is of concem to the communities.

Although the residents of several Nunavik villages are able to identify some of these sites, we currently have no idea of their exact number and location, or of the types and quantities of abandoned material, equipment and chemical wastes. Consequently, it is impossible to assess the real threat they pose for the territory and or to properly orient cleanup, rehabilitation and restoration efforts.

Small-scale cleanup has been going on since 1997. Seven regions have benefited from this initiative, with the cleanup work being carried out by the Inuit communities located nearest to the abandoned sites. Priority was given to sites containing a large volume of material whose breakdown or decay could cause contamination and endanger the health of humans and animals using these sites. The results are still very piecemeal. Although they do not indicate the exact extent of the problem in Nunavik, they do show that, given the nature and amount of debris found on the sites, the problem is serious. The local communities and their representatives fear that if nothing is done, eating venison from the hinterland could pose a human health risk. In addition to meaning the short-term loss of a valuable economic activity, this would have a direct impact on the eating habits and grocery bills of Inuit households, which would be forced to buy more imported products.

The problem is compounded by Nunavik's geographical location. Not being part of the Northwest or Yukon territories, Nunavik does not have access to certain federal programs, such as the Arctic Environmental Strategy. And because it is situated in the Far North, Nunavik benefits only marginally from Québec's environmental programs, which are geared primarily to the south. These programs could have helped meet the urgent need for knowledge but, for this reason, cannot be used. In short, in the current context, the people and authorities of Nunavik are facing an environmental threat of unknown proportion. The present research proposal is aimed at filling this knowledge gap.


75°00′
74°00′
73°00′
72°00′
71°00′
62°00′
61°00′
60°00′
Charles Island
Cap de Nouvelle-France
Détroit d'Hudson
Hudson Strait
Salluit
SALLUIT, VN
Pointe Rouge
Baie Déception
Baie Foul
Lac François-Malherbe
Baie King-George
Lac Vanasse
RIVIÈRE-KOKSOAK, NO
BAIE-D'HUDSON, NO
Cap La Potherie
Baie Wakeham
Kangiqsujuaq
KANGIQSUJUAQ, VN
Cap Neptune
Baie Joy
Pointe Frontenac
Pointe Bégon
Lac Flaherty
Lac Rouxel
Lac Nantais
Lac Lesdiguières
Lac Klotz
Lac Duquet
Lac Aggautik
Lac Châtelain
Lac Couture
Lac Bécard
Lac Qalluviartuuq
Lac du Pélican
Parry
Lac Suluvvautik
Lac Jérémie
Lac Payne
Lac Tunusuk
Anuc
Lac Barvillier
MAP 1
ABANDONED MINING EXPLORATION SITES IN NUNAVIK: PILOT PROJECT
Location of pilot project area
LIMITS
Location of project area
Perimeter of the RADARSAT image – Pilot project zone
1:1 500 000 Scale
30 0 30
Kilometers
GÉTIC UNIVERSITÉ LAVAL
BACKGROUND MAP PRODUCED BY LE SERVICE DE LA CARTOGRAPHIE, MINISTÈRE DES RESSOURCES NATURELLES, QUÉBEC 1995

1.2 Objectives

The main objective of this project is to determine the extent of the problem of mining exploration sites abandoned in Nunavik prior to 1975 and to assess their threat to the environment. The operational objectives of the project are to:

i. determine the number of abandoned exploration sites;
ii. identify the exact location of these sites according to their geographical coordinates;
iii. identify sites abandoned prior to January 1, 1975 and those abandoned after this date;
iv. characterise the located sites, i.e. identify toxic substances, equipment and material present on the site.

1.3 Method

1.3.1 Pilot project

Attainment of these objectives for Nunavik as a whole, or even just for the most heavily explored regions (Labrador and Ungava Troughs) is, for the moment, unrealistic. As yet, there is no established method that could be used alone for this project, either because of efficiency limits or because it would be too expensive. This project therefore consists in a pilot project aimed at evaluating the efficiency and costs of different methods in a limited study area. The results will be used to produce specifications for the required inventory work and also provide us with a much better idea of the nature and extent of the problem.

1.3.2 Delimitation of pilot zone

The pilot area is 2500 sq. km., or a 50 by 50 km area corresponding to a RADARSAT image. The geographical centre of this area is just over 70 km west of the village of Kangiqsujuaq and 30 km northeast of the Cratère du Nouveau-Québec. The residents of Kangiqsujuaq have located numerous abandoned sites and equipment in this area. The pilot area was chosen according to two criteria: 1) the known presence of abandoned exploration sites (as reported by residents of Nunavik); and 2) its location in the Ungava Trough, where exploration work was partially concentrated prior to 1975.

1.3.3 Methods ruled out

Two of the methods initially considered have been ruled out: the annual activity reports of targeted mining companies, and aerial photography.

Québec's Mining Act requires companies to submit an annual activity report. The information obtained from the Ministère des Ressources naturelles du Québec (MRNQ)

confirmed that mining companies were extremely active in the territory: at least 40 different companies conducted exploration work in Nunavik up until 1975. Several of these companies have since been merged or have gone out of business. Their activity reports are poorly organized, and those that interest us are archived, making this option a long and costly procedure. While all of these companies' drill holes can be sited, geographical coordinates do not tell us the size, number or spatial distribution of abandoned sites containing debris and equipment. More importantly, geochemical prospecting, the technique used by numerous mining companies in the early 1960s, requires little or no drilling.

Preparations for site inventory rapidly raise the question of cost: while the inventory is to cover all of Nunavik, it targets first and foremost the Labrador and Ungava Troughs and adjacent areas, since this is where the majority of mining exploration was carried out between 1950 and 1975. This priority area represents nearly 300 000 sq. km. While aerial photography immediately comes to mind as a possible inventory technique, because Nunavik is located far from the kind of development associated with industries that extract primary resources over large areas (e.g. forestry, hydroelectricity), very little has been conducted in the territory. In fact, the most recent coverage dates to the early 1960s. In 1999, companies specializing in this field estimated the cost of aerial photography for a 10 000 sq. km. area in Nunavik — 100 x 100 km, scale 1:10 000 — at $300 000, which was too expensive.

1.3.4 Methods used

Three methods have been used: interviews, observation and remote sensing.

A researcher spent one week in June 1999 in the area interviewing key informants in collaboration with the Corporation of Kangiqsujuaq. The goal was to map sites known to residents of this community. In fact, this may be the only way to locate some of the sites. In addition to validating the pilot area, the interviews enable us to collect information on the knowledge acquired during site cleanup carried out to date.

Observation during aerial surveys followed snowmelt in July 1999. Three observers, including the researcher, conducted aerial surveys of the pilot area over the course of 5 days. The objective is to identify the exact location of all abandoned sites and equipment in a systematic manner (equidistant flight lines 1 km apart, altitude 300 m.), and to photograph as many different elements and sites as possible liable to be located using remote sensing.

A chemist specializing in dangerous substances joined the team of three observers in July 1999 on days devoted to site characterisation. This work require a helicopter. The team also carried out detailed site surveys: description, photos and geographical coordinates of the various equipment, soil and liquid sampling. All photographs and sitings previously obtained have been compiled and submitted to remote sensing experts

at the beginning of September. Soil and liquid samples are stored at Université Laval for subsequent analysis, as needed.

Remote sensing. At a cost of $3 000 for 4 RADARSAT images covering a 10 000 sq. km. area, remote sensing has the potential to be the most economic technique. The problem is that there is no known precedent in the use of satellite data, either optical or radar, to locate mining exploration sites, including the data from satellites currently covering Nunavik and which offer the best resolution, i.e. SPOT (10 m par pixel) and RADARSAT (8.8 m par pixel). Until fall 1999, no high resolution satellites (1 to 4 m per pixel) cover the priority study area. One satellite is launched with success in fall 1999, called IKONOS, but its imagery could be extremely expensive, even prohibitive.

Abandoned equipment is strewn over areas ranging from 10 to over 100 sq. m. Furthermore, the geometry, spatial distribution and physiographic context of certain equipment vary significantly. Given the characteristics of the available observation satellite data, the selected method consists in using a mining-related data base in conjunction with the spaceborne remote sensing data to be assessed. Analysis of known data is presumed to enable us to calibrate the remote sensing data and determine whether they can be used to locate sites, assess the extent of mining activity and inventory the different types of equipment abandoned on sites. Data processing entails enhancing satellite images to various scales in order to enhance the information sought and then producing image maps by establishing production standards that can subsequently be used during regional analysis.

The remote sensing work is carried out in four main phases: (i) analysis of statutory work (geophysical surveys and drilling); (ii) entry of satellite data; (iii) processing of remote sensing data; and (iv) data analysis.

1.4 Communications and reports

A steering committee composed of one representative from the Kativik Regional Government (KRG), Makivik Corporation, the Kativik Environmental Advisory Committee (KEAC) and GÉTIC monitored work and ensured that the Inuit population was kept informed of the project's objectives, research program and results. This report also presents containing survey record model — for site characterisation and geographical coordinates — for meeting the operational objectives defined earlier.

2. SURVEY

Three research techniques were used in order to retrace the sites: (i) interviews with key informants, (ii) aerial surveys and (iii) remote sensing. The interviews took place in Kangiqsujuaq on June 9th and 10th 1999. The community of Kangiqsujuaq had previously agreed to participate in this pilot study. The aerial surveys took place between July 15th and July 19th 1999. Finally, the final report on this remote sensing work was submitted on March 10th, 2000.

In this text, "abandoned site" refers to any location containing one or more pieces of equipment that are generally associated with mining exploration, which is now abandoned. The designation "abandoned" is based on the opinions expressed by the key informants or, in the absence of such an expressed opinion, on the observation of a lack of activity at the site, whether the equipment located there has been put in order or remains scattered.

2.1 Interviews with key informants

The co-ordinator of the GÉTIC's pilot study presented an overview of the project at a regular meeting of the Corporation of Kangiqsujuaq's Council, held on Monday, June 7th 1999. After meeting with the participants, it was agreed that the work could begin the following Wednesday, June 9th 1999.

The Wednesday morning was devoted to the dissemination of information about the project over the community radio station by Mr. Charlie Arngak, mayor of Kangiqsujuaq. The same morning, two key informants from the community of Kangiqsujuaq, Mr. Amaamak Jaaka and Mr. Papikatuk Sakiagak, participated in locating abandoned sites on topographical maps having a scale of 1:50 000. The two participants each have a fishing camp at the western limits of the community's territory, 80 kilometres and 100 kilometres in a straight line from the village respectively. These camps are recycled cabins found amongst the equipment abandoned by the exploration companies. The mayor of Kangiqsujuaq and one municipal employee, Mr. Peter Kiatainaq, were present at the meeting. The mayor welcomed the informants and provided them with more information about the project, while Mr. Kiatainaq acted as interpreter.

The afternoon was dedicated to a joint interview in the presence of the two informants. The goal of this interview was to briefly conclude the first stage and then to sum up the experiences of clean-up efforts over the past years, considering the organisation of work, security measures, lessons to be drawn, and so on. This work in Kangiqsujuaq ended Thursday afternoon with an assessment of the two days, in the company of the mayor and the interpreter.

At this stage in the project, with this research technique, the objective was to locate all abandoned sites within a target zone 70 kilometres in diameter, detailed in Map 2[1]. The goal of this process was to enable the researcher to order appropriate satellite images, which would cover the majority of the abandoned sites identified by the informants. Each of the sites was plotted and marked on a map by the informants.

2.1.1 Result

In all, 37 sites were located in the circular zone. Among them, at least three are camps that members of the community visit in order to carry out fishing-related activities. In all, 34 sites were directly related to the abandonment of exploration equipment. Map 2 illustrates the location of all the sites indicated by these two informants. The majority of sites are found within ten kilometres of either bank of the Povugnituk River.

2.2 Aerial survey

The recognition of sites by aerial survey consisted of a series of flights aboard a seaplane, following parallel and equidistant flight lines one kilometre apart and flying at an altitude of 300 metres, at the speed of 100 miles per hour.[2]

Briefly stated, the observers posted at the back side windows were in charge of taking photographs, writing down the co-ordinates of the site as they were picked up and displayed by the Global Positioning System (GPS), and briefly describing the abandoned equipment. Two 35mm cameras were used for the photography, one of which was equipped with a 38-140mm zoom lens. The two observers in the front side windows, including the pilot, ensured constant observation of the ground below. The first ground observation of a site would allow the pilot to slow down and begin the necessary turns in order to pick out the geographical co-ordinates of the site with the GPS as well as to take photographs. After this, with everyone's agreement, the pilot would bring the seaplane back to the flight line in progress in order to continue the observation. Each person, equipped with binoculars, had to observe and scrutinise the surface for a distance of 500 metres from the side of the plane. A table in Appendix 2 identifies each of the flight lines,

---

[1] The co-ordinates of the centre are as follows: North 6820000.0 m., East 590000.0 m. (UTM (NAD27) Grid 18 — Map 35 H/11).

[2] The aerial survey observation technique was the subject of a meeting with Mr. Jean-François Roy of the Direction de la conservation des forêts at the Ministère des Ressources naturelles du Québec (MRNQ), on January 19th, 1999. Ms. Chantal Seuthé and Mr. Mario Hinse of the Service des applications géospatiales (SAG) of MRNQ were present, as members of the project team acting as resource-people in remote sensing. The purpose of this meeting was to learn about different techniques for observing the ground surface from a plane. Mr. Roy is a specialist in these techniques. For security reasons, he favoured a Beaver seaplane or a Cessna equipped with floats and extra reservoirs. He emphasised the security of the flight, specifying that his department kept double-engine planes for the precise purpose of conducting long observation campaigns.

MAP 2

ABANDONED MINING EXPLORATION SITES IN NUNAVIK : PILOT PROJECT

—

Abandoned sites and key informants : Positioning by examination on map

Legend

ABANDONED SITE (SOURCE)
MINING EXPLORATION

× Position by examination on map (informant)

i-14 → Site number (Appendix 1)

LIMITS

⊕ Perimeter center

Perimeter of examination on the map

1:250 000 Scale

5 Miles 0 5

5 Kilometers 0 5

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BACKGROUND MAP PRODUCED BY THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, 1984

73°45′ 73°30′ 73°15′ 73°00′ 72°45′ 72°30′ 72°15′

61°45′ 61°30′

Purtuniq COLLINE DE L'AMIANTE

Rivière Déception Est

Lac Binfret

Lac Letendre

Lac Qanartaliup Tasinga

Lacoudray

Rivière

Kattiniq

Lac Raglan

Lac de la Tente Déchirée

Lac Merville

Lac Wakeham

Lac Félix

Lac Est

Lac Long

Lac Renne

Lac Guindeau

Lac des Bombardiers

Lac Fleury

Lac Mequillon

Lac du Hibou

Lac Vaillant

Lac Carré

Lac Roebrune

Lac Vincenza

Lac Qargaluk

Lac Itirvituarjuk

Lac de l'Ours Blanc

Lac Perrotte

Saint-Germain

Lac Laflamme

Lac Cournoyer

Lac du Cratère

RIVIÈRE DE POVUNGNITUK

CRATÈRE DU NOUVEAU-QUÉBEC

ADMINISTRATION RÉGIONALE KATIVIK

i-1 i-2 i-3 i-4 i-5 i-6 i-7 i-8 i-9 i-10 i-11 i-12 i-13 i-14 i-15 i-16 i-17 i-18 i-18a i-19 i-20 i-21 i-22 i-23 i-24 i-25 i-26 i-26a i-27 i-28 i-29 i-30 i-30a i-31 i-32 i-33 i-34

showing the co-ordinates at each extremity (control points), the direction of the flight (east or west), and the number of sightings and observations carried out during each pass.

2.2.1 The team

Johnny May's Air Charter company, owned by Air Inuit, was hired to provide the aerial surveying service. The equipment used was a Beaver seaplane. The pilot, Mr. Jean-Marc Béniguet, began to participate closely in the work immediately upon his arrival in Kangiqsujuaq on Wednesday, July 14th. With the arrival of Mr. Willie Adams, from Makivik Corporation's Mapping Service, in the afternoon of the same day, the team was able to hold their first meeting. The other members of the surveying team were Mr. Peter Kiatainaq of the Corporation of Kangiqsujuaq and the co-ordinator of the GÉTIC. Among the team, only Mr. Adams had prior experience in exploration by aerial survey with parallel flight lines. The objective and the details of the project, as well as the distribution of roles on board the aircraft, were on this meeting's agenda.

With the help of the pilot, a GPS with precision of up to one metre was attached to the plane[3]. It was fuelled by rechargeable batteries, with an estimated lifespan of up to six hours. The pilot was responsible for the definition and the location of the 50 planned flight lines, oriented from east to west. From flight line number 1, the furthest to the north, to flight line number 50, the furthest to the south (Appendix 2), the plan was to cover the entire interior of the pilot zone that had been decided upon following the interviews in June in Kangiqsujuaq, an area corresponding to the 50 km by 50 km square of a RADARSAT image (Map 3). A van was rented in order to ensure shuttle service between the lake and the gas pumps, which are located in the village, in order to fuel the plane quickly between each flight. In spite of everything, from July 15th to July 19th, there were no more than two flights per day, for an average duration of three hours per flight.

2.2.2 Survey

The observation began in the northern sector of the pilot zone. The first flight lines covered an area in which strong exploration and exploitation mining activity prevailed, associated with the Katinniq nickel mine. This choice corresponds to several objectives. First, starting in the north allowed the observers to familiarise themselves with the agreed upon surveying tasks without much risk of missing an abandoned site — according to the informants, the sites present in this sector are active. Secondly, in order to facilitate the accomplishment of the remote sensing work, it is necessary to locate both exploration and exploitation equipment of varying sizes and functions, while distinguishing between equipment used for exploration and that used for exploitation.

---

[3] GPS instrument system Pathfinder Pro XRS TRIMBLE brand: 12 channel receptor, Everest technology, usage from –30 degrees Celsius to +65 degrees Celsius, 100% entirely sealed, water and shock resistant.

Photo 1 — Johnny May's Air Charter seaplane chartered for aerial surveying service.

Between July 15th and 19th, eight recognition flights were carried out. In one case, the planned flights of July 17th were cancelled due to poor weather. With these flights, 43 flight lines were covered, numbers 1 to 43, with the exception of flight line number 4, which was accidentally missed. Flight line number 4 was not resumed due to the costs involved and also due to the observations of the sites in the adjacent flight lines, which were active and almost all associated with work in progress at the Katinniq mine.

Flight lines number 44 to 50 were cancelled due to the high costs involved, with the aim of economising and ensuring the helicopter flights planned for the following days during the stage of site characterisation. This decision took into account both the cross checks between observations made on board the seaplane, and the sites located by the key informants during the interviews in June. In this way, the majority of sites indicated by the informants were also found by aerial survey and, moreover, the informants did not know of any abandoned sites in the sector covered by the cancelled flights. This decision was further justified by the small number of plottings (two) completed during the preceding flight lines included in the sector examined by the informants (numbers 35 to 43).

2.2.3 Unforeseen events

Besides the weather, the operation experienced other unforeseen events. First of all, Mr. Kiatainaq was only able to participate in the first two flights, as the deafening sound of the motor put him into an extremely drowsy state. Mr. David Bisson, the team's chemist, replaced him in the following flights. Mr. Kiatainaq then ensured the team's transportation and the van shuttle service between the lake and the village in order to fuel the plane for the remainder of the flights. He came back on a full-time basis during the characterisation stage.

Also, the nose of the seaplane obstructed the view from the front windows and the width of the cabin and the floats caused the observers to miss some sites during the plane's first pass. The sites missed were in the exact flight line of the plane. For example, a communication antenna about 30 metres high, set up for the Katinniq mine, was completely missed by the observers. This antenna was sighted during the following flight line. At the same time, due to the excellent visibility conditions, which permitted observation of the surface up to one kilometre away through the side windows, all of the sites which may have been missed in this way on the seaplane's first pass were likely sighted on subsequent flight lines. (Photo 1)

Moreover, a given site was often noted more than once. The rule was to report every unidentified site using the present technique. Yet, from high in the air, with the alternation in the direction of the flight lines (east, west, east...), several of the sites that had been identified and plotted in the preceding flight line appeared in a different angle during the subsequent flight. Even though it was suspected that these sites were indeed

those that had been plotted a short time prior, if any one of the observers did not recognise the site, that constituted sufficient justification to interrupt the flight line in progress in order to carry out a new observation of the site, including plotting the co-ordinates, photographing and briefly describing the site. Also, the distance between the flight line in progress and the site was of no importance; priority was given to discovering all sites regardless of time, even if this meant completing several records of a given site. Integration of the data collected was reserved for the analysis stage.

The data collected with the aid of the GPS system that had been rented for this purpose (precision of up to one metre) and attached to the seaplane were limited. The life of the batteries was found to be much shorter than the manufacturer's claim; rather than the expected lifespan of six hours, the batteries only lasted 60 to 90 minutes. The seaplane's GPS system (precision up to 100 m.) was used in the place of the rented system. Only one plotting from the aerial survey, K-18, from flight line number 18, is missing from the map due to the absence of the rented equipment, an absence that was noticed in the village upon examination of the co-ordinates. Due to the cost involved, a second flight over this site was not attempted. According to our notes, it contained three to five 205 litre drums and one or two boring pipes, all situated close to the northern sector where most of the sites are still active.

Numbering the positions and classifying the information collected during the observation stage, especially the photographs, was the largest cause of concern for the team. In spite of daily assessments of our work, the correspondence between the numbering of the positions and the photographs taken at each site presented some difficulties. The problem was mainly due to the deafening sound in the cabin of the plane, caused by a window left slightly open in order allow the GPS locating antenna to pass through, which limited any possibility of verbal communication. Especially in this context, the observation of two neighbouring sites complicated efforts to communicate the number of the site among team members, as each one was concentrated on the tasks of writing, photographing and taking down the GPS co-ordinates. All the data collected was verified at the end of the day. Still, only the photographs were reclassified after having been examined in connection with the written observation notes.

2.2.4 Result

In all, 55 records of site position were completed during the aerial surveys. Each was marked on Map 3, with the exception of listing K-18 (see above). The majority of the sites are located within ten kilometres of either bank of the Povugnituk River.

2.3 Remote sensing

The goal of this pilot project is to determine the most time-effective and, if possible, cost-effective technique or combination of techniques, which will permit us to complete

MAP 3

ABANDONED MINING EXPLORATION SITES IN NUNAVIK: PILOT PROJECT

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Mining sites and observers: Positioning by aerial survey and examination on foot

Legend

ABANDONED SITE (SOURCE)
MINING EXPLORATION

- × Position by examination on map (informant)
- • Position by aerial survey (observer)
- ○ Position by examination on foot (observer)
- K-14 → Site number (Appendix 2)

ACTIVE SITE (SOURCE)

- ⊡ Position by aerial survey (observer)

LIMITS

- RADARSAT satellite image – Pilot project zone
- SPOT PLA satellite image

1:250 000 Scale

5 Miles 0 5

5 Kilometers 0 5

BACKGROUND MAP PRODUCED BY THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, 1984

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K-1 K-2 K-3 K-4 K-5 K-6 K-7 K-8 K-9 K-10 K-11 K-12 K-13 K-14 K-15 K-16 K-17 K-19 K-20 K-24 K-25 K-26 K-27 K-28 K-29 K-30 K-31 K-32 K-33 K-34 K-35 K-36 K-37 K-38 K-39 K-40 K-41 K-42 K-43 K-44 K-45 K-46 K-48 K-49 K-50 K-51 K-52 K-53 K-54 K-55 K-60 K-61

Purtuniq · COLLINE DE L'AMIANTE · Rivière Deception · Lac Tendre · Lac Qanartaliup Tasinga · Lacoudray · Rivière · Kattiniq · Lac Est · Lac Long · Lac de la Tente Déchirée · Lac Raglan · Lac Merville · Lac Wakeham · Lac Félix · Lac du Bombardier · Lac Guindeau · Lac Renne · Lac Fleury · Lac Roebrune · Lac Mequillon · Lac Vaillant · Lac du Hibou · Lac Corre · Lac Vincenza · Lac Qarqaluk · Lac de l'Ours Blanc · Lac Perron · Saint-Germain · Lac Laflamme · Lac Itirvituarjuk · Lac Cournoyer · RIVIÈRE DE POVUNGNITUK · CRATÈRE DU NOUVEAU-QUÉBEC · Lac du Cratère

ADMINISTRATION RÉGIONALE KATIVIK

73°45′ 73°30′ 73°15′ 73°00′ 72°45′ 72°30′ 72°15′ · 61°45′ · 61°30′

and to have at our disposal an inventory of all abandoned sites in the whole Nunavik region — including remote sensing.[4]

2.3.1 The team

The verification of the potential of remote sensing was made possible by the involvement of the Service des applications géospatiales (SAG) of MNRQ. The involvement of the SAG took the form of the loan of resource people, authorised by Mrs. Danielle Pilon, in charge. The verification itself, however, was awarded to a sub-contractor. The sub-contractor was recruited via a call for tender put out by the GÉTIC, detailed with the aid of personnel from the SAG, namely Mrs. Seuthé and Mr. Hinse. The call was put out on January 22nd, 1999. Following the project co-ordinator's examination of all submissions, and with the help of Mrs. Seuthé, the firm MIR Télédétection Inc. was hired on February 2nd, 1999, pending approval of necessary financing for the project. Mr. Michel Rheault, president, and Mrs. Isabelle Ouellet, project leader, both specialists in remote sensing, were our principle contacts throughout the project.

Also, shortly before the submission of this research project to different organisations likely to provide funding, the GÉTIC requested and obtained the participation of Mr. Rasmus O. Rasmussen, professor of geography and specialist on Greenland, affiliated with the North Atlantic Regional Studies (NORS) research centre at the University of Roskilde, Denmark. Mr. Rasmussen has already conducted remote sensing experiments in Greenland, of which some were aimed at detecting environmental impacts of mining exploration sites. His role, similar to that of the SAG experts, was to evaluate the work done by MIR Télédétection Inc., at every version of the report. Mr. Rasmussen also attended the firm's presentation of their final report at the GÉTIC's office at Université Laval on March 2nd, 1999 (Appendix 3). Following this meeting, he evaluated the final report — see Appendix 4.

2.3.2 Verification

Remote sensing is an option that could be verified at a minimal cost following the tests carried out in the preceding methods (2.1 and 2.2): the co-ordinates and the description of the sites and the equipment provides the necessary basis, the "field truth", which permits the testing of this potential. The test in Nunavik took advantage of SPOT PLA (1997) and LANDSAT (1995) optical satellite images, as well as summer and winter RADARSAT (1999) radar satellite images. All of the images are medium-resolution, with precision of eight metres (RADARSAT), ten metres (SPOT PLA) and

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[4] Remote sensing is a technique that appeared necessary to Mr. Gérard Duhaime, project director, from the first stages of reflection: the region of Nunavik is immense and the absence of any precedents in this domain in Canada justifies a test of the potential of this process.

Photo 2 — Abandoned exploration equipment : the tracked « Muskeg » (Site #40)

Photo 3 — Current exploration equipment : pipes and cabins near Katinniq (Site #6)

thirty metres (LANDSAT). The high-resolution optical images, with precision of one to two metres, were simulated in order to know this potential, which was non-existent at the beginning of the project.[5]

The approach submitted by MIR corresponded to the criteria set out by the SAG, which took into account the goals of our project. Thus, the principle objective of the remote sensing work can be defined as follows: to attempt to establish a clear correspondence between the tested satellite data and the mining exploration equipment. In other words, the results, if positive, must allow for the identification of equipment on abandoned sites without any further field-based verification being necessary to validate the results. In sum, after the capture and the appropriate processing of satellite images of Nunavik, there should be no need to resort to aerial surveys or any other technique involving additional costs. (Photos 2 – 3)

The final report submitted by MIR Télédétection Inc. is reproduced in its entirety in Appendix 3. The work carried out and the results obtained are explained in detail in this report. The demonstration benefits from the inclusion of the reproduction of parts of different satellite images that were used. These images are compared against each other for the analysis of a small number of sites of varying sizes, including sites of a large dimension associated with the exploitation of the Katinniq mine. According to our experts' opinion, MIR's work was carried out in accordance with generally accepted rules of practice and the results are reliable (see Appendix 4).

2.3.3 Result

No medium-resolution satellite data can be associated with any piece of equipment identified during the fieldwork in pilot project's zone in July 1999. Medium-resolution, therefore, cannot recognise abandoned sites.

The high-resolution satellite data did, however, allow for the association of shapes to pieces of equipment larger than one to two square metres: buildings of different sizes and transportation equipment are easily distinguished. However, the aerial photographs used to simulate these satellite data were taken outside of the pilot zone, which excludes any possibility of furthering the analysis of a correspondence between the field data (not available) and the simulated satellite data. The availability of these field data, for example, could have led to better results concerning the recognition of small pieces of equipment such as barrels of hydrocarbons (205 litres) and pipes used for drilling, which are the pieces most frequently observed on the ground (see Appendix 3).

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[5] A satellite of this kind, IKONOS-2, was launched on September 24, 1999, during this project. It covers Nunavik. However, the breaking-in period of this satellite could take from six months to a year according to resource people at SAG.

Photo 4 — Boxes of drilling cores pilled (Site #21)

Photo 5 — Empty, rusted calcium chloride drums (100 lbs) massive pile (Site #47)

2.4 Discussion

With regard to the goal of this project, the techniques of interviews with key informants and aerial surveys allowed for the discovery and count of various pieces of equipment on the territory. These techniques were, therefore, efficient. (Photo 4)

However, we believe that several sites were missed using these two techniques. At the characterisation stage, during a walk of several kilometres that led us to the most massive abandoned site, we came across two drilling sites with large quantities of empty, rusted calcium chloride drums (100 lbs.) used for boring in the permafrost (see photograph and Map 3, sites K-60 and K-61). These sites had not been distinguished from the surrounding rocky, rust-coloured environment. In fact, it was necessary to be quite close to the site during the walk in order to notice the heap of drums — Photo 5.

In addition, some of the sites, pointed out by the informants but absent from the results of the aerial surveys, may be characterised by the presence of drums of this kind. As for the absence of these two sites among those mentioned by the informants, there are two possible explanations: (i) these sites may have been associated with the most substantial site or (ii) during the interviews, the two informants emphasised that they did not claim to know all the sites containing abandoned equipment. The first explanation seems to be the most likely, as intensive clean-up efforts took place during summer 1998, less than a kilometre away.

We will address the question of enumeration in section 3.4, which is devoted to the location of sites.

3. LOCATION

Precise geographical co-ordinates are necessary in order to provide for efficient characterisation and clean-up work, avoiding needless delays to their accomplishment. The informants' location and inscription of the sites on topographical maps of a scale of 1:50 000 on the one hand, and the use of GPS during aerial surveys on the other hand, permitted the attainment of this objective. MIR Télédétection's use of MNRQ's Système d'information géominière du Québec (SIGEOM) database led to the discovery of new data that will facilitate the inventory of Nunavik.

For both the site locations identified in the interviews and those collected in longitude and latitude during the flights, the site co-ordinates were transformed into a control system of 1000 m. UTM (Universal Transverse of Mercator), Grid 18, Datum 1927. This is a system present on topographical maps of the region, printed and distributed by the Ministry of Energy, Mines and Resources, Canada. This facilitates rapid location of the sites on the maps.

3.1 Interviews with key informants

The informants did not have any difficulty in recognising the sites on the 1:50 000 scale topographical maps when asked to indicate the location of abandoned sites. As each site was indicated and marked, the co-ordinator of the GÉTIC registered a number and wrote down the informants' comments about the characteristics of the identified site. Most of the sites were briefly described. However, the next day, during the group interview, additional comments were made about many of the sites. This information was copied down in a notebook, and later retranscribed. The co-ordinates were plotted and listed, keeping the original numbering (see Appendix 1).

The interview with the first informant, Mr. Amaamak Jaaka, allowed for the location of almost two thirds of the sites in the area targeted at this stage, an area 70 kilometres in diameter. He concentrated on the north-westerly half of the zone. The second informant, Mr. Papigatuk Sakiagak, concentrated on the south-easterly half of the target zone, in the centre of which he has a fishing camp. However, he also pointed out some other sites further to the north.

3.2 Aerial survey

The GPS system rented for this project, with precision of up to one metre, should have addressed the concern of reducing, as much as possible, the margin between the plane and the site at the moment the co-ordinates were recorded. Unfortunately, the rechargeable batteries had a very short lifespan, which impeded the achievement of this

Photo 6 — Drilling equipment and helicopter — active exploration site (Site #11)

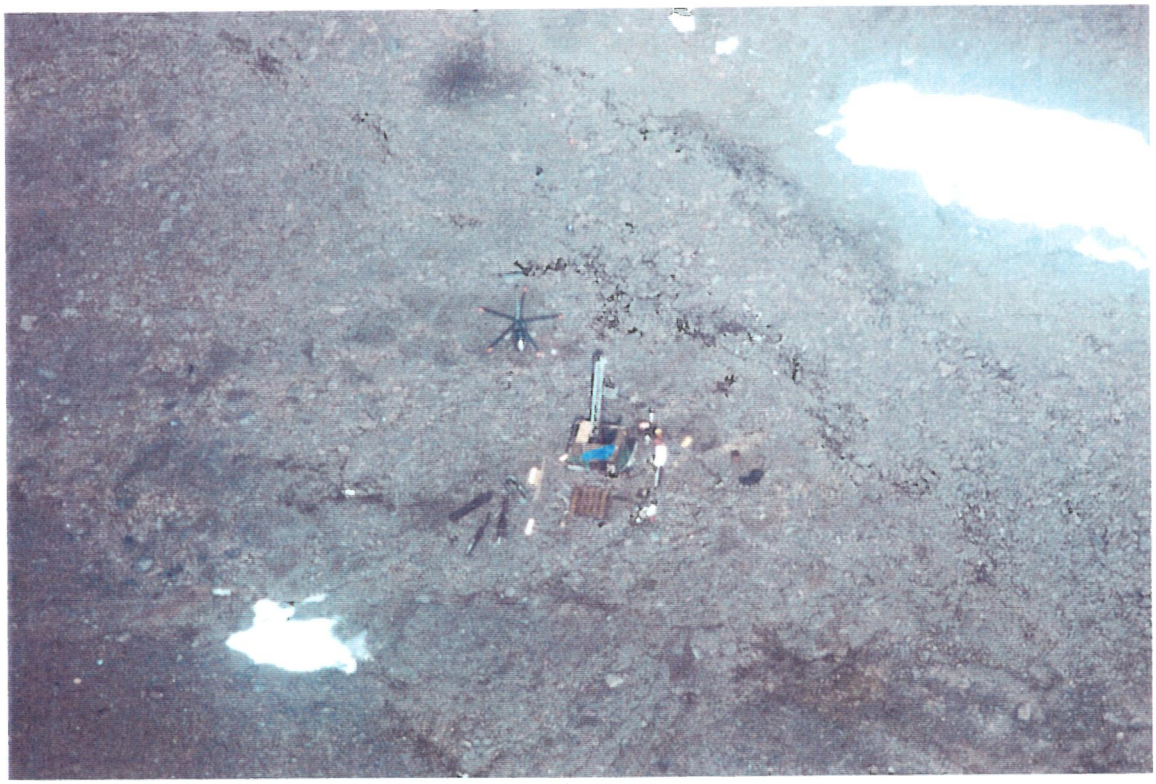

Photo 7 — Mining exploration camp — active exploration site (Site #14)

goal for all of the positions. Instead, many of the sites were recorded using the seaplane's GPS system, which was precise up to 100 metres.

As well, taking into account the difficulty of capturing the co-ordinates with the plane at a 90 degrees vertical position above the site, the recorded co-ordinates are all likely to include an undetermined margin of variation from the actual position on the ground. However, upon examination of Map 3, it is possible to see that for a given position, the margin of variation between this recording and the nearest site located in the interview is often minor, often under 550 metres.

3.3 Remote sensing

MIR planned to use the drilling locations recorded at MRNQ in its work. This approach, with the goal of establishing "[translation] correspondences that may exist between the information visible on the remote sensing data and the equipment itemised during the surveying of the ground"[6], allowed the other members of the group to better understand the potential of the Système d'information géominière du Québec (SIGEOM):

> [translation] The SIGEOM data are distributed by the Ministère des Ressources naturelles du Québec. The findings of the work undertaken on sheets SNRC 35 H/11, 35 H/12 and 35 H/6 were acquired in order to carry out this project. The SIGEOM data of sheet SNRC 35 H/5, however, were not available at the time of this study. [...]
>
> The most pertinent information contained in this database are:
>
> - Number and title of the statutory report delivered by the company;
> - Type of activity undertaken: boring, geophysics, geochemistry;
> - Year of project carried out;
> - Companies involved.
>
> MIR Télédétection Inc. 2000: 11

By using the drilling co-ordinates, MIR tested their potential to identify the mining activity zones. These zones would be used in order to delimit the acquisition of the necessary satellite data (SPOT PLA and/or LANDSAT) in order to clarify this activity before resorting to high-resolution satellite data for the same zones, in order to identify the equipment — Photos 6 - 7.[7] However, as the quote indicates, these data are not yet available for all of Quebec.

During a meeting with Mr. Robert Tremblay, environmental mining engineer with the Service du développement minier of MRNQ on January 24th, 2000, we learned of the existence of the *Catalogue des gîtes minéraux du Québec* (Avramtchev 1982a) and the *Carte des minéraux du Québec* (Avramtchev 1982b). The catalogue and the map of a scale of 1:250 000, were published in 1982. They make up a whole and are available for

[6] MIR Télédétection Inc. 2000: 10.

[7] MIR Télédétection Inc. 2000:77.

each region of Quebec, including those found in the Nunavik region. In some ways, they were the principal authorised reference available before the SIGEOM was set up: they were based on information found on the mineral deposit index cards published by the MNRQ, which are now archived.[8]

A folder is available for each region, which includes the map and the catalogue. The map provides geological and mineral information. The mineral information gives the nature, shape, size and identification of the deposits. The catalogue has two parts. The second part classifies the deposits in alphabetical order according to their mineral substances. The first part identifies the deposit's index card number (marked on the map), the township in which each deposit is found and the principle information about each deposit: name, shape, size, state and substance.

The indication of the state of the deposit provides vital information because it explains the development of the deposit in 1982; whether it was a showing (I), a prospect (P), a deposit (G), a mine (MA) or a quarry (CA) in the process of being exploited, or a closed mine (MF) or quarry (CF). The first three states are directly linked to mining exploration.[9]

Even though the showing (I) indicates only a "[translation] mineralisation which has not been the object of any work", the two others, prospect (P) and deposit (G) are so called due to the nature of the work previously conducted there: in the first case to obtain some dimensional parameters and, in the second case, to evaluate the tonnage. The three were plotted on the *Carte des gîtes et minéraux du Québec*[10] and have been meticulously replotted on Maps 4 and 5, attached.

3.4 Discussion

The co-ordinates obtained from the three sources, the key informants, the aerial surveys and the MRNQ documents on the mineral deposits in Quebec (Avramtchev 1982a, 1982b), allow for a certain comparison between the data. A "certain" comparison only, as the first two sources led to determinations of position based on the discovery of abandoned mining exploration equipment, whereas the data drawn from the MRNQ documents refers to the deposits themselves, without attention to equipment.

We believe that the determination of position carried out by the informants and by aerial survey are reliable. The examination of 11 sites for which both techniques were

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[8] Mr. Tremblay suggested this possibility when a question was raised as to the exact potential of the SIGEOM data. None of the government workers from this same ministry, with whom we met at the beginning of 1999, informed us of this source. According to Mr. Tremblay, one reason would be the restricted circulation of these documents: those who possess them consider them to be too precious to risk lending and losing.

[9] Avramtchev 1982a:1-3.

[10] Avramtchev 1982b:35-H.

MAP 4

ABANDONED MINING EXPLORATION SITES IN NUNAVIK: PILOT PROJECT

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Mining sites and ore deposits: Positioning according to Avramtchev (1982b)

Legend

ABANDONED SITE (SOURCE)

MINING EXPLORATION

- Position by examination on map (informant)
- Position by aerial survey (observer)
- Position by examination on foot (observer)

ACTIVE SITE (SOURCE)

- Position by aerial survey (observer)

ORE DEPOSITS

- Position according to Avramtchev (1982b) – see Appendix 8
- S-35H/12-15 – SHOWING – (ore deposit number): known mineralisation, without exploration work (Avramtchev 1982a)
- P-35H/11-8 – PROSPECT – (ore deposit number): exploration work – dimensional parameters (excluding evaluation of tonnage) (Avramtchev 1982a)
- D-35H/11-7 – DEPOSIT – (ore deposit number): exploration work – evaluation of tonnage (Avramtchev 1982a)

LIMITS

- RADARSAT satellite image – Pilot project zone
- SPOT PLA satellite image

1:250 000 Scale

5 Miles 0 5

5 Kilometers 0 5

BACKGROUND MAP PRODUCED BY THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, 1984

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used in order to produce the position supports this conclusion. In 60% of the cases (seven out of eleven), the distance between each of the positions varies between 150 and 400 metres. For 27%, or the majority of the remaining positions (three out of four), it varies between 400 and 500 metres. This observation leads one to believe that the other positions, whether noted by the informants or obtained by aerial survey, maintain similar proportional margins of variation in relation to the precise co-ordinates of the sites.

The precision between the two techniques can be assessed in another way due to the availability of six positions taken from the *Carte des gîtes minéralisés du Québec*. In this way, in the zone to the south of the active mining sites, where the abandoned mining sites are concentrated, the positions produced by the informants and by aerial survey are very close to those established for a mineral deposit (D-35 H/11-7) as well as for each of the five prospects. In fact, the results are that the positions closest to the prospects were obtained in the interviews in five out of six cases, with a difference varying between 100 and 800 metres. Only one position taken from the aerial surveys (K-34) presents such a result with a distance of 700 metres from the deposit (D-35 H/11-7). However, the two informants also plotted two sites not far from this deposit, 1100 metres and 1150 metres away. It is thus probable that the informants associated these two abandoned sites with the mineral deposit.

We also verified the possibility that the locations of showings were found close to the positions determined by the interviews or by aerial survey, even though that state of development of a deposit generally does not include any drilling exploration work. Among the 14 positions of showings situated to the south of the active mining sites, only two include positions which can be associated to the same number of showing, namely showings S-35 H/12-15 and S-35 H/10-1, with differences of 600 metres (I-10) and 500 metres (I-31). Among the probable explanations for the presence of abandoned equipment at these two sites is drilling work that took place later than 1982.

The enumeration of the abandoned sites thus benefited from the precision of the positions and the availability of the Carte des gîtes minéralisés du Québec, as well as from the notes gathered as each technique was applied, and from the viewing of slides taken during the aerial surveys and the examination on foot. After having examined all of these data, we established a rule for the delimitation of the sites: a site includes all pieces of equipment between which an adult can walk in under five minutes on this terrain, that is, all pieces of equipment located under 300 metres (1000 feet) from each other. This rule is based on the results of the characterisation work, see 5.2. Above this limit, we consider it to constitute a separate site. As a result, a dozen mergers of positions were made in the pilot zone, some of which join together positions established by both or only one of the two techniques. In one case, up to five positions were amalgamated in this way. Only two positions were left aside due to a procedural error in the capturing of the co-ordinates.

The *Index des sites miniers de la zone pilote* (Appendix 6) presents the sites' enumeration, the combinations of positions, the corresponding flight line numbers and a brief description of the abandoned equipment. The numbering of the sites is at times discontinuous: the same numbering of sites was presented to MIR Télédétection Inc. by the GÉTIC in September 1999, thus the absence of certain numbers reflects the new integration of positions – and of sites – during the subsequent phases.

There are now 12 active mining sites in the pilot zone and 47 abandoned mining sites, including the two sites noted during the examination on foot, see Map 5. The 47 abandoned sites can be classified in the following way, according to the technique:

- 15 determined by interviews with informants, of which
  * 2 intersect the positions taken from the *Carte des gîtes minéralisés du Québec* (showing);
- 19 determined by aerial survey;
- 2 determined by examination on foot;
- 11 determined by the combination of positions determined by interviews and by aerial survey, of which
  * 5 intersect the positions taken from the *Carte des gîtes minéralisés du Québec* (prospect and mineral deposit).

Outside of the pilot zone, close to its borders and mainly to the east, ten abandoned sites were also located, of which one (Site #68) intersects with a position taken from the *Carte des gîtes minéralisés du Québec* (showing).

4. IDENTIFICATION

The identification of abandoned sites raises the questions of who is responsible and of which year the work took place. It is necessary to identify which of the sites were abandoned prior to January 1st, 1975 and which were abandoned afterwards, as companies responsible for the state of the equipment and of the sites abandoned prior to January 1st, 1975 are not subject to any requirement to clean-up.[11] Briefly stated, the determination of the moment when the work stopped and the site was abandoned has a direct link to the determination of responsibility for future clean-up work: before 1975, the responsibility falls to the government whereas after 1975, the company must take responsibility.

4.1 Interviews with key informants

At the beginning of the interviews, the key informants were invited to identify the abandoned sites with reference to the pivotal date of January 1st, 1975, prior or afterwards. All equipment that was abandoned on the territory could be plotted and associated with a site. During the interviews, the informants spent a great deal of time examining the maps before completing their contribution.

Sites identified date back to the period before 1975.[12] The reliability of this information is confirmed in part by observations from the plane: the informants had equally rejected those sites at which some activity, or at least recent activity, was detected. Furthermore, part of the remote sensing work reinforces this observation, as we will see below.

4.2 Aerial survey

This technique does not permit one to distinguish between the earlier and later sites, before or after January 1st, 1975. At best, we were able to differentiate between the sites where there was still a certain amount of activity and those where there was none, or those which were abandoned. It is also necessary to mention that clean-up work undertaken by the community of Kangiqsujuaq changes the appearance of the abandoned sites: the equipment is put in order and the debris is gathered together in stacks, which gives the appearance of certain maintenance efforts, at the very least. Upon completion of the flight lines, there was no cause to doubt that the sites identified by the informants all dated back to the period prior to 1975.

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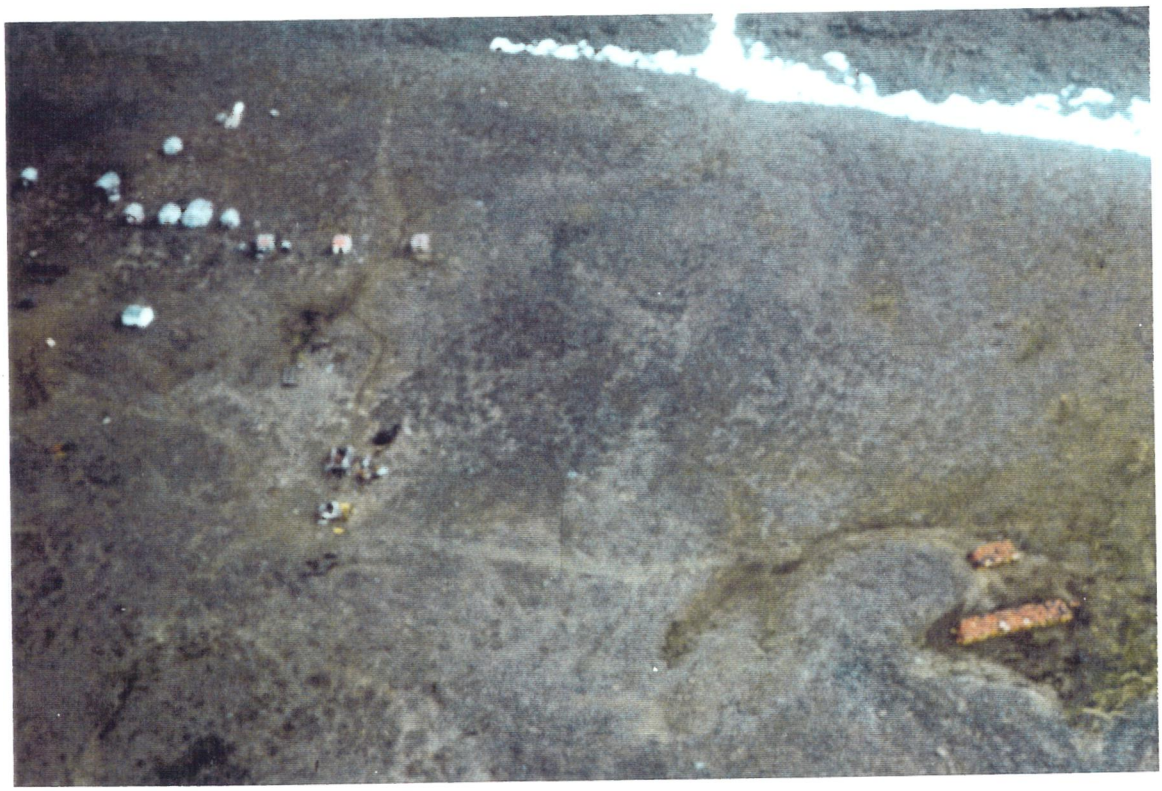
[11] Lepage, H., Barrett, M., 1998:1.

[12] According to the key informants, in one case (Site #68), the abandoned site was a geologists' camp dating prior to 1950.

Photo 8 — Raglan Mine camp — active exploration site (Site #3)

Photo 9 — Expo Ungava Mines camp — abandoned exploration site(Site #25)



4.3 Remote sensing

As mentioned (3.3), part of the remote sensing project brought attention to the drilling points recorded at MRNQ. Based on the data available in the SIGEOM data bank, MIR Télédétection produced a database including the following characteristics[13]:

- Mining company involved;
- Identification number of work carried out;
- Year work was carried out;
- Type of mining activity (drilling, geochemistry, geophysics);
- Volume of mining activity carried out.

MIR's analysis of these data[14] "[translation] shows, first of all, that the mining activity in the study area was carried out by approximately twenty mining companies operating alone or as a group and that this mining activity has been going on since the mid 1950's." In the pilot zone, according to MIR, the "[translation] greatest volume of mining activity was taken up by five groups":

- Falconbridge and its subsidiary company, Raglan (1957 to 1995) — Photo 8;
- Expo Ungava Mines (1958 to 1972) — Photo 9;
- Amax Exploration (1969 to 1970);
- Bilson Quebec Mines (1962 to 1966);
- Asarco Nickel (1957 to 1958).

In every case, the activity is mainly associated with boring. MIR drew up an illustration based on the years the plotted drillings took place. This illustration shows the cycles of activity between 1957 and 1995 (Appendix 3: Figure 11): the late 1960's is by far the most active period, followed by a period in the late 1950's, and by two less significant periods at the beginning of the last two decades (1980 and 1990). In all, 1358 drillings took place in the pilot zone during this period, "[translation] Some relying on geophysical anomalies and sometimes subject to a geochemical analysis": 180 drillings with geophysical extractions were carried out in the northern zone where the active mining sites were identified, and ten (10) drillings with geochemical analyses were carried out in the centre of the pilot zone, the area in which the most substantial abandoned mining exploration sites are concentrated. The company Expo Ungava Mines carried out the latter drillings.[15] This company ceased its drilling activity in 1972.

There is a good chance that the products of concentrated acids abandoned at the most massive abandoned site date back to this period and that the situation is attributable to this company. However, according to MIR, these drilling data cannot permit one to

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[13] MIR Télédétection Inc. 2000: 24 (Appendix 3).

[14] MIR Télédétection Inc. 2000: 26-27 (Appendix 3).

[15] MIR Télédétection Inc. 2000: 25 (Appendix 3).

Photo 10 — 1999 Nunavik Rangers' camp in Wakeham Bay; abandoned site, white tents.

Photo 11 — Drilling equipment on site — active exploration site (Site #4)

"[translation] testify to the responsibility of a specific mining company for the abandoned equipment":

> [translation] For example, 14 drillings were carried out between 1970 and 1981 within a radius of 1.5 km. around site 29. Three different companies or groups of companies carried out this work. It is not easy to establish that any one of these companies is responsible. In the same way, no drilling took place within a radius of 1.5 km. around site 43, which does not allow one to link any company to the abandoned equipment.
>
> MIR Télédétection 2000: 30

As it is, among the drilling data contained in SIGEOM, the year allows for the determination of the period to which they belong. Although it may not establish the responsibility of one or more companies for the abandoned sites identified by one technique or another, this capacity makes it possible, as of now, to more clearly address the impact of the problem to the governmental organisations concerned.

4.4 Discussion

The sites marked on the maps by the informants are identified on the basis of the depth of the informants' knowledge of the territory, and the history associated with recent transformations, including those caused by the mining industry, which has had a strong presence in the region of the Ungava trough since 1957. This could be based on the informants' own participation in this work, or on that of their close relatives. Indeed, even if the exploration companies were not open to visitors passing by the camp, members of the Inuit community were often members of the work teams. Specialised journals in mining such as "The Northern Miner" rarely missed an opportunity to mention these Inuit members in their reports conducted on the territory and especially to display the Inuit participation in photographs supporting the text. Thus, our principal informants, both elders, were able to attest to, and identify, sites from the earliest period based on first-hand information — Photo 10.

Although aerial surveying is inefficient for establishing the period to which equipment left behind may belong, it does allow observers to determine that the sites found within the corridor of the network of roads linking Douglas Harbour to Deception Bay are not abandoned — Photo 11. Even where there was no recent activity, the site was generally free of the debris and scattered equipment that are characteristic of abandoned sites. To a certain degree, then, aerial surveying does allow for the discovery of sites that have been used after 1975.

Remote sensing, by means of the drilling data found in SIGEOM, thus produced analyses that turn out to be pertinent in establishing the year, the companies and the types of drilling. MIR's hypothesis with regard to favouring the satellite data was the following:

> The density of the drilling carried out on the territory is certainly indicative of the magnitude of the mining activity. As such, the probability of observing mining equipment is likely greater if the density of the drilling is high.
>
> MIR Télédétection 2000: 30

Even if MIR's reservations about the pertinence of the SIGEOM data for establishing ownership of the equipment are appropriate, it must also be considered that the dispersion of the drilling sites on the territory makes it difficult to locate the centre; the camp of the exploration sites which succeeded one another throughout the years for any given mineral deposit. Finding a concentration of drilling sites with SIGEOM, presumably with a camp in the middle or nearby, would make another kind of work necessary, that of processing computerised data. However, this would entail both time and availability of data for the entire territory, which was not the case for the pilot zone.

The *Catalogue* and the *Carte des gîtes minéraux du Québec* (Avramtchev 1982a, 1982b) make it possible to circumvent this difficulty as they contain information about the progression of the work at the beginning of the 1980's (1982), with a recording of the deposit in the territorial space. To this is added a number, which is associated with an index card that provides an up-to-date description of the development of the work. We believe that this source may be advantageous and worth exploring further in order to perhaps achieve the desired objectives of creating an inventory as quickly as possible.

5. CHARACTERISATION

The characterisation of abandoned mining exploration sites taps into various sources that were solicited during the fieldwork carried out in Nunavik. In order to grasp better the significance of this stage, it is useful to agree upon the definition of the term "characterisation".

> [translation] The ultimate objective of any characterisation study is to determine the presence and the degree of contamination of the environment (water-air-soil). Comparing the results of the analysis with known norms and criteria, it is also possible to evaluate the impacts of the contamination on the environment and the potential risk that the soil poses to human health.
>
> A characterisation study can also be conducted in order to know the face contents (natural contents) of the ground before implementing a new industrial activity or in order to know the quality of the land, either before a settlement or reuse of the land, or at the time of cessation of a company's activities.
>
> Anderson 1999: 1

The characterisation work undertaken in the framework of this project consisted of (i) a review of existing information and (ii) a preliminary, or exploratory, characterisation aiming at confirming the presence or the absence of contaminants and to determine their type. The exhaustive characterisation, which aims at establishing the boundaries of the contamination with greater certainty, was left out of the pilot project: this stage is undertaken upon the confirmation of the presence of contaminants.

In general, the review of the existing information aims to give a historical background of the land and the activities that took place upon it.

> [translation] The objective of this phase is to familiarise oneself with the site and to define the problem regarding the ground based on the available data. In the case that the data from the first stage provide sufficient indication to suspect the presence of contamination, then phase two — preliminary characterisation — must be commenced.
>
> Anderson 1999: 2

Information transmitted by the Kativik Regional Government (KRG) at the beginning of 1999 is at the source of the decision to include characterisation in the pilot project. Indeed, during the work aimed at determining the pertinence and the objectives of a project to inventory the abandoned mining exploration sites, the KRG personnel who are responsible for environmental files allowed us to view a video document produced by their communication department and local partners.

Photo 12 — Site #25 seen from west; presumed fireplaces (turned black soil) (Site #25)

Photo 13 — Part of the chemicals of the easternmost cabin (Site #25)

The document, dated back to 1997, reviews a number of the abandoned sites in Nunavik. The village of Killiniq, weather stations and abandoned mining exploration sites are brought to the screen in this way. At that time, according to the images, only the village of Killiniq was undergoing clean-up efforts. The other sites are situated either near the villages, or at the western boundaries of the territory visited by the members of the community of Kangiqsujuaq.

In fact, in Kangiqsujuaq, the abandoned sites linked to mining exploration lie around the village's surroundings, that is to say from several kilometres to the south-west, on the banks of Wakeham Bay, to the limits of the land visited by the community, more than 100 kilometres to the west. A large part of the report was dedicated to the most westerly sites. There, one discovers relatively substantial abandoned sites with camps consisting of six to twelve cabins, depending on the site, which are still standing, as well as drilling and transportation equipment and drums, left behind with no prospect of future use and certainly with no concern as to their visual impact: in disarray and not having been put in order, they are in the middle of wooden and iron debris that has been scattered by years of abandonment to the elements, notably the wind, which is a particularly powerful element in this part of Nunavik.

At the largest site (Site #25), a technician interviewed on site testified as to the work in which he participated in the early 1970's. Employed at that time by a sub-contractor to the exploration company, he spoke of chemicals abandoned on the site, which are used for processing and analysing samples taken from the drilling: essentially concentrated acids, all of which are still stored in one of the cabins. However, the interior of the small building is in such disorder that it is not possible to distinguish the quantities and the different potential chemicals, apart from the acids identified by the technician at the time the report was made. (Photos 12 – 13)

The information contained in the document was sufficient to foresee and prepare a preliminary characterisation of the sites within the framework of the pilot project. The method employed for the preliminary characterisation is detailed in the report made by the chemist, David Bisson, available in Appendix 9. The results are detailed in section 5.4. His participation, initially planned for at least ten sites, was finally limited to two, Sites #25 and #40; a change caused by the last-minute cancellation of the helicopter's availability. At short notice, the seaplane was once again put to use by the team, as well as walking. The breadth of sites #25 and #40, as well as the statements that the key informants made about them, justified this choice. These sites were visited on July 20th and 21st 1999.

At this stage in the project, as at the other stages, we took advantage of every occasion to gain more information about the sites and their state of abandonment. This information is provided below, according to the contribution provided by each of the techniques employed. It is followed by a summary of the contribution of the chemist

Photo 14 — Camp section; cabins recycled as fishing camp; « Muskeg » tracks (Site #40)

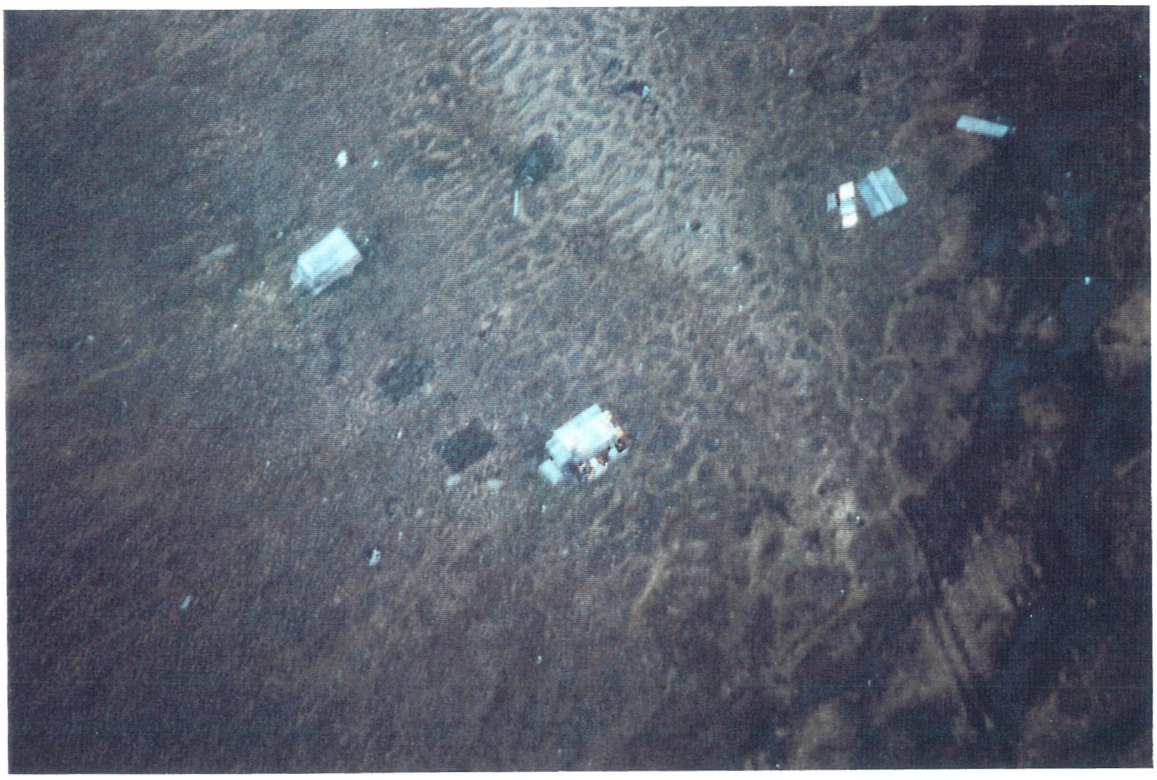

Photo 15 — Airplane cabin and wing, gas tanks, at Lac Vaillant (Site #40)

specialising in dangerous goods. The results are followed by a general overview of the other abandoned sites in the pilot zone, as closing to section 5.

5.1 Interviews with key informants

The informants had little to say about the sites. They had both previously made several statements on this topic. Their comments about the equipment left on the sites that they had identified were brief. Two elements are mentioned more frequently than the others, the chemicals and the barrels of petroleum products.

The abandoned sites with chemical products are identified first: the first five positions are those where such products are still on site (Map 2) — we further combine position I-2 and position I-3 into Site #23 (Map 5). After, there is no particular order to the numbering and the description of the sites. Furthermore, the informants mentioned the presence of unsecured chemical products at Sites #23 (positions I-2 and I-3) and #29 (positions I-4 and I-5) to justify the absence of clean up work at these sites up until now. It is also necessary to presume that, given the scope of the clean-up work carried out in 1998, Site #25 was then judged secure, the chemical products there being all (?) grouped together in a closed cabin.

Site #40 at Lac Vaillant (positions I-15, I-16 and I-18) is the object of the informants' request: if there are water-quality tests, it is necessary to verify the quality of the lake where the containers of toxic chemicals have presumably leaked. This site was differentiated from the others before the clean-up work by the presence of petroleum barrels along the banks, of which several were soaking in the water. It has another particularity: the informants brought up the discovery of dead foxes on the site of the cabins where the food for the personnel was stored — food that the foxes presumably consumed. In 1998, the clean-up work at this site included the destruction by fire of these cabins and stocks of food. This episode was regularly brought up during our stay by several people, once they learned of the reason for our presence in the village.

The 205 litre (45 gallons) barrels of petroleum are present at almost all the sites. The informants mention them, but rarely dwell on their number. The number of barrels at Sites #25 and #60 are specified, with "several hundred" and "two dozen", respectively.

The presence of cabins at the camps, "Muskeg" tracked vehicles, propane tanks and high metallic tripods, used for lifting the drilling pipes, that have been left in place are the principle elements explained in detail in the descriptions. The drilling pipes and the rubber hoses are also mentioned. (Photos 14 – 15)

In the course of the interviews, they asked the Corporation's personnel to find, and permit us to view, available video documents, so that we could judge for ourselves the condition of several sites which had been subject to clean-up efforts over the preceding year, before, during and after. KRG's video document was the first document suggested

Photo 16 — Abandoned site at noon : few barrels and equipment (Site #41)

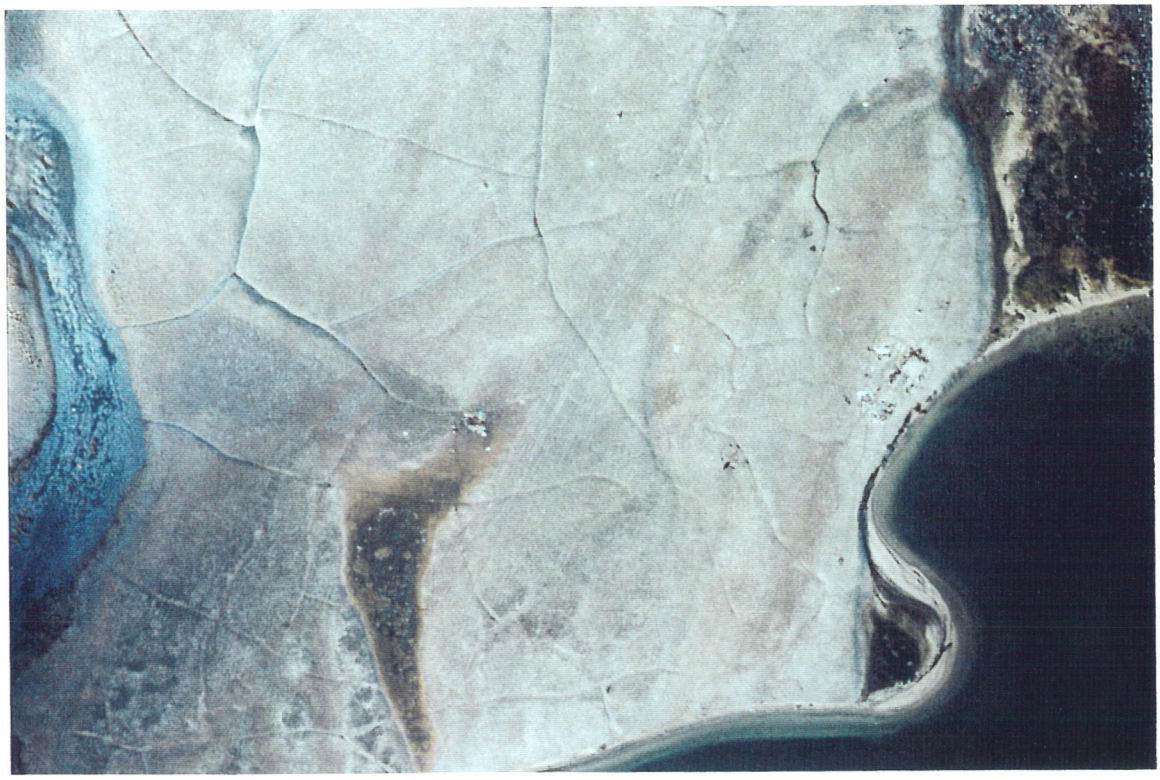

Photo 17 — Abandoned site at sunset : barrels scattered throughout the beach (Site #41)

to us. It was followed by a video-cassette recorded by one of the informants at the time of clean-up of Sites #25, the largest, and #40, situated at Lac Vaillant.

5.2 Aerial survey

The survey retraced several abandoned sites that had been identified by the key informants and also permitted the discovery of new ones. Flying over, the presence of equipment automatically led to the plotting of the sites, but the description of the elements remained brief. In fact, several of the sites that were retraced contained few pieces of equipment, often barrels and/or drilling pipes. At other sites, the diversity surprised the observers, who did not make out some of the equipment, either because of the colour and/or the small size or else because of the observers' lack of familiarity with the elements that make up a drilling site — Photos 16 - 17. There are the examples of Sites #46 and #47, where the heaps of rusted barrels of brine, used for boring in the permafrost, escaped observation: they were located July 21st during the walk to Site #25, where, otherwise, they were taken for a dumping ground for Site #26, the correction was made upon viewing of the photographs.

It is really upon examination of the photographs, developed as slides, that we came to know the detailed characteristics of each site. In order to recognise the elements and pieces that make up the equipment of a drilling site, we regularly consulted the book by J.D. Cumming and P. Wicklund, from Ontario, *Diamond Drill Handbook*, published in 1956. A description of the elements observed in each photograph, for each site, is available in Appendix 7 – the *Index des sites miniers de la zone pilote* (Appendix 6) guides the researcher to each of the photographs of a site numbered on Map 5. The photography carried out at each site permitted, at the same time, the correction of erroneous initial observations or a lack of detail in the description of certain sites. Moreover, the analysis benefited from the possibility of enlargement, to validate their classification by site, or their reclassification, in the case of photographs mistakenly attributed to another site, for reasons explained in section 2.2.

The regrouping of positions achieved through aerial survey generally relies on the results of this viewing, on the one hand, and the key informants' description, on the other hand. Remember that the sites could be flown over more than once, due to the rule adopted by the team: it sufficed for any one of the observers to express reservations about a site – as to the question "already flown over or not?" – for the pilot to head over in order to complete a new plotting with a description and photos.

It was in the course of these viewing sessions that we decided to establish a rule for the spatial delimitation of the site. Already, after having watched the videocassettes that had been made available upon the request of our key informants, we had learned of the presence of debris spread over long distances at certain sites, compared to others — before knowing, also, the types of drilling campaigns, either (i) with evaluation of

Photo 18 — Debris scattered with oil drums, a cabin and drilling equipment (Site #23)

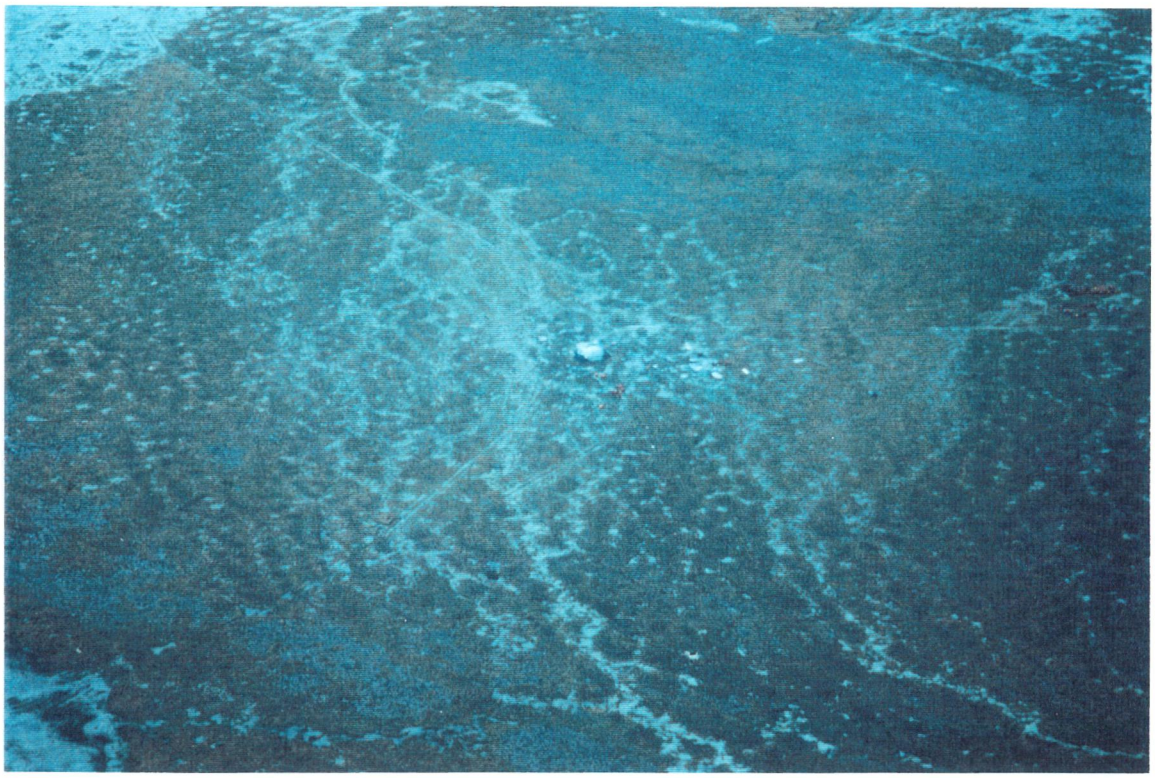

Photo 19 — Overlook of Site #25 from northern side with trails used (Site #25)

tonnage (spread out in the area) or (ii) without evaluation of tonnage (more localised). The state of the ground at the time of the thaw, as well as the clear visibility of the tracks made with tracked vehicles, permitted us to clarify this rule.

First of all, we are sure that, unless forced to walk, the workers at these drilling sites used these vehicles regularly to get around, including snowmobiles later on. The nature of the ground that we walked on during our hike to Site #25 was a conclusive experience: it took the team 3 hours on foot (one way) to cover the 10 kilometres between the site and Lac du Bombardier, the closest spot that the pilot found to let us off. The ground has practically no trees, little vegetation, with the exception of grassy strips surrounding the puddles of water during the thaw, but is dominated by large, rocky blocks at the slightest elevation: thus, walking there, one is constantly off-balance, practically jumping continuously from one block to the other.

In summary, at a distance of one kilometre and less, the count of nearby sites systematically underwent an examination of the elements based on the following definition: the delimitation of a given site includes all pieces of equipment between which an adult can walk in under five minutes on this terrain; that is, all pieces of equipment located under 300 metres (1000 feet) from each other. Pieces of equipment located at a greater distance are considered to be part of a separate site.

The photographs taken during the locations in question were scrutinised in order to identify the layout of the elements, the distance between each one and, in the cases where they located the same elements (according to the definition above), the positions were integrated into one site, with one number — see *Index des sites miniers de la zone pilote* (Appendix 6). The debris making up the string of elements along a given path were, in this way, integrated into one site — Photo 18. Site #25, even after its clean-up in 1998, covers an area almost 500 metres long and 300 metres wide — Photo 19. For this reason, in the count of the sites, the rule of the distance on the basis of geographical co-ordinates was only applied systematically when several kms. separated two positions (Map 5).

Thus, the elements combined in the photographs permit the beginning of a preliminary characterisation of the sites, providing the dimensions, which allow one to detail with more certainty the elements of equipment. However, it is impossible to determine whether or not contaminants are present without actually visiting the sites.

5.3 Remote sensing

The medium-resolution satellite data were not able to identify abandoned mining sites. To this end, in the course of the preliminary characterisation, a series of GPS positions and photographs of different elements present at Sites #25 and #40 were produced in order to verify the RADARSAT and SPOT PLA images, but in vain. All the same, the simulation of high-resolution images similar to those soon to be produced by

the IKONOS satellite, and the possibilities of the SPOT PLA and LANDSAT satellites are worth mentioning.

The high-resolution images can certainly replace the photographs taken during the aerial surveys: elements of the examined sites that are larger than two square metres have distinct lines, even if they are unknown. A test for the focus on elements one to two square metres would be advantageous in order to establish the potential of the IKONOS satellite without any doubt. But, even if this test is successful, each of the shots must hit the sought after targets in order for them to be considered as an option: their price is high, even without taking into account that the images must be processed in order to achieve the desired outcome from the acquired data.

The characterisation capacities of the SPOT PLA and LANDSAT medium-resolution satellites are good when their images are combined. Together, they can help to locate the impacts of exploration activity on the landscape, providing, in this way, an initial assessment of their effect. An example is grass crushed by the passage of tracked vehicles. Based on these zones of activity, and drilling concentrations, MIR proposes to proceed to capturing high-resolution images: the elements of abandoned sites are potentially in the middle of the zones. However, they cannot replace preliminary characterisation of the sites, which requires visitation of the site.

5.4 Preliminary characterisation

The characterisation carried out by the chemist, Mr. Bisson, concentrated mainly on the ground of the targeted sites, Sites #25 and #40, the last situated at Lac Vaillant.

On the basis of information gathered during the preceding stages, three potential contaminants were originally considered, petroleum products, concentrated acids and calcium chloride. However, taking into account the high chances that the potential contamination dates back to the abandonment of the sites, that is to say, more than 25 years, the petroleum products are the main possibility.

> [translation] The migration of contaminants is an important element of ground characterisation. The ground is clayey and composed of many rocks and stones. Also, due to the northern climate, the ground is permanently frozen, except in summer, and then only the top 30 centimetres thaw.
>
> One must also consider that the potential contamination took place more than 25 years ago. The light hydrocarbons (volatile) migrated easily, either by air or through the ground (water). It would, therefore, be surprising if one could find these contaminants. The heavy hydrocarbons, however, are more likely to be found in the ground being studied. As they are more hydrophobic, they do not have the same probability of being washed off by precipitation. Furthermore, as the ground is permanently frozen, the contaminants would tend to stay in one place, at very least the migration of the contaminants would be slowed down. For these reasons, we only consider the petroleum products, organic products with straight-chain carbons, in the analysis of ground contaminants.
>
> Bisson 1999: 4

MAP 5

ABANDONED MINING EXPLORATION SITES IN NUNAVIK : PILOT PROJECT

Abandoned and active mining sites

Legend

ABANDONED SITE (SOURCE)

MINING EXPLORATION

- Position by examination on map (informant)
- Position by aerial survey (observer)
- Position by examination on foot (observer)
- Joint position (informant + observer)
- 14 → Site number (Appendix 6)

ACTIVE SITE (SOURCE)

MINING EXPLOITATION

- Position by aerial survey (observer)

MINING EXPLORATION

- Position by aerial survey (observer)

ORE DEPOSITS

- Position according to Avramtchev (1982b) – see Appendix 8
- S-35H/12-15 – SHOWING – (ore deposit number) : known mineralisation, without exploration work (Avramtchev 1982a)
- P-35H/11-8 – PROSPECT – (ore deposit number) : exploration work – dimensional parameters (excluding evaluation of tonnage) (Avramtchev 1982a)
- D-35H/11-7 – DEPOSIT – (ore deposit number) : exploration work – evaluation of tonnage (Avramtchev 1982a)

LIMITS

- RADARSAT satellite image – Pilot project zone
- SPOT PLA satellite image

1 : 250 000 Scale

5 Miles 0 5

5 Kilometers 0 5

GETIC UNIVERSITÉ LAVAL

BACKGROUND MAP PRODUCED BY THE SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES, 1984

Due to the possibility that the ground at mining exploration sites may be contaminated by petroleum products, a characterisation of the ground was done. It consisted "[translation] principally of collecting some samples of the soil and water from the targeted area in order to analyse their straight-chain hydrocarbonic content." The sampling was targeted and the majority of the samples are composite. The samples were taken in places suspected to contain contaminants — a targeted sampling. These samples were composed of several individual samples, which were combined in equal proportions, in order to have an average concentration of the contamination in the sampled zone — a composite sample —, or taken at a specific place — a unique sample. (Bisson 1999: 5)

The chemist, Bisson's report is available in Appendix 9. It includes the description of Sites #25 and #40, the results of the chemical analysis and the detailed evaluation of the risk to human health. Diagrams and photographs of the characterised sites accompany the report. The following text presents an overview of this report.

5.4.1 Site #40

This site is divided into two centres of attention (positions K-49 and K-51). To the north (K-49)[16], it is actually made up of remaining housing facilities for the mining exploration company's personnel, less than 100 metres from the bank of Lac Vaillant. The ground is covered with grass along the bank and around the cabins. A part of the facilities were destroyed or gathered together in piles at a good distance during the clean-up efforts in 1998. Two of the remaining cabins, with heating equipment and five diesel fuel drums (each with a capacity of 205 litres), are used by Mr. Amaamak Jaaka, key informant for the pilot project, during his fishing trips to the area. Some empty propane tanks lie in the background, behind one of the cabins. The principal potential source is the diesel fuel contained in the drums. The ground samples were taken near the drums (3 samples), the tanks (1 sample) and around the main cabin (1 sample). Also, a sample of run-off water was taken in front of the second cabin.

To the south (K-51), one finds the principal area where the equipment was abandoned. It surrounds a small bay, favourable for disembarkation from the seaplane. Five sections, of which three are made up of piles of debris from the clean up in 1998, stand out during the flight over the site. The two others (Sections A and B) are in the immediate environment of the bay where the ground, made up of black earth covered with grass and hay, is disturbed by the repeated passage of tracked vehicles; it is also

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[16] The site was mistakenly identified as K-39 in the chemist's report during the visit to the sites. The site is in fact the one corresponding to position K-49, integrated into Site #40.

Photo 20 — Place where the drums were stacked at Lac Vaillant (Site #40)

Photo 21 — Drums and gas tanks piled during the 1998 clean-up (Site #40)

there that the drums were located before being moved. Three ground samples and one water sample were taken at this place. (Photo 20 – 21)

The places where the drums were stacked (Sections C and D) are further away from the bank, facing the bay. A pile measuring ten metres by seven metres (C) contains 60 empty fuel drums (205 litres), some welding gas tanks, more than a dozen propane tanks and, fewer in number, pieces of mining exploration equipment such as screens, wooden and metallic beams, and so on. A composite ground sample was taken (at the four sides of the pile). Another heap, measuring five metres by five metres (D) had 43 empty drums (205 litres) of petroleum products as well as some kitchen appliances (refrigerator, propane stove) — a composite ground sample was taken (at the four sides of the pile).

The site where the dead foxes were found (E) was also the object of a composite sample collection. The cabin was burned on the spot in 1998 and all that is left are some rusted tins of food. A sample of run-off water was also taken approximately ten metres from the site.

The samples from Site #40 submitted for analysis were limited to those taken in the southern part of the site (K-51). The results of the analysis of both the water and the ground samples were negative.[17]

5.4.2 Site #25

This is the largest abandoned site in the pilot project zone. The characterisation was carried out over a period of less than two hours, due to the constraints of limited seaplane availability and the ten kilometres separating the landing site from the actual site, which was covered on foot. The perimeter corresponds to a 500 metre (east-west) by 300 metre (north-south) rectangle[18]. To the south, its boundary is marked by the bottom of a hill, at the foot of which full (18) and empty (16) propane tanks are piled up on their sides. To the west, two large heaps of barrels (205 litres) dominate the landscape. To the north two temporary garages and two "Muskeg" tracked vehicles stand out in the middle of disorderly heaped up metallic and mechanical rubbish from drilling equipment. To the east, the laboratory containing chemical products marks the boundary with, opposite, a mobile workshop set-up on a tracked trailer (three metres by three metres) — with a table and bench for examining drilling cores.

This space is divided in two in the centre by a row of nine cabins of the same size (five metres by four metres) with doors opening to the north, with the exception of one,

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[17] The samples subject to the analysis are numbered SK51-A (water sample), SK31-B, SK51-F and SK51-G (where the arctic foxes died) — the last three are all ground samples. A copy of the document outlining the results of the ground and water analyses carried out by Laboratoire de génie sanitaire du Québec inc. (1986) is available in Appendix 10.

[18] Figure 6 in D. Bisson's report (Appendix 9 — Bisson 1999:17) is inaccurate in the identification of the cardinal points: the marked points must by inverted in order to have the real orientation.

Photo 22 — Garage containing a « Muskeg »; scattered pile of equipment aside (Site #25)

Photo 23 — Part of the chemicals of the easternmost cabin (Site #25)

slightly larger, turreted cabin, situated near the centre. The row is oriented east to west. Facing the largest cabin, there are two other cabins apart from the row, one 20 metres to the south and another one 25 metres to the north. Across this perimeter, one can observe other piles and burning areas, resulting from the clean up efforts in 1998.

The two garages are filled with equipment; one contains a tracked vehicle and the other contains different mechanical maintenance equipment — Photo 22. The cabins, as a general rule, are empty or contain only non-toxic elements such as bits of scrap iron, mattresses, drilling cores, and so on, with the exception of the cabin situated to the far east of the site, which contains chemical products — Photos 23.

This cabin was very likely a laboratory, as it holds two hoods as well as a work counter. The bottles of chemicals are almost all situated in the hoods and accessible. "[translation] Many of the containers are intact and the majority are filled to capacity". These chemicals are the following:

Name of chemical	Number of containers			Total volume of chemical
	Full	Empty	Broken	Litre
Hydrofluoric acid	39	2	0	19,5
Nitric acid	4	4	2	10,0
Hydrochloric acid	5	0	0	12,5
Sulphuric acid	11	0	0	27,5
Hydrobromic acid	8	0	0	1,6
Boric acid	1	0	0	4,0
Methanol	1	0	0	20,0

The chemists' evaluation of these chemicals is as follows:

> [translation] The majority of the chemicals are hazardous concentrated mineral acids. The concentrated mineral acids are all very corrosive and most of them are toxic. The handling of these chemicals would be dangerous for any person without adequate training. One of the chemicals, hydrofluoric acid, is extremely hazardous and toxic.
>
> Bisson 1999: 18

This cabin is easily accessible to anyone as the door is only held closed by a nail, which was put back in place after every visit.

The piles on the sites are almost all the result of clean-up efforts in 1998. The largest piles are those with the barrels (205 litres), situated in the west, with 705 and 305 barrels, respectively, lying on their side, in two rows, on flat, trodden ground. Next, in order, one comes across a scattered pile of drilling equipment rubbish on the western side of one of the garages: some barrels of varying sizes, wooden beams, wheels, high metallic shelving with drilling pipes, black rubber hoses and other, unknown pieces. To the north-east of the site, where it is less crowded, there is a large metallic reservoir (four metres by one metre) and, nearby, barrels placed in a square and a dozen drilling pipes,

Photo 24 — Dump used by people based at Site #25; one kilometer south (Site #53)

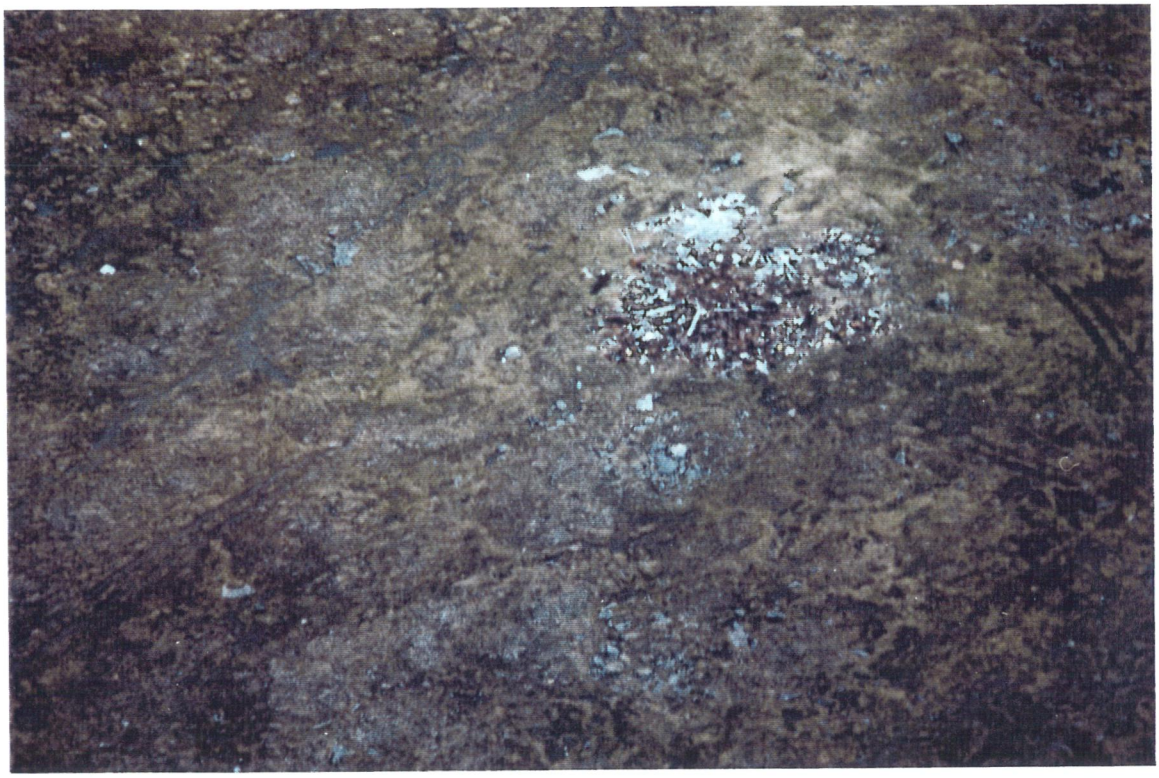

Photo 25 — « Muskeg » and « Ski-doo » nearby a garage; drilling pipe (Site #25)

which have been put in order. One large pile dates back more than 25 years: it is boxes of drilling cores, forming piles measuring one cubic metre each and grouped together by tens under tarpaulins, found to the south of the most southerly cabin.

A striking component of this site is the marks created by the passage of tracked vehicles and the use of other equipment. Indeed, the two garages are at the intersection of two paths, oriented east-west and north-south, which can be observed from high in the air. For the time being, we do not know all the destinations. However, to the east, where we walked, the dominant activities were drilling work and provision of supplies from Lac du Bombardier, accessible by seaplane. The path to the south, which crossed the hill, leads to the camp dump, situated more than a kilometre away, with a mess of debris in the middle of a burning area approximately 20 metres in diameter — Photo 24. With the use of the equipment, it concerns old burning areas which are noticeable along the path oriented east-west, near the metallic reservoir. Nearby, some barrels of calcium chloride are gathered together.

At least two large burning areas darken the ground surrounding the garages — Photo 25. One of these is associated with the 1998 clean-up, when the scrap wood and other materials, such as mattresses, which were spread out on the site were gathered together and burned. The other is near two large beams placed on top of a slope, as if for placing vehicles in order to examine their undersides.

Five samples were taken at Site #25, just outside the cabin: two samples of run-off water and three composite samples of the ground. The samples from Site #25 that were submitted for analysis are the three ground samples. The results of the analysis are judged to be negative.[19]

> [translation] The results clearly show the absence or very weak concentration of heavy hydrocarbons, as they are below the detection limits of the method used. The analysed samples give a general idea of the state of the soil at these sites. In light of these results, contamination of the soil by petroleum products is very unlikely.
>
> Bisson 1999: 20

Furthermore, according to Bisson, "[translation] Of all the inspected elements, the most important one from the point of view of the risk to human health is the cabin containing the chemicals"[20], located at Site #25. Likewise, he estimates that the gas cylinders also present a certain risk: the "[translation] hazards associated with the gas cylinders result not only from the nature of the chemical compounds found in the

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[19] The analysis of samples from Site #25 and #40 "was carried out, applying a process called "test C10-C50", which corresponds to the analysis of hydrocarbons. This test allows for the identification of heavy hydrocarbon content, caused by petroleum products. As this was the most probable contaminant, no other analysis was carried out. The samples were conserved, in case of future analyses." (Bisson 1999: 20)

[20] Bisson 1999

Photo 26 — Gas tanks piled aside an airplane cabin (Site #40)

Photo 27 — Tent platform with oil barrels nearby a lake (Site #35)

cylinders but also from the fact that they are contained in very heavy bottles and, at times, at very high pressure — Photo 26. A visual assessment of the valves determined that they were in good to medium condition." (Bisson 1999:22-23). His recommendations are the following:

> [translation] The chemicals found at site K-31 represent a real risk to human health. All attention should be focussed on this site. As these chemical products may be harmful and hazardous to human health, it is very important that they be treated and eliminated. The elimination of these chemicals must be done by qualified people. The different concerned authorities should be made aware of the results of the present report as soon as possible.
>
> Bisson 1999: 23

In Kuujjuaq, on the way home, Bisson informed ARK's general manager of his recommendations, before writing a preliminary report following his return to Quebec on July 27th, which was forwarded to the president of ARK by the director of the GÉTIC.

5.4.3 Other abandoned mining exploration sites

In order to have a general idea of the characteristics of the other sites, if is necessary to consider the data from the aerial survey. After examining the data, MIR, a company specialising in remote sensing and geology, assessed the pilot zone's situation as follows:

> [translation] (...) the mining activity carried out on the territory complies with the evaluation of the mineral potential, the choice of exploration methods used, and the required physiographic considerations for cost optimisation. As such, the equipment installed on the exploration sites is generally located according to planned operations. The mining camps are located on flat ground, generally sheltered from the wind, sometimes near stretches of water in order to favour the provision of supplies by seaplane. The barrels of hydrocarbons are sometimes located near these stretches of water or near used equipment. As for the exploration equipment, it is generally located near the site where the actual exploration activity was carried out. It is often associated to the construction of secondary roads or paths and can be observed on both bare and vegetation-covered zones.
>
> MIR Télédétection 2000: 22

In view of the planned tests, to systematise the identification of elements of equipment on the remote sensing data, the information about the sites located by means of aerial survey were regrouped into three categories, which were established according to their likelihood of being identified by remote sensing — Photo 27. In brief, these categories are the following:[21]

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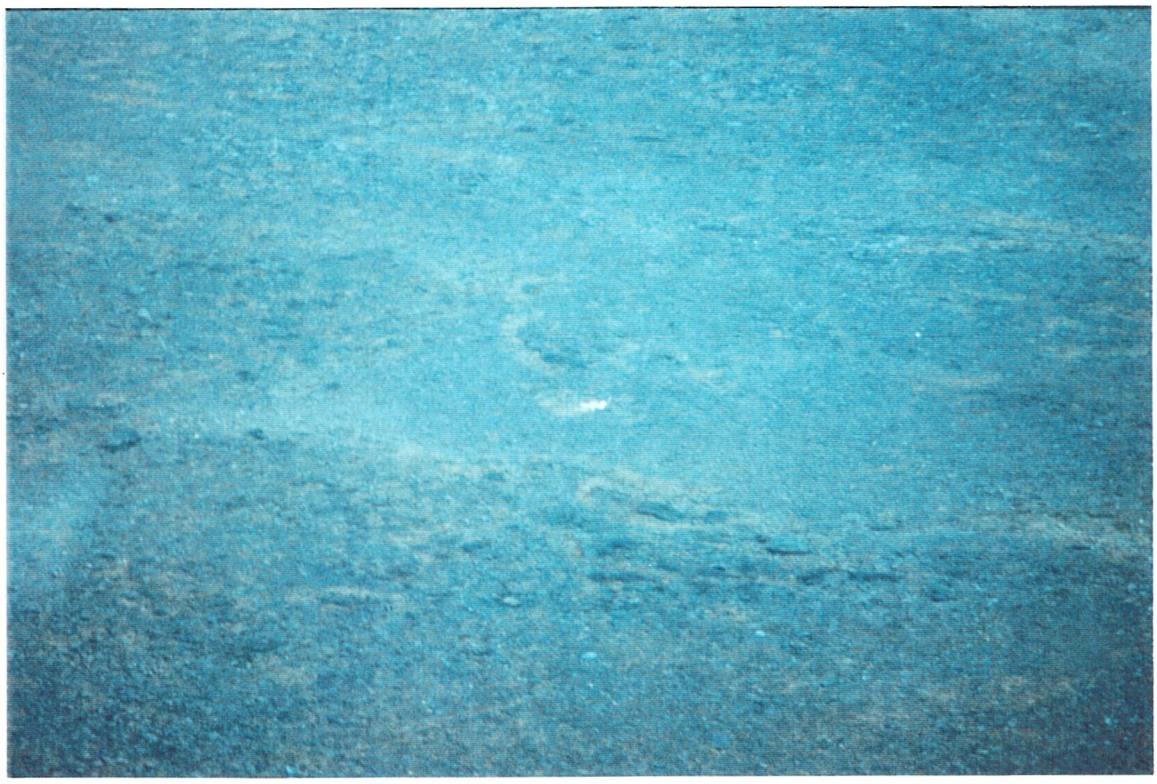
[21] MIR Télédétection 2000:24-25.

Photo 28 — Second class site : a pile of calcium chloride barrels (Site #26)

Photo 29 — Third class site : ten (10) drilling pipes (Site #10)



First class
Site with a large quantity of mining equipment, covering a large surface area;
characteristics:
- presence of three to ten buildings;
- average surface area of approximately 30 m^2 per building;
- piles of 50 or more barrels.

Second class (Photo 28)
Site with a medium quantity of mining equipment, covering a medium surface area;
characteristics:
- presence of one to three buildings;
- average surface area of approximately 20 m^2 per building;
- piles of 10 to 50 barrels;
- concentration of diverse equipment (shelving, cabins, etc.).

Third class (Photo 29)
Site with a small quantity of mining equipment, covering a small surface area;
characteristics:
- piles of less than 10 barrels;
- isolated objects (diverse containers, signs, etc.).

The classification of sites obtained in this way is presented in Table 1. For the most part, the numbering of the sites corresponds to that on Map 5, but is limited to those observed from the plane, namely Sites #1 to #47, and includes the mining exploitation sites, put in brackets ([]). When a site includes a position plotted on the map by a key informant, it is followed by a plus sign (+).

Table 1 — Classification of sites from the GÉTIC's field campaign, according to size
Aerial survey — July 15th to 19th, 1999

First class site	Second class site	Third class site
[1]	[4] (cabin)	[2]
[3] (building)	[5]	9
[6]	21 (shelving)	10
[7]	22	12
[11]	24	13
[14] (building)	26	15
17	27	16
23++ (cabin)	29++	18
25+ (building)	30	19
31+	35+ (camp)	[20]
32	36	28
40+++ (cabin)	37+ (camp)	33+
46	41 (building)	34
47	43 (camp)	38
[8] (container)		39
		42
		44
		45

References: MIR Télédétection 2000: 23;
Index des sites miniers de la zone pilote (Appendix 6).

Photo 30 — Moving workshop on a tracked trailer nearby cabins (Site #25)

Photo 31 — Closing the cabin with chemicals inside; nailing the door (Site #25)

Sites #23, #40 and #29 include more than one position identified on the map by the key informants. Sites #25 and #40 were characterised, the first with the confirmed presence of chemical products, the second with the presumed presence of containers of toxic chemicals at the bottom of Lac Vaillant. Sites #23 and #29 are the two other sites associated with the presence of chemical products, according to the key informants who have avoided them up until now for clean-up operations. (Photos 30 – 31)

The presence of these chemical products should not be surprising. In a book that is considered to be a treatise on geochemistry in mining exploration, of which the first publication date is 1962, this situation has an explanation:

> An internally run laboratory may be preferable for large surveys, for exploration groups conducting numerous surveys over period of years, and for surveys in remote regions where shipping of samples would be difficult or time-consuming. (...)
> The promptness with which analytical data are required varies with the nature of the operation. In an orientation survey preparatory to laying out a program, data are often needed within a day or so from the time of collecting the sample, and can best be provided by a mobile analytical unit at the field camp.
>
> Rose et al. 1979: 546.

CONCLUSION

Remote sensing data from medium resolution satellites — data of 8 - 10 m. per pixel from SPOT PLA or RADARSAT which regularly cover Nunavik — cannot precisely recognize specific geometry of on site equipment. The multi-spectral image — LANDSAT TM — is suitable in connection with the identification of human influenced areas, but too coarse to a more precise delineation of these areas. The combination of multispectral and panchromatic images, LANDSAT TM and SPOT PLA, enables the determination of major sites of human influence, but the imagery is not suitable for the identification of specific objects. The analysis of panchromatic high resolution images shows potentials. However, there is no precise indication of a potential for identification of smaller objects such as individual barrels or small groups of oil barrels — see R.O. Rasmussen 2000: Appendix 4. Part of the SIGÉOM data base of the ministère des Ressources naturelles du Québec (MRNQ) can be useful to document areas which would not be otherwise and to identify the year the mining exploration work took place — however certain zones of Nunavik are not yet integrated in the data base.

The techniques which use aerial surveys with observers on board and surveys with key informants give the most reliable inventory results, which can be improved using minor corrections. They determined that 47 abandoned sites exist within an area of 2 500 square kilometers. The *Catalogue des gîtes minéraux du Québec* (Avramtchev 1982a), and the *Carte des gîtes minéraux du Québec* (Avramtchev 1982b), on a scale of 1:250 000, give new perspectives as to the successful completion of the inventory: the *Catalogue* and the *Carte* published in 1982 (Ungava Trough and Hudson Bay regions) and in 1990 (Labrador Trough region) form a whole and are available for each of the regions of Nunavik — this data on the sites combined with interviews with key informants offer great potential at the least cost to complete the inventory.

As for characterisation of the sites, the pilot project has shown this can only be determined by on site visits via helicopter. The chemicals which have been noted by people of Kangiqsujuaq at an abandoned site, located 70 km west of the village consist of 100 litres of highly concentrated and extremely toxic acids, easily accessible to any passer-by. The analysis shows that the soil of the two abandoned sites which were visited in the targeted zone is not contaminated by hydrocarbons — these being the two most important sites, of which one contains the concentrated acids.

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