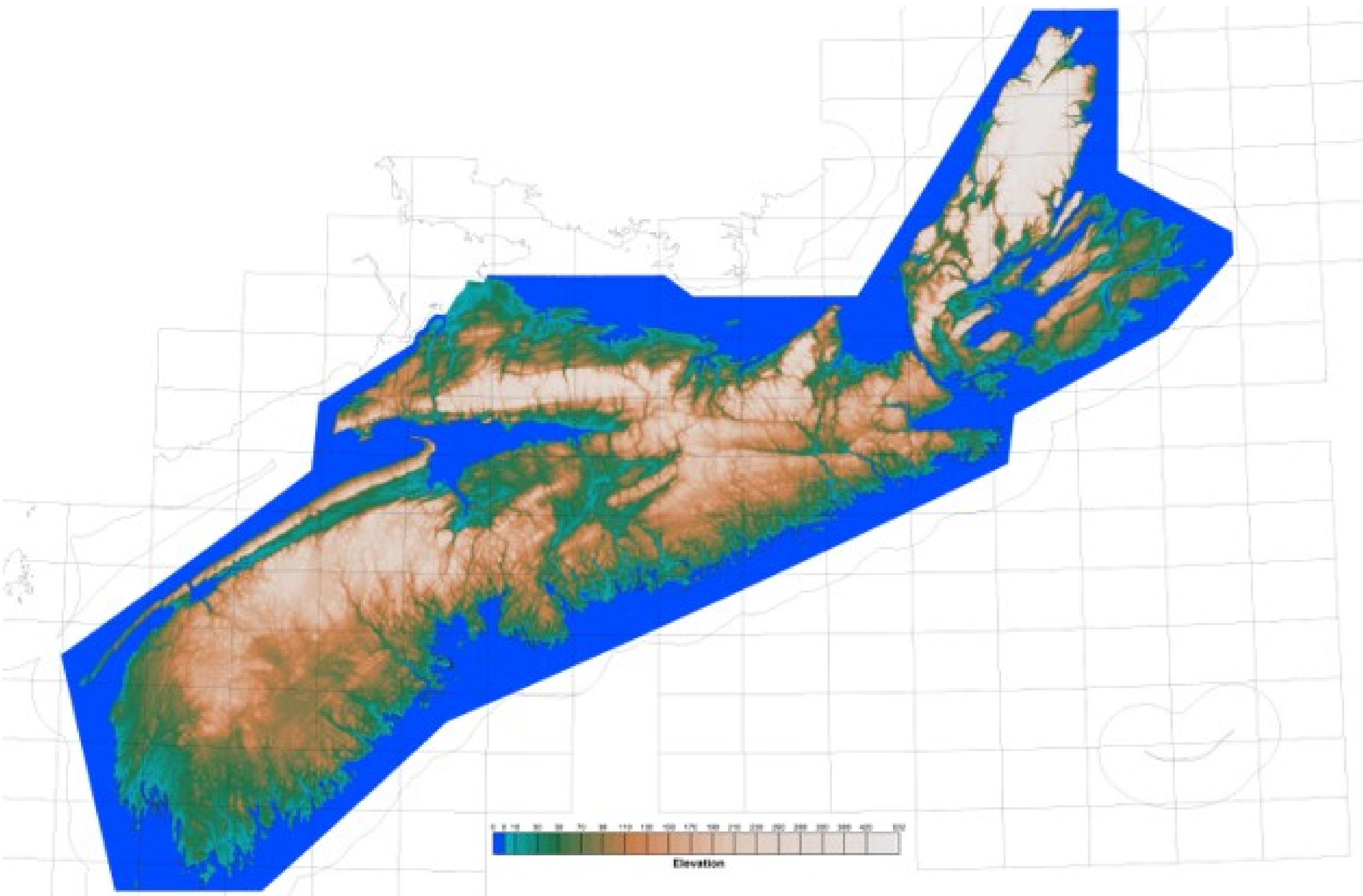
MINERALS PLAY FAIRWAY

Attracting investment and job creation to Nova Scotia



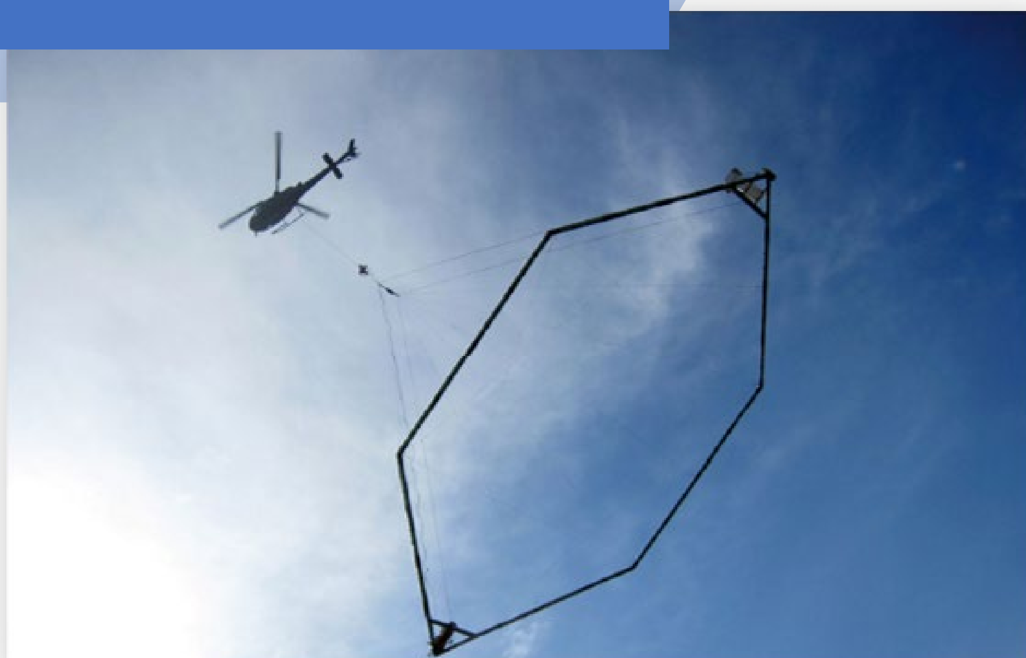
Submitted by:

MANS
Mining Association of Nova Scotia

October 2018

MINERALS PLAY FAIRWAY

WOULD GENERATE A FREE, BEST-IN-CLASS DATABASE OF GEOPHYSICAL KNOWLEDGE THAT WILL HELP ATTRACT INVESTMENT AND JOB CREATION TO NOVA SCOTIA.



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This report was made possible thanks to funding from the Government of Nova Scotia's Mineral Resources Development Fund (MRDF). MRDF is a grant program that supports prospecting, advanced exploration, minerals-related research and education. More information about MRDF is available at https://novascotia.ca/natr/meb/mrdp.asp.

Executive Summary

Nova Scotia's mining and quarrying industry is seeking $19.5 million in government funding for an airborne geophysical survey program. The project, called *Minerals Play Fairway*, would improve our geological understanding of Nova Scotia, help find future mines and quarries, and be an essential tool for attracting investment and job creation to the province.

Minerals Play Fairway is modelled on the highly successful Nova Scotia oil and gas Play Fairway Analysis. In 2008, the Department of Energy commissioned a $15 million Play Fairway Analysis and geoscience data package program with the goal of stimulating offshore petroleum exploration activity. The resulting data was made available for free to the global oil and gas industry and attracted over $2 billion in investment in Nova Scotia's offshore.[1]

This needs assessment report is the first step toward building a minerals version of Play Fairway – a free, best-in-class database of geophysical knowledge that will help attract investment and job creation to Nova Scotia. The oil and gas Play Fairway was a made-in-Nova-Scotia success story and copying it for the mining industry would help the industry grow and create jobs for Nova Scotians.

The report analyses the province's publicly-held airborne geophysical data and recommends that government fund the following geophysical surveys:

- A province-wide magnetic, radiometric and VLF survey;
- A regional gravity gradiometry and magnetic survey in the St. Mary's Basin and Cobequid-Chedabucto Fault System; and
- A series of five regional electromagnetic (ZTEM) surveys.

The Need for Minerals Play Fairway

Nova Scotia's mining and quarrying industry employs 5500 Nova Scotians, mainly in rural areas, and generates $420 million per year in economic activity. Fostering mineral exploration is

[1] https://energy.novascotia.ca/oil-and-gas/offshore/play-fairway-analysis

essential to ensuring the industry's ability to keep creating new jobs for Nova Scotians. If we do not do exploration today, there will not be new mines tomorrow.

Many jurisdictions help reduce the time, risk and cost of exploration by offering free geophysical data to exploration companies. This is a common and effective way of attracting interest and investment.

Nova Scotia's Department of Energy and Mines maintains a significant airborne geophysical database. However, much of the data dates from the 1980s and the technology to conduct surveys and process the data has improved immeasurably in the decades since.

Put simply, Nova Scotia's geophysical database is like a rotary telephone in a wireless world. We need to modernize it.

Other Benefits of Geophysical Data

While Minerals Play Fairway's main focus is to help find mineral deposits and attract investment to the province, there are several other ways in which Nova Scotians would benefit from the survey program detailed in this report:

- There are many different types of chemical and physical geohazards in Nova Scotia that have the potential to place the public and infrastructure at risk. The sinkhole in Oxford's Lions Club park is a recent example. Deadly radon gas is another. The data from Minerals Play Fairway could be used to help identify potential geohazards and protect Nova Scotians from them.
- The geophysical data generated by the Minerals Play Fairway could also help identify potential deposits of onshore oil and gas and complement the Department of Energy and Mines' recent *Nova Scotia's Onshore Petroleum Atlas project (2013-2017)*.
- Geophysical data can also be used to help find and delineate aquifers. Increasing our knowledge of Nova Scotia's aquifers would help improve water management, especially given potential impacts on our water supply caused by climate change.

Improving our geophysical knowledge of the province would lead to improved safety, economic opportunities and better land, water and environmental management.

Minerals Research Association of Nova Scotia

In August 2018, the Mining Association of Nova Scotia (MANS) established a new organization called the Minerals Research Association of Nova Scotia (MRANS), a not-for-profit to focus on research activities that will help the province's mining and quarrying industry grow and create jobs, including managing Minerals Play Fairway.

Establishing MRANS is another example of how Minerals Play Fairway is modelled on the oil and gas Play Fairway Analysis. The oil and gas Play Fairway was government-funded but managed by the Offshore Energy Research Association (OERA).[2] MRANS would play the equivalent role for the Minerals Play Fairway that OERA played for the oil and gas version.

MRANS is a separate organization from the Mining Association of Nova Scotia (MANS), with its own board, legally established under the Societies Act.

While Minerals Play Fairway was the impetus for establishing MRANS, MRANS will also conduct and facilitate other minerals-related research in partnership with government, industry and universities.

Partnership with Government

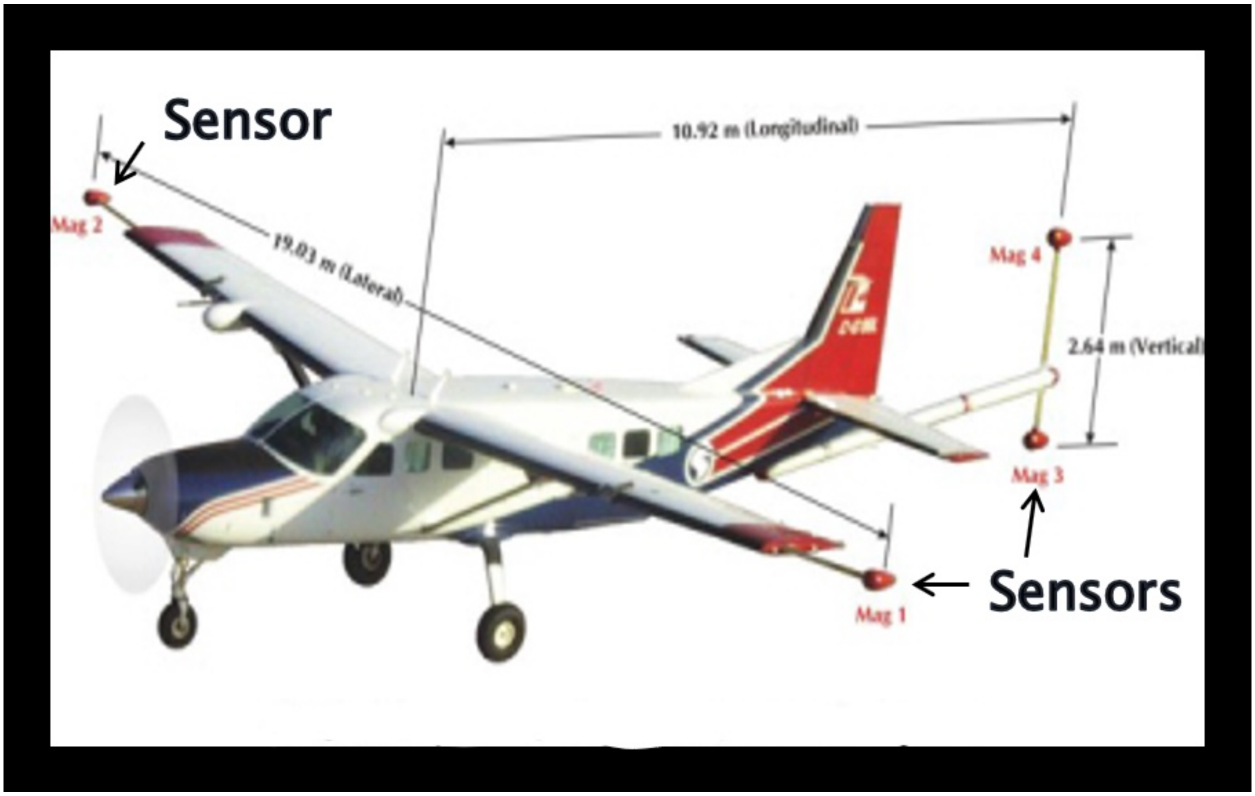
The partnership between the mining industry and the Government of Nova Scotia has been very successful in recent years. Government policy decisions - including extending the fuel tax rebate to the industry, the recent Mineral Resources Act overhaul, the establishment of the Mineral Resources Development Fund and the creation of the new Department of Energy and Mines - helped make 2017 a turnaround year for the industry.

We believe Minerals Play Fairway is an opportunity to continue to build on this success and the industry/government partnership that has already accomplished so much.

The Department of Energy and Mines has been offered a dedicated seat on the Minerals Research Association of Nova Scotia's board. Having the Department represented on MRANS' board mirrors the relationship the Department has with the Offshore Energy Research Association. It ensures industry and government will work in partnership on this initiative, and it will give government direct involvement and oversight of the organization and any government funds granted to MRANS.

Minerals Play Fairway is a unique opportunity to build a free, best-in-class database of geophysical knowledge that will help attract investment and job creation to Nova Scotia.

[2] http://www.oera.ca


Sensor
10.92 m (Longitudinal)
Mag 2
19.03 m (Lateral)
Mag 4
2.64 m (Vertical)
Mag 3
Sensors
Mag 1


C-GSGV
SURVEY

Minerals Play Fairway Background

Nova Scotia's mining and quarrying industry is seeking $19.5 million in government funding for an airborne geophysical survey program. The project, called *Minerals Play Fairway*, would improve our geological understanding of Nova Scotia, help find future mines and quarries, and be an essential tool for attracting investment and job creation to the province.

Minerals Play Fairway is modelled on the highly successful Nova Scotia oil and gas Play Fairway Analysis. In 2008, the Department of Energy commissioned a $15 million Play Fairway Analysis and geoscience data package program with the goal of stimulating offshore petroleum exploration activity. The resulting data was made available for free to the global oil and gas industry and attracted over $2 billion in investment in Nova Scotia's offshore.[3]

This needs assessment report is the first step toward building a minerals version of Play Fairway – a free, best-in-class database of geophysical knowledge that will help attract investment and job creation to Nova Scotia. The oil and gas Play Fairway was a made-in -Nova-Scotia success story and copying it for the mining industry would help the industry grow and create jobs for Nova Scotians.

The plan for Minerals Play Fairway includes four main stages:

Stage 1 – Needs Assessment

In spring 2018, the Mining Association of Nova Scotia (MANS) received a $62,000 grant from the provincial government's Mineral Resources Development Fund to conduct a needs assessment of the province's publicly-held airborne geophysical data. This report is the result of that initiative. It analyzes Nova Scotia's geophysical database and makes recommendations for improving it in order to attract more investment and job creation to the province.

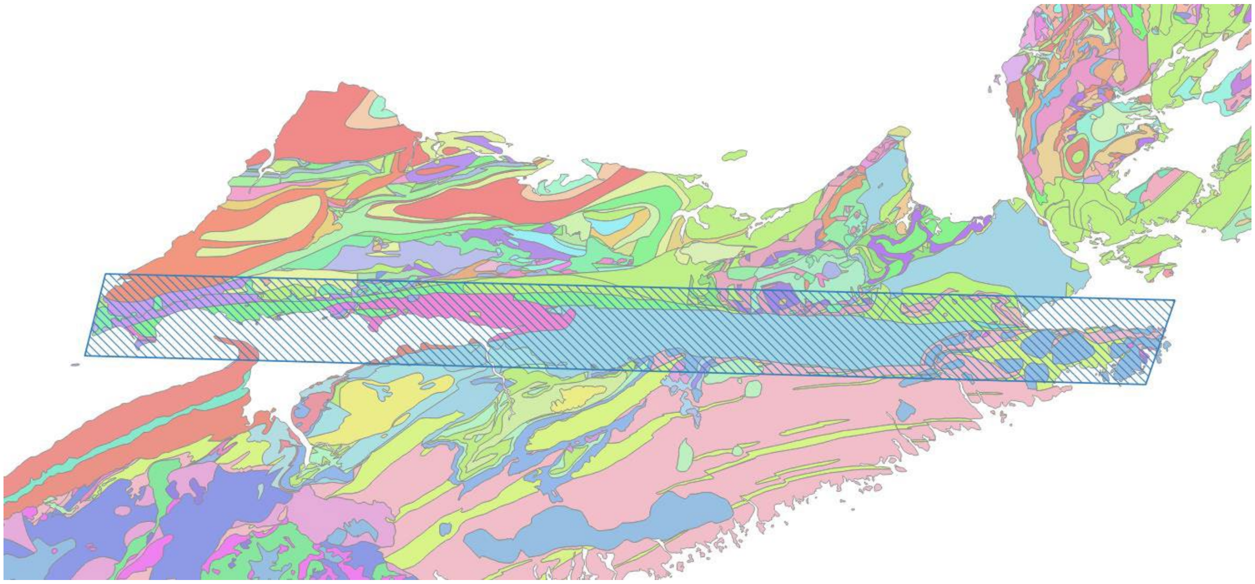
Specifically, the needs assessment recommends conducting two phases of surveys:

<u>Surveys Phase 1:</u>

- A province-wide magnetic, radiometric and VLF survey
  - Flight Line Spacing – 200 metres to result in a grid with a 40 m resolution.
  - Flying Height – 100 m mean terrain clearance.
  - Aircraft Type – Fixed wing aircraft.
  - Survey Speed – approximately 75 m/s.
  - Minimum of 3 aircraft surveying to complete survey in approximately 32 weeks.
  - Total cost: $4,838,000

[3] https://energy.novascotia.ca/oil-and-gas/offshore/play-fairway-analysis

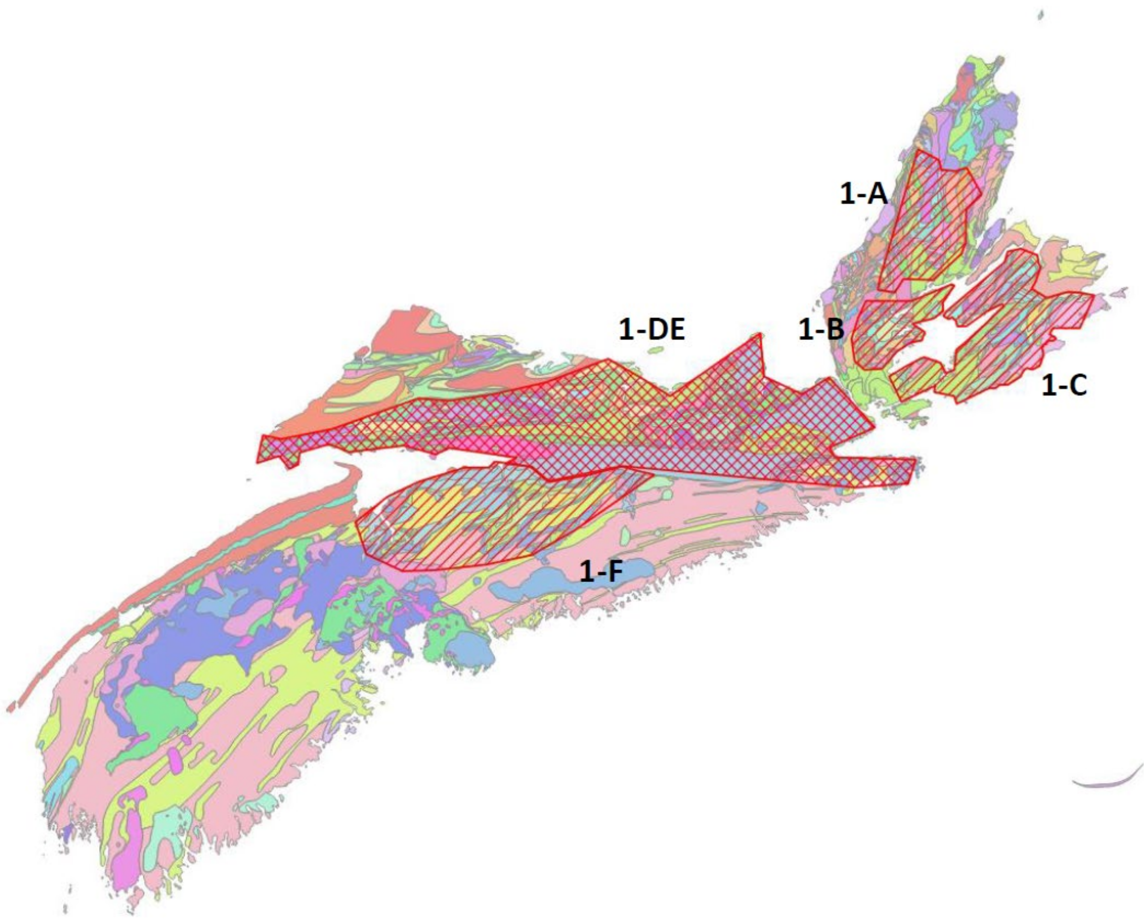
- A regional gravity gradiometry and magnetic survey
  - Location: St. Mary's Basin and Cobequid-Chedabucto Fault System
  - Flight Line Spacing – 250 metres
  - Total cost: $4,533,500



Proposed gravity gradiometry survey area in the St. Mary's Basin and Cobequid-Chedabucto Fault System.

<u>Surveys Phase 2:</u>

- A series of five regional electromagnetic (ZTEM, or Z-Axis Tipper Electromagnetic) surveys
  - These follow up surveys would only be done after the Phase 1 surveys, discussed above, are complete.
  - Flight Line Spacing – 200 m to result in a grid with a 40 m resolution.
  - Flying Height – 100 m mean terrain clearance, sensor heights to be determined.
  - Aircraft Type – Mix of Fixed wing and Helicopter aircraft.
  - Survey Speed – approximately 75 m/s for Fixed wing and 25 m/s for Helicopter.
  - Three surveys with one helicopter with a total data acquisition of approximately 16 weeks and a fixed wing aircraft with a total data acquisition of approximately 16 weeks.
  - Total cost: $9,845,000.



Proposed regional follow up surveys.

More details on the survey recommendations are in the appended report, “Assessment of the current state of Airborne Geophysical Data for Nova Scotia,” which starts on page 23.

The needs assessment was conducted by geophysical consulting firm Paterson, Grant & Watson Ltd. (PGW).[4] With 45 years of experience in mineral and oil and gas exploration, Toronto-based PGW are recognized global experts in geophysics and have conducted similar projects for companies and governments around the world.

Stage 2 - Funding

This report lays out a clear, well-defined plan for modernizing Nova Scotia’s airborne geophysical database and the associated costs. The focus of Stage 2 is seeking $19.5 million in government funding to implement the report’s recommendations.

Stage 3 - Survey Program

With government funding secured, Stage 3 would involve conducting the geophysical data collection and processing recommended in this report.

[4] www.pgw.ca

Stage 4 – Investment Attraction and Marketing

A sometimes-overlooked component of the oil and gas Play Fairway Analysis is the extent to which the survey data was marketed to the global oil and gas industry. When Nova Scotia did its oil and gas Play Fairway Analysis, it was not unusual for jurisdictions to acquire survey data and make it available for free as a means of attracting interest. The key ingredient that Nova Scotia pioneered was proactively promoting that data in ways above and beyond what other jurisdictions were doing at the time.

Nova Scotia did not just generate the data and post it on a web site – Nova Scotia aggressively promoted it as part of attracting over $2 billion in investment in Nova Scotia's offshore.

It is therefore essential to the success of Minerals Play Fairway that a proactive investment attraction and marketing program be conducted to promote the new, free geophysical data to the global mining industry.

The Need for Minerals Play Fairway

Nova Scotia's mining and quarrying industry employs 5500 Nova Scotians, mainly in rural areas, and generates $420 million per year in economic activity. Fostering mineral exploration is essential to ensuring the industry's ability to keep creating new jobs for Nova Scotians. If we do not do exploration today, there will not be new mines tomorrow.

Mineral exploration is a long-term, high-risk activity. Only one in every 10,000 exploration projects results in an actual mine and it typically takes at least ten to fifteen years of exploration, data analysis, planning and financing to bring a mine into production.

For this reason, many jurisdictions help reduce the time, risk and cost of exploration by offering free geophysical data to exploration companies. This is a common and effective way of attracting interest and investment. Studies from other jurisdictions show that the return on investment from government-funded geoscience, measured by tax revenue increases and economic development, is many times greater than the cost.[5]

Nova Scotia's Department of Energy and Mines maintains a significant airborne geophysical database. However, much of the data dates from the 1980s and the technology to conduct surveys and process the data has improved immeasurably in the decades since. Our database no longer meets global industry standards.

For example, our data was mostly collected in a time before global positioning systems (GPS), meaning survey data had to be aligned with maps by hand, which inevitably creates inaccuracies. Much of the data was collected and originally analysed with analogue technologies, meaning its quality is lower than what is used today. Survey flight heights and line spacing were often much larger than what is considered appropriate today. Also, because of its age, we often no longer have the raw survey data to work with, just maps that are not up to modern standards.

Nova Scotia's geophysical database is like a rotary telephone in a wireless world.

Put simply, Nova Scotia's geophysical database is like a rotary telephone in a wireless world. We need to modernize it.

Conducting a major survey program like the one recommended in this report would have several advantages over our current geophysical database:

[5] See appendix, page 62, the section entitled "Benefit – Cost of Publicly Available Geoscience Data."

- It would send a signal to the global mining industry that Nova Scotia is open for business. It would be a key tool to promote the province as an excellent place to invest and help catch the eye of outside companies and investors.
- It would bring Nova Scotia up to the level of other jurisdictions in Canada and around the world by making a modern, best-in-class geophysical database available for free to the global industry.
- The free geophysical data would stimulate exploration in Nova Scotia and reduce the time, risk and cost of finding mineral deposits.
- The data would be collected and analysed with the same equipment, same specifications, by the same people, using the same methodologies. It would provide a consistent data set across the province without the technical problems that come from compiling decades-old data, collected by different people using different technologies.

The annual Fraser Institute survey of global mining executives shows, year after year, that Nova Scotia is seen as the least attractive jurisdiction in Canada in which to invest.[6] For this reason, it is not enough for us to match what other jurisdictions are doing to attract investment – we need to do more because we are at a competitive disadvantage to start with. This report therefore recommends a state-of-the-art survey program that will give us a geophysical database that is comparable to, or better than, other jurisdictions in North America.

The Government of Nova Scotia has laid the foundation through recent policy decisions to improve the province's reputation. It has proven itself to be a strong supporter of the industry and the Mining Association of Nova Scotia is using these policy decisions to argue that the province is worth a second look.[7]

Minerals Play Fairway is the next major step we can take to prove that Nova Scotia wants the investment and job creation the mining industry can provide.

[6] https://www.fraserinstitute.org/studies/annual-survey-of-mining-companies-2017
[7] http://www.mining.com/web/canadas-nova-scotia-worth-second-look/

Other Benefits of Geophysical Data

While Minerals Play Fairway's main focus is to help find mineral deposits and attract investment to the province, there are several other ways in which Nova Scotians would benefit from the survey program detailed in this report.

Geohazards - There are many different types of chemical and physical geohazards in Nova Scotia that have the potential to place the public and infrastructure at risk. The Department of Energy and Mines' Geoscience and Mines Branch does excellent work identifying and mapping potential geohazards and the data from Minerals Play Fairway would be invaluable to the Branch's work in this area.

For example, radon is a naturally occurring gas produced by radioactive decay of uranium, found in measurable quantities in most rocks and soils in Nova Scotia. Radon is the second leading cause of lung cancer, behind smoking. Minerals Play Fairway could help increase our knowledge of uranium occurrences and potential sources of radon gas, and thereby help protect Nova Scotians from this serious public health risk.

More information about radon and its health risks can be found on the Lung Association's web site: https://ns.lung.ca/lung-health/radon-gas.

A 2018 sinkhole in Oxford's Lions Club park is an example of a geohazard.

Other potential geohazards include sinkholes, landslides and damage to, and loss of, ocean-front property due to coastal erosion and flooding.

Media stories in 2018 reminded Nova Scotians how geohazards can impact our safety and daily lives. A sinkhole in Oxford's Lions Club park is believed to be the result of an underground gypsum deposit eroding in water and leaving a cavern under the park.[8] Gypsum is a soft rock that is prone to this sort of erosion and sinkholes are often caused by caverns caving in as a result of gypsum erosion. Nova Scotia has tremendous gypsum deposits and has historically been one of the largest global suppliers of gypsum.

It is important that we continue to improve our understanding of potential geohazards to protect Nova Scotians and our infrastructure.

Oil and Gas – The geophysical data generated by the Minerals Play Fairway could also help identify potential deposits of onshore oil and gas and complement the Department of Energy and Mines' recent *Nova Scotia's Onshore Petroleum Atlas project (2013-2017)*.[9]

Aquifers – Geophysical data can also be used to help find and delineate aquifers, subsurface geological formations from which a sufficient quantity of water can be extracted to serve as a water supply. Increasing our knowledge of Nova Scotia's aquifers would help improve water management, especially given potential impacts on our water supply caused by climate change.

Improving our geophysical knowledge of the province would lead to improved safety, economic opportunities and better land, water and environmental management.

[8] https://www.cbc.ca/news/canada/nova-scotia/as-oxford-sinkhole-grows-it-s-like-watching-a-disaster-happen-in-slow-motion-1.4800076
[9] https://energy.novascotia.ca/onshore-atlas-version-1-2017

Minerals Research Association of Nova Scotia

In August 2018, the Mining Association of Nova Scotia (MANS) established a new organization called the Minerals Research Association of Nova Scotia (MRANS), a not-for-profit to focus on research activities that will help the province's mining and quarrying industry grow and create jobs, including managing Minerals Play Fairway.

Establishing MRANS is another example of how Minerals Play Fairway is modelled on the oil and gas Play Fairway Analysis. The oil and gas Play Fairway was government-funded but managed by the Offshore Energy Research Association (OERA).[10] MRANS would play the equivalent role for the Minerals Play Fairway that OERA played for the oil and gas version.

MRANS would, for example, manage the funds granted by government, hire service providers to conduct the geophysical surveys and the processing of the data, ensure the results of the survey program are designed to maximize their potential to help attract investment from the global mining industry, assist in marketing the free data to the global industry and be accountable to the government for the results of the project.

There are several reasons why we believe it would be best for MRANS to manage Minerals Play Fairway rather than government managing it:

- An industry-led, nimble organization like MRANS would be the most efficient and effective way of undertaking the project. MRANS could get the job done faster and get us to the investment attraction phase sooner. This was the province's experience with the oil and gas Play Fairway Analysis and we believe the same would be true for Minerals Play Fairway.
- It is generally-agreed that government procurement can be a complicated and slow process. MRANS could conduct requests for proposals and hire service providers to implement the geophysical survey program much quicker than government.
    - This needs assessment report is an example of this. The Mining Association of Nova Scotia issued an RFP for geophysical consultants to conduct the needs assessment and was ready to hire consultants within a matter of weeks. This allowed us to hit the ground running on the needs assessment immediately after receiving funding from the Mineral Resources Development Fund.
- A non-governmental organization is better-able to manage the multi-year survey program recommended in this needs assessment. If the funding for Minerals Play Fairway is provided up-front, as it was for the oil and gas Play Fairway Analysis, MRANS can manage the funds and implement the survey program over more than one fiscal year. This could be much more complicated in government where accounting rules require funds not spent at the end of the fiscal year to be spent on debt reduction and

[10] http://www.oera.ca

where activities can be delayed or simply cancelled through the annual budget process and changing priorities.

MRANS is a separate organization from the Mining Association of Nova Scotia (MANS), with its own board, legally established under the Societies Act. However, MANS is seeding MRANS by covering costs associated with its establishment and donating staff time to manage the new organization.

While Minerals Play Fairway was the impetus for establishing MRANS, MRANS will also conduct and facilitate other minerals-related research in partnership with government, industry and universities. For example:

- Given the resurgence of gold mining in Nova Scotia, MRANS might pursue research related to the geology of the province's gold deposits as a means to attract additional industry interest in them.
- Nova Scotia has tremendous gypsum deposits and has traditionally been one of the largest global suppliers of gypsum. Gypsum is a strategic resource for Nova Scotia. Research into new uses of gypsum and new markets could lead to significant growth and job creation in the industry.
- Research related to environmental management could help reduce mining's environmental footprint and build social license for the industry.
- MRANS could manage additional survey projects after Minerals Play Fairway is complete. Ontario, for example, does at least one large, government-funded survey per year to continually improve its geological knowledge. It would create significant benefits if Nova Scotia did the same.

A general meeting of MRANS' membership was held on September 20, 2018 in Halifax and the following board was elected for the 2018-19 term:

1. Pat Mills, President, former plant manager of National Gypsum's Milford quarry.
2. John Wightman, Managing Director of the GOLDFIELDS Group of companies and Executive Director of the Prospectors Association of Nova Scotia.
3. Dr. Sally Goodman, Chief Geoscientist, Atlantic Gold.
4. Dr. Jacob Hanley, Chairperson and Full Professor, Department of Geology, Saint Mary's University.
5. Patrick Hannon, Mining and Geological Engineer and Past President of MineTech International Limited.
6. George O'Reilly, retired Mineral Deposit Geologist.
7. Rick Horne, Consultant.

MRANS is ready and able to enter into a grant agreement with the Department of Energy and Mines to make Minerals Play Fairway happen. MRANS would accept and manage the funding and fulfill all necessary deliverables.

Partnership with Government

The partnership between the mining industry and the Government of Nova Scotia has been very successful in recent years. Government policy decisions - including extending the fuel tax rebate to the industry, the recent Mineral Resources Act overhaul, the establishment of the Mineral Resources Development Fund and the creation of the new Department of Energy and Mines - helped make 2017 a turnaround year for the industry.

We believe Minerals Play Fairway is an opportunity to continue to build on this success and the industry-government partnership that has already accomplished so much.

The government's importance in providing funds to Minerals Play Fairway is obvious. Just as government funded the oil and gas Play Fairway Analysis which attracted so much investment to the province, we need the government to also fund Minerals Play Fairway so it can be used to grow the industry and create jobs.

However, the government also has an important role to play in the project by contributing its expertise and experience in various ways. The government's Geoscience and Mines Branch employs a large number of experts in various aspects of the province's geology, geoscience and mining industry. The branch's expertise and partnership are essential to the success of Minerals Play Fairway.

Geoscience and Mines Branch would also play an important role in getting maximum value out of the data generated by Minerals Play Fairway. For years to come, government experts would do research and interpret the data, use it to identify geohazards and other potential concerns for Nova Scotians and our infrastructure, help promote the data to the global industry and use it to advance potential mining projects. The roles of Geoscience and Mines Branch and the Minerals Research Association of Nova Scotia are complementary.

We have therefore worked with the Department of Energy and Mines to build a partnership on Minerals Play Fairway. For example:

- Funding for this needs assessment came from the department's Minerals Resources Development Fund, so the government has been a partner and funder of this initiative from the start;
- The Minerals Research Association of Nova Scotia has invited Energy and Mines to be a member of MRANS at no charge; and
- Geoscience and Mines Branch staff were asked to participate in our August 9, 2018 consultation meeting about the needs assessment. There was roughly an equal number of representatives at that meeting from industry and from the branch, which provided invaluable assistance to the consultants doing the needs assessment and was symbolic of the partnership government and industry are building on the project.

Most significantly, MRANS has offered a dedicated seat on its board to the Department of Energy and Mines. Having the Department as a member and giving it a board seat mirrors the relationship the Department has with the Offshore Energy Research Association. It ensures industry and government will continue to work in partnership on this initiative, and it will give government direct involvement and oversight of MRANS and any government funds granted to it.

Geophysics 101

Geophysics is the study of the physical properties of the Earth, especially its electrical, gravitational and magnetic fields. Geophysical data help us "see" underground, from a few meters to several kilometers, so we can draw conclusions about geological structures and processes. Geophysical surveys are safe, non-invasive, and cost effective at providing valuable data sets over a large area in a short period of time.

Geophysical data are used for a wide range of applications. The mining and oil and gas industries use geophysics to find mineral and oil and gas deposits, and to understand the subsurface rock layers and structures in which deposits are found. Engineers use geophysical data to analyze subsurface conditions prior to construction projects, and to identify geohazards that can impact infrastructure and human safety. Geophysical surveys can also be used to find and delineate aquifers/groundwater, and to map subsurface conditions at contaminated sites.

Geophysical data can be collected by three main methods - airborne surveys, ground-based surveys and marine surveys. Airborne surveys are typically used to obtain regional data sets for exploration purposes and provide an excellent "first look" at subsurface conditions within an area. Airborne geophysical surveys are performed with small airplanes or helicopters, whereby the geophysical instrumentation is fixed to the aircraft. This allows large areas to be surveyed quickly and efficiently compared to doing surveys on the ground.

Airborne surveys are usually designed with wide survey line spacing (i.e. 150-200 metres apart) and flown at an altitude of 100-200 metres above ground, depending on local circumstances. This provides comprehensive and detailed information over the survey area, while ensuring safety and minimal impact to the environment.

The real benefit of any geophysical data set is that it provides valuable information pertaining to conditions below the ground surface. Geologists and engineers can use geophysical data to increase the accuracy of their mapping and geological models, which optimizes any follow-up studies or investigations, such as mineral exploration. This improves quality and makes the overall project much more efficient, safe and successful.

Budget

This report recommends conducting a series of geophysical surveys which would cost an estimated $19.2 million in total.[11] This figure includes estimated survey costs, mobilization and demobilization, and project management and quality control by a geophysical consulting firm.

There are a number of management and administrative expenses for which the Minerals Research Association of Nova Scotia would have to charge in order to manage the project and ensure its success, such as:

- Staff time to manage the survey project and its budget;
- Travel expenses;
- Legal/contracts counsel to ensure the project and taxpayers dollars are fully protected; and
- If required by the government, an annual financial audit of MRANS to ensure full confidence in MRANS' management of the government grant.

MRANS will require a fee of 1.5%-2% of the survey budget to cover the management and administrative expenses associated with the project.

This brings the total cost of the project to approximately $19.5 million.

[11] More details are available in the appended report which starts on page 23.

Appendix:

Assessment of the current state of Airborne Geophysical Data for Nova Scotia

ASSESSMENT OF THE CURRENT STATE OF AIRBORNE GEOPHYSICAL DATA OF NOVA SCOTIA

Assessment of Existing Data and a Proposal for the Acquisition of New Geophysical Data

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Executive Summary

After a review of the current state of the publicly available geophysical data in the province of Nova Scotia it was concluded that the present state of the data is not fit for purpose for modern mineral exploration. It is recommended that there be a survey of the entire province of Nova Scotia at spacing of 200 m between lines with magnetic gradiometry, radiometrics and VLF instrumentation using a number of fixed wing aircraft. As well, an airborne gravity gradiometry and magnetic survey to be flown over the extents of the Cobequid-Chedabucto Fault Zone where there are numerous known mineral deposit types. Subsequently, a number of follow-up electromagnetic surveys to be flown to determine structure and conductivity of targets at depth specifically aimed at metal bearing mineral deposits.

The data from these new high-resolution geophysical surveys will provide to the prospector, mining and exploration company a “level playing field” of publicly available data throughout the province. The recommended survey would be flown at the same survey specifications universally to provide a contiguous data set with equal resolution, quality and data deliverables. The data set would no longer be a “patchwork” of different surveys flown at different dates, resolutions, flying heights, etc.

The Prospectors & Developers Association of Canada (PDAC) has recently developed a strategic plan for the next five years to enhance the mining sector’s competitiveness at home and abroad. One of the pillars of this plan to attain competitiveness is “The type, quantity, quality and accessibility of public geoscience information available to mineral explorers is improved and helps increase the rate of discoveries in Canada. “[1] Knowledge is key to future discoveries whether it be greenfields (unexplored or sparsely explored areas) or brownfields (in and around known mineral deposits) exploration. Knowledge reduces exploration risk by the prospector or exploration company. A definite benefit-cost ratio or return on investment has been demonstrated in other exploration theatres where geoscience data has been collected and made public.

Such high-quality data would be useful today and decades into the future as newer and better interpretational tools and techniques are developed. The availability of such data could spur mineral exploration by providing a “best in class” data set that would rival the data from any province in Canada, and in many cases, even worldwide. Few locations could boast such a complete and consistent set of geoscience data.

[1] CORE, The Voice of Mineral Exploration, Fall 2018, Prospectors & Developers Association of Canada (PDAC), C. Ainsworth-Vincze, Editor-in-Chief.

Introduction

In April 2018, the Mining Association of Nova Scotia (MANS) circulated a Request for Proposal (RFP) seeking a geophysical consultant to provide:

- a proposal to analyze Nova Scotia's publicly-available airborne geophysical data and provide a "needs assessment" to review the condition, currency and usefulness of the data to address Nova Scotia's exploration needs.
- a cost and schedule to complete the work. If the project does not receive full Government of Nova Scotia funding, MANS reserves the right to renegotiate budgets and scope based on the available approved funding.

In June 2018 Paterson, Grant & Watson Limited (PGW) was chosen to provide this assessment for MANS.

The project consisted of three phases.

1. Assessment of the current state of the publicly available Geological Survey of Canada (GSC) data of airborne magnetic, radiometric, very low frequency (VLF) electromagnetic data and ground gravity data.
2. Assessment of proprietary data sources through NI 43-101 reports, assessment reports and news releases. High quality and large area surveys would be considered for purchase rather than a new survey flown.
3. Based on the above assessment, the proposal of a new geophysical data acquisition program outlining the coverage, geophysical methods used and survey parameters. In addition, follow-up surveys with complementary geophysical methods have been proposed over selected target areas.

Background Material

Geophysical survey methods are remote sensing techniques that have the ability to image at surface and under cover, i.e., beneath soils, sediments and in some cases, water to the bedrock below. New mineral deposit discoveries that outcrop at surface have become increasingly rare, thus methods that can locate targets at depth are important for the future of the mining industry. Geophysical methods often do not detect target minerals directly, such as gold or copper, but give a picture of the lithology (the type of rocks), structure (fold, faults, etc.) and geochemical alteration processes that have occurred, all of which can be used to vector towards new discoveries.

Geophysical surveys use numerous techniques and technologies to measure different physical properties of rocks. These physical properties include magnetic susceptibility, density, natural radioactivity, electrical conductivity, amongst others. In the following discussion, only airborne geophysical methods are reviewed.

Magnetics Methods

Magnetic methods measure the magnetic response of rocks and minerals that is induced by the magnetic field of the earth. The size of the induced field is dependent upon iron bearing minerals such as magnetic iron and iron-titanium oxide minerals, including magnetite, titanomagnetite, titanomaghemite and titanohematite, and some iron sulphide minerals, including pyrrhotite and greigite. Theses mineral are most commonly found in high concentrations in volcanic rocks such as basalts or sedimentary banded iron formations (BIFs), but also to a lesser extent in plutonic rocks such as granites. Measurements of the magnetic field display the distribution of magnetic rocks in the earths crust and reflect the geological history of the area. So long as there is a sufficient physical property contrast (i.e. sufficient change in magnetic mineral content between adjacent rock packages), the magnetic method will show structural features including faults, folds, shear zones, intrusions, and/or alteration from surface to the Curie point (depth at which magnetic properties are destroyed due to heat). Surficial sediments such as soils and overburden, and most sedimentary rock types (e.g. limestones and sandstones) contain very little magnetic mineral content, thus they appear almost invisible to the magnetic sensors and we are able to resolve the underlying magnetic basement or intra-sedimentary magnetic features (i.e. intrusions).

Enhanced images of the magnetic field can be easily produced with computer software packages and displayed in a variety of ways. These enhanced images are created to bring out subtle features and trends, to find edges of geological bodies and to make the image more easily interpretable. Examples of such enhanced images are the Magnetic Field Reduction to the Pole, First and Second Vertical derivatives, Tilt derivative and Analytic Signal to list a few (**Figure 1**).

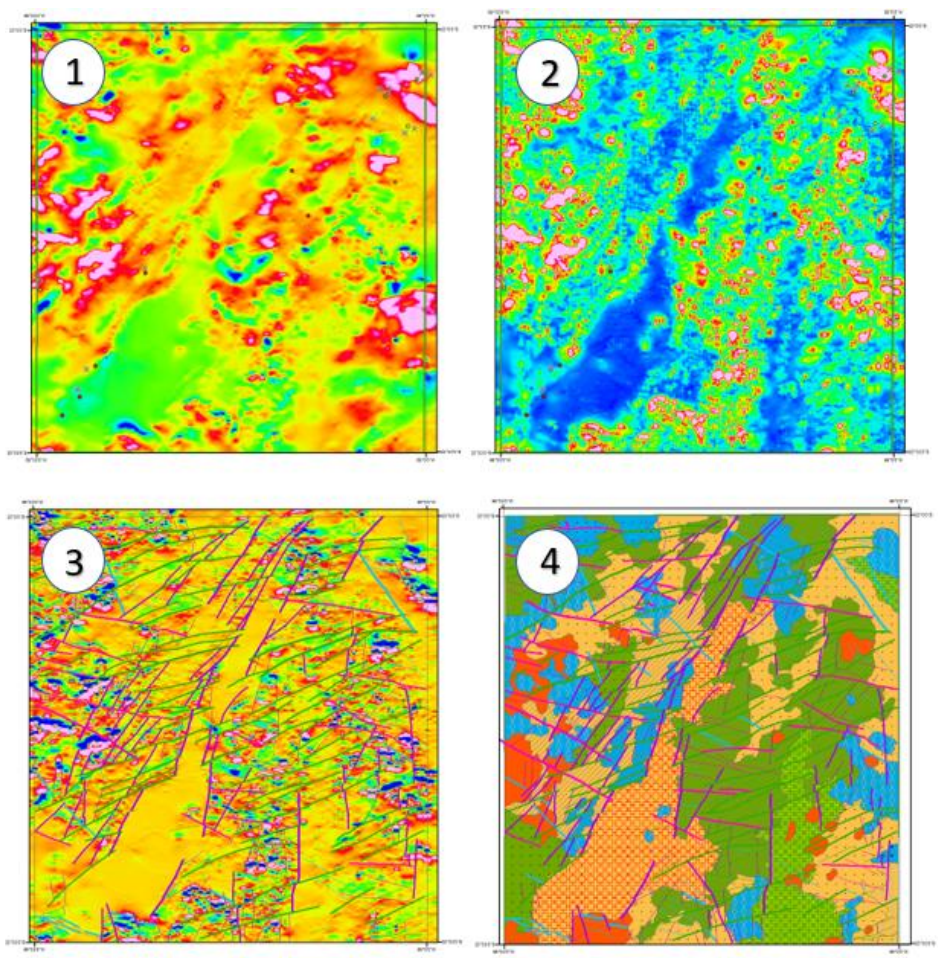

Figure 1. Example of enhanced images of (1) Reduction to the Pole, (2) Analytic Signal, (3) First Vertical Derivative and (4) Interpretation of the same original image of the magnetic field.

Modelling and inversion of the magnetic data can resolve the approximate depth to the magnetic source as well as its dip, strike, size and shape.

The most common current configuration of magnetic sensors for airborne magnetic surveying is in a magnetic gradiometry configuration. Magnetic gradiometry uses two or three magnetometers mounted on booms extending from the wings and tail of the aircraft, rather than a single magnetic sensor (**Figure 2**). These configurations allow for measurements of the lateral and longitudinal gradients across the aircraft and are used to enhance the spatial resolution of the data when gridded.

Figure 2. A fixed wing magnetic gradiometry system (left) with sensors located in tail and at each wing tip and a towed helicopter (right) system with two laterally spaced magnetic sensors.

For example, the extra sensors allow the resultant total magnetic intensity image to be much more continuous due to the extra information measured. A structure that is oblique to the survey flight line will be detected by the closer wing tip sensors before the other. If the feature was perpendicular to the flight line, then both wing tip sensors would detect the structure at the same time. In **Figure 3** below, the same magnetic data is used to create the image with and without using magnetic gradient data. More geologically realistic and laterally continuous structure are created with the gradient information rather than a corrugated structure (sometime called "pearls on a string"). This allows for a more accurate interpretation of the location of structural faults, the size, dip and shape of the magnetic bodies, especially if they are small or narrow.

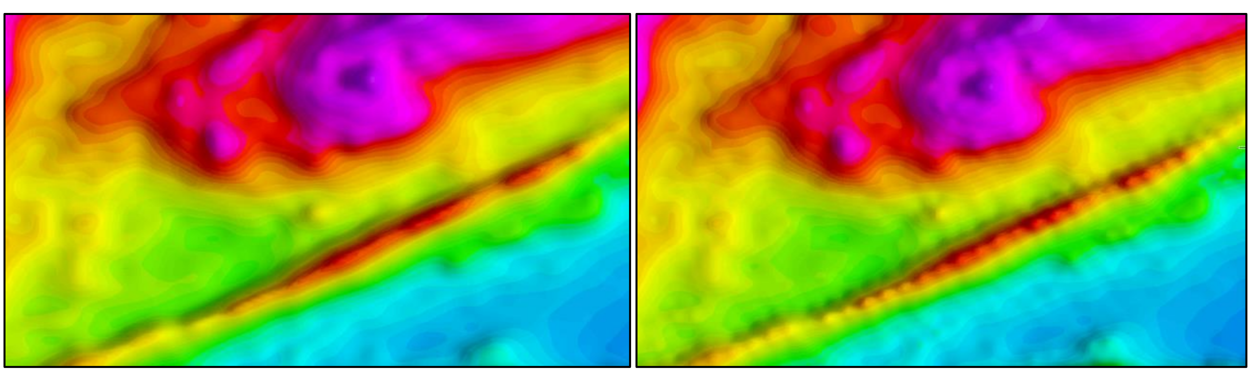

Figure 3. Images of gradient enhanced (left) and single sensor (right) total magnetic intensity.

Radiometric Methods

The radiometric method measures naturally occurring gamma-ray radiation from the earth's surface. Specifically, the energy associated with the decay chain of radioelements Potassium (K), Thorium (Th) and Uranium (U) are measured. Radiometrics may be considered to be a form of remote geochemical detection as it is measuring the relative abundances of these elements. Radiometric surveys only measure radiation from the top 30 to 50 cm of the surface of the earth which is considerably more shallow than other geophysical techniques. Despite soil coverage, the underlying rocks do geochemically influence the soil above, though surficial processes are often also reflected in the data. As with magnetics, different types of rocks have different concentrations of K, Th and U. For example, mafic rocks such as basalts which are often associated with a large magnetic signals, have a low overall radiometric signal (counts). Thus, the method is useful for geological mapping at surface and targeting mineralization. For example, K alteration found as halos to porphyry copper deposits are detectable with the radiometric method. As well as mineral exploration, the radiometric surveys have other uses, such as radon monitoring related to public health. Due to the absorption of the radiation by water, this method is only useable over land.

The radiometric data may be imaged as grids of the K, Th and U concentrations separately, grids of the ratios of various elements or as a combination where each element only varies in shades of red, green and blue, respectively. Such as image is known as a ternary image, as shown for this example from Nigeria (**Figure 4**). Uranium rich rocks dominate in the north and west as shown by the predominance of blue colours. Potassium rich rocks dominate in the south as shown by the red colours. Structural features such as the folded layers are visible in the centre of the image as well as sharp boundaries between different types of rocks in the southeast.

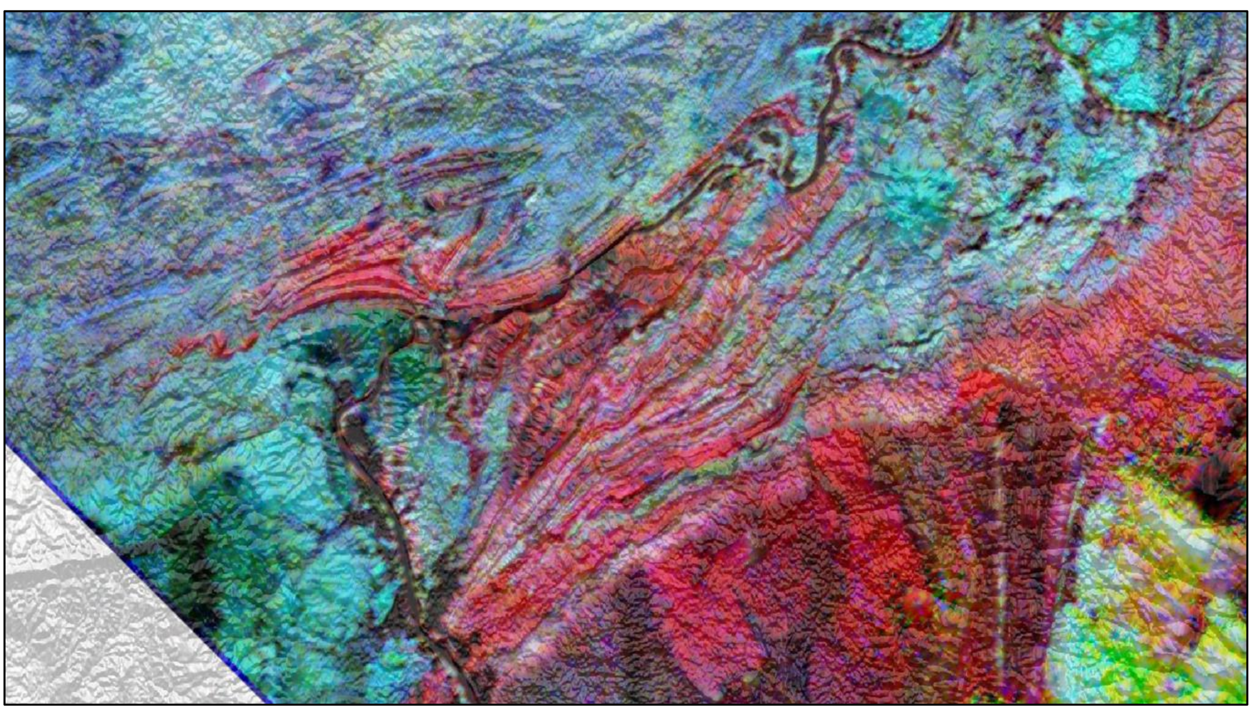

Figure 4. An example of a ternary image from Nigeria with K (red), Th (green) and U (blue).

Gravity Methods

Airborne gravity instrumentation has been commercially available for over twenty years and is a proven method that can rival ground gravity surveying. This method measures density variations of rocks through subtle changes in the gravitational pull upon the instrument sensor(s). There are two basic types of airborne gravity instrument systems; scalar gravity and gravity gradiometry. The former measures the gravity field (gravitational acceleration) and the latter measures the gravity difference or gradient of the gravity field (rate of change of the gravitation acceleration). A gravity gradiometry system is more sensitive to shorter wavelengths and is better at resolving near surface gravity anomalies (to approximately 2 km in depth) while a non-gradient system is better at resolving large scale, regional structures. Both systems have considerably higher resolution than satellite gravity (e.g. GRACE) which is not yet suitable for exploration scales.

As with magnetics, a number of enhanced products may be created to detect the location and structure of faults, contacts, etc. The image below (**Figure 5**) is from a combined Geological Survey of Canada and Ontario Geological Survey aeromagnetic and gravity gradiometry survey in the area of Ontario's "Ring of Fire" (Rainsford et al.)[2]. Known chromite deposits are shown by the yellow stars and appear to be associated with high gravity gradient anomalies.

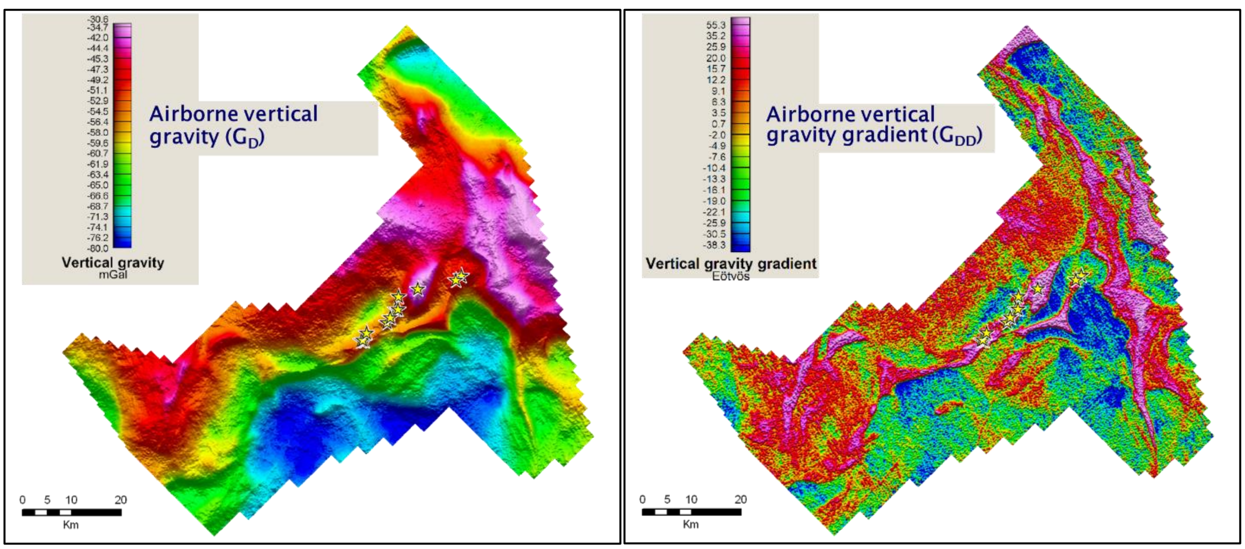

Figure 5. Airborne gravity (left) and the vertical gradient (right) measured from an airborne gravity gradiometry system.

Electromagnetic Methods

Electromagnetic (EM) methods measure the conductivity (or inversely the resistivity) of the earth. Metallic minerals are conductive, but generally electromagnetic methods detect the presence sulphides (pyrrhotite, pyrite, galena, magnetite, etc.) associated with the metals as well as graphite deposits. Conductivity is also affected by connectivity of the sulphides within the rock, water content (porosity,

[2] Rainsford, D.R.B., Dorio, P. A., Hogg, R. L. S. and Metsaranta, R.T. The use of Geophysics in the Ring of fire, James Bay Lowlands – The Chromite Story in: In "Proceedings of Exploration 17: Sixth Decennial International Conference on Mineral Exploration" edited by V. Tschirhart and M.D. Thomas, 2017, p. 649–662.

saturation and salinity) and mineral alteration (chlorite, sericite, silicification, carbonate). This method requires a transmitter of electromagnetic energy and a receiver that measure the signal after it has been altered by the conductive rocks below. Due to the high conductivity of sea water, an electromagnetic survey in Nova Scotia would only be flown over land.

There are two types of electromagnetic systems; active and passive. An active system, also known as a controlled source, requires a transmitter to send a pulse of energy into the ground below. If there are conductive bodies in the ground, this primary field will induce an electrical current which in turn produces a secondary magnetic field. The secondary field is then measured by a receiver. With processing, the location, shape, depth and conductivity of the conductor can be calculated. The depth of penetration of the electromagnetic signal is dependent of the power of the transmitter and presence of any conductive cover in the area of investigation. Conductive cover will impede the electromagnetic pulse and limit the depth of penetration. Typical helicopter active electromagnetic systems such as the Versatile Time Domain Electromagnetic (VTEM) system, can penetrate up to 800 m below the surface in ideal geological conditions.

Within the active electromagnetic method there is still further two subdivisions depending upon how the energy is transmitted into the ground. The Time Domain method (TDEM) transmits a high-power pulse of energy over a very short time. This pulse in continually repeated and the receiver measures how rapidly or slowly that energy pulse dissipates or decays within the rocks. A good conductor will take a long time for the energy to decay away while a poor conductor will take only a short period of time. The Frequency Domain method (FDEM) transmits continuous low power energy, but at a series of different frequencies. The receiver measures how each frequency has changed in amplitude and phase (an offset or delay) from the original frequency. Current TDEM system are accepted as having greater depth penetration than modern FDEM system which are restricted to the upper few hundred metres from surface in ideal geology.

Yet another form of an active electromagnetic system is VLF or Very Low Frequency. VLF was originally designed as a means to communicate with submarines by transmitting very long wavelength signal (3 to 30 kHz) from transmitters located around the globe. VLF energy penetrates the ground and is modified by conductive bodies within it. An aircraft with a VLF receiver will measure the presence of conductive overburden or tabular conductors in a resistive host rock up to a depth of 100 m below surface in ideal geological conditions. VLF is also capable of penetrating about 20 m into seawater. It is a simple, yet useful reconnaissance tool that requires no onboard transmitter.

A passive system or magnetotelluric method uses naturally occurring electromagnetic currents in the earth created by lightening strikes around the world. It has a much deeper depth of penetration, up to a few kilometers in ideal conditions. Thus, it is useful for crustal scale studies to determine magmatic sources of some mineral deposit types or mining districts. If a potential magmatic source is detected at depth, then there is the possibility of feeder veins, faults systems or some type of geological plumbing system that can act as pathways to bring the metallic mineral deposits at or near surface. A number of advantages of the magnetotelluric method are outlined in Jansen and Cristall (2017)[3] and quoted below.

[3] Jansen, J. C. and Cristall, J. A. (2017) Mineral Exploration Using Natural EM Fields, in "Proceedings of Exploration 17: Sixth Decennial International Conference on Mineral Exploration" edited by V. Tschirhart and M.D. Thomas, 2017, p. 349–377.

The paper also cites a number of case histories for porphyry copper, Olympic Dam (Iron-Oxide-Copper-Gold, IOCG) type, sedex, magmatic Ni-Cu-PGE and Uranium unconformity deposits.

> "1. Natural field EM methods are sensitive to a broader range of conductivity contrasts, allowing more subtle variations between altered and unaltered host rock to be distinguished;
>
> 2. Natural field EM methods can achieve greater depths of investigation; and
>
> 3. With respect to airborne surveys in mountainous regions where a low and consistent terrain clearance cannot be maintained, the slower attenuation of the natural field signal compared to active source systems makes it advantageous to acquire natural field data."

The following example from the Copaquire porphyry deposit in northern Chile[4] (**Figure 6**) shows a section of inverted ZTEM data as an image of resistivity (the inverse of conductivity). ZTEM is the Geotech Inc. proprietary instrument system of this passive magnetotelluric method. This section shows an estimated 3 km depth of penetration and is able to define two possible porphyry cores with a possible alteration halo.

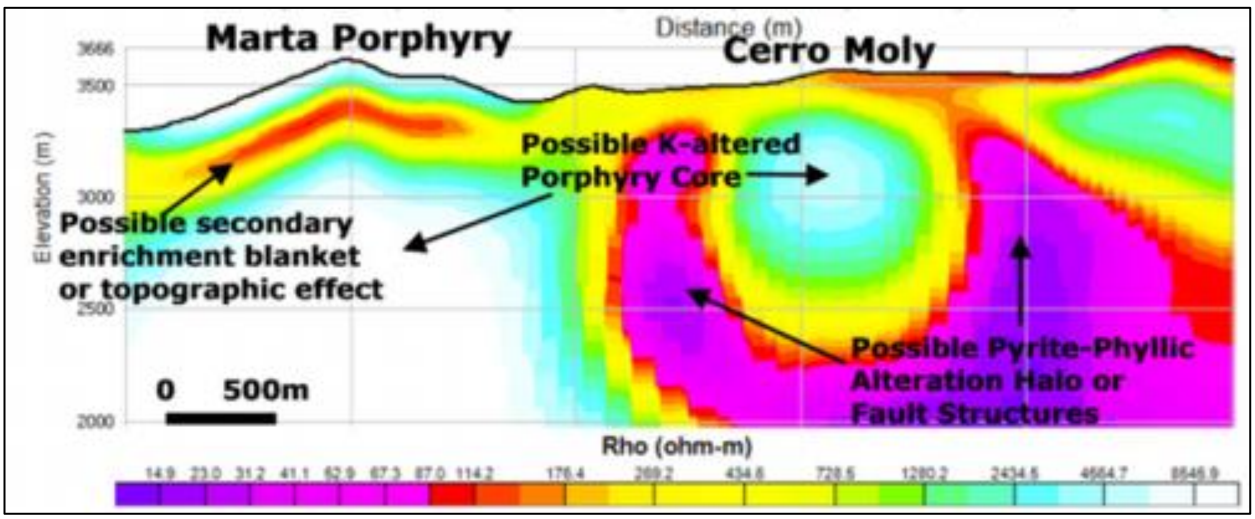

Figure 6. An inversion of ZTEM data into a resistivity section of the Copaquire porphyry deposit.

Geophysical Methods and Mineral Deposits

Each geophysical method measures a different physical property such as magnetic susceptibility, density, gamma-ray radiation energy, conductivity, etc. It will only measure an "anomaly" or change where there is a sufficient change in that physical property between adjacent rocks. One may have a situation in which two neighbouring lithologies or rocks will have similar magnetic susceptibilities but differ substantially in their geochemistry. In such as case the magnetic method will fail to resolve the contact between adjacent units, however, the radiometric method will be able to. Likewise, a granitic intrusion may appear as one body in the radiometric data but may have internal banding or layering as seen as a change in the

[4] Izarra, C., Legualt, J. and Fontura, C. ZTEM™ Airborne Tipper AFMAG Rresults over the Copaquire Porphyry, Northern Chile. 2011. Geotech Technical Paper. http://geotech.ca/papers/ztem-airborne-tipper-afmag-results-over-the-copaquire-porphyry-northern-chile/

magnetite concentration in the enhanced magnetic images. It is therefore useful to measure multiple physical properties with different geophysical methodologies simultaneously or in subsequent surveys.

The following summary table (**Figure 7**) by Ford et al. (2007)[5] evaluates the usefulness of various geophysical methods for a number of mineral deposit types in terms of understanding the geological framework (or 3D understanding) of the deposit as well as targeting the deposits directly. For our discussion, we will confine ourselves only to the airborne versions of the geophysical methods.

Geophysical Method	Air or Ground	Application	Diamonds	Lode Gold	VMS Deposits	MVT Lead-Zinc Deposits	SEDEX Deposits	Porphyry Copper Deposits	Uranium Deposits	Olympic Dam-Type Deposits	Magmatic Ni-Cu-PGEs Deposits
MAGNETIC	Air	Geological Framework	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
		Direct Targeting	Highly Effective	Generally Ineffective	Highly Effective	Generally Ineffective	Moderately Effective	Highly Effective	Generally Ineffective	Highly Effective	Moderately Effective
	Ground	Geological Framework	Highly Effective	Highly Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Moderately Effective
		Direct Targeting	Highly Effective	Moderately Effective	Highly Effective	Generally Ineffective	Moderately Effective	Highly Effective	Generally Ineffective	Highly Effective	Moderately Effective
ELECTRO-MAGNETIC	Air	Geological Framework	Moderately Effective	Moderately Effective	Moderately Effective	Generally Ineffective	Moderately Effective	Generally Ineffective	Highly Effective	Generally Ineffective	Highly Effective
		Direct Targeting	Highly Effective	Moderately Effective	Highly Effective	Generally Ineffective	Moderately Effective	Generally Ineffective	Highly Effective	Moderately Effective	Highly Effective
	Ground	Geological Framework	Highly Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Generally Ineffective	Highly Effective	Generally Ineffective	Highly Effective
		Direct Targeting	Highly Effective	Generally Ineffective	Highly Effective	Moderately Effective	Moderately Effective	Generally Ineffective	Highly Effective	Moderately Effective	Highly Effective
ELECTRIC	Ground	Geological Framework	Generally Ineffective	Generally Ineffective	Moderately Effective	Moderately Effective	Generally Ineffective	Generally Ineffective	Generally Ineffective	Moderately Effective	Highly Effective
		Direct Targeting	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Generally Ineffective	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective
GRAVITY	Air	Geological Framework	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective
		Direct Targeting	Highly Effective	Generally Ineffective	Highly Effective	Moderately Effective	Moderately Effective	Generally Ineffective	Generally Ineffective	Moderately Effective	Highly Effective
	Ground	Geological Framework	Highly Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective
		Direct Targeting	Highly Effective	Generally Ineffective	Highly Effective	Highly Effective	Highly Effective	Moderately Effective	Generally Ineffective	Moderately Effective	Highly Effective
RADIOMETRIC	Air	Geological Framework	Moderately Effective	Highly Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Moderately Effective
		Direct Targeting	Generally Ineffective	Moderately Effective	Moderately Effective	Generally Ineffective	Generally Ineffective	Highly Effective	Highly Effective	Highly Effective	Generally Ineffective
	Ground	Geological Framework	Generally Ineffective	Highly Effective	Moderately Effective	Generally Ineffective	Moderately Effective	Highly Effective	Highly Effective	Highly Effective	Moderately Effective
		Direct Targeting	Generally Ineffective	Moderately Effective	Moderately Effective	Generally Ineffective	Generally Ineffective	Highly Effective	Highly Effective	Highly Effective	Generally Ineffective
SEISMIC	Ground	Geological Framework	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective
		Direct Targeting	Moderately Effective	Generally Ineffective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective

Qualitative Applicability Rating of Geophysical Method: Highly Effective Moderately Effective Generally Ineffective

Figure 7. Utility of Geophysical Methods in Exploration for Specific Mineral Deposit Types.

Aeromagnetics is useful "across the board" for the different mineral types to define the geological framework. That is, geological terrains, faults, folds, etc. at surface and at depth can be derived from the magnetic data. Further processing, modelling and inversion can provide information as to the size and shape of the rock units. Radiometrics is also generally highly or moderately effective for all of these mineral types at surface and in conjunction with aeromagnetics provides the best combination to create a lithological and structural interpretation of an area. Gravity data (scalar gravity and gravity gradiometry) also provides more information to the geologic framework while being more effective for some types of

[5] Ford, K., Keating, P. and Thomas, M. D. (2007) Overview of geophysical signatures associated with Canadian ore deposits in Mineral deposits of Canada: a synthesis of major deposit-types, district metallogeny, the evolution of geological provinces, and exploration methods; by Goodfellow, W D (ed.); Geological Association of Canada, Mineral Deposits Division, Special Publication no. 5, 2007 p. 939-970.

direct targeting. Finally, electromagnetics is designed specifically for the sulphide bearing mineral deposits.

Other Benefits of Geophysical Surveys

A geophysical survey has numerous benefits beyond that of resource exploration.

Lahti et al. (2005)[6] describe a variety of scenarios in which airborne magnetic, electromagnetic and radiometric data have been used in non-exploration ways. Examples given were for mapping groundwater aquifers in glaciofluvial formations, certain types of wastewater ponds, landfill monitoring, environmental risks associated with old uranium mining operations, and monitoring background radiation levels.

Airborne radiometric surveys have used to map the amount of naturally occurring radon within the soil produced by the trace natural uranium decay in bedrock. Radon is a health risk and knowledge of the risk areas allow homeowners to install equipment to minimize exposure. A map of potential radon risk has been produced for Nova Scotia[7], but was produced using samples of indoor air. A geophysical survey will map the risk areas where no such samples have been taken.

In summary, radiometric data provide a radioelement baseline that is applicable for comparison with anthropogenic activity such as contamination from industrial sources, nuclear accidents and lost sources (e.g. satellite re-entry, medical). They are useful to plan geochemistry surveys as they map the characteristics and sometimes the sources of regolith and transported material (e.g. fluvial sediments).

Relative Costs of Different Airborne Geophysical Methods

There is a wide range of costs between the various geophysical methods. More often than not, two or more geophysical methods are measured aboard the same aircraft platform for efficiency, e.g. magnetics and radiometrics. The cost is also dependent on the type of aircraft platform. A helicopter platform is much more expensive than a fixed wing platform on a per kilometer rate as a helicopter is less efficient, but is able to provide superior quality data. If the location of the survey is isolated or rugged, costs will also increase. Dentith and Mudge (2014)[8] have summarized the various methods with respect to cost and the area of investigation, as shown in **Figure 8** below. The airborne methods of fixed wing magnetics/radiometrics, aerogravity gradiometry, fixed wing and helicopter electromagnetics and aerogravity all cover large areas of investigation with each being more expensive than the previous. Ground acquisition for gravity, magnetics, resistivity and induced polarization (IP) data rival or exceed the costs of an airborne survey in terms of $/km but cover much smaller areas and are more suitable for deposit scale investigations. Finally, ground seismic surveys are the most expensive and cover the least amount of area.

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[6] Lahti, Mari; Vanhalla, Heiki; Mattsson, Annina; Beamish, David; Lerssi, Jouno. 2005 Environmental applications of airborne geophysics: groundwater and contaminated soil in Finland, Germany and United Kingdom. In: Airo, Meri-Liisa, (ed.) Aerogeophysics in Finland 1972-2004: methods, system characteristics and applications. Espoo, Finland, Geological Survey of Finland, 155-175. (Special Paper Geological Survey of Finland).
[7] https://fletcher.novascotia.ca/DNRViewer/?viewer=Radon
[8] Dentith, M. and Mudge, S. T. (2014) Geophysics for the Mineral Exploration Geoscientist. Cambridge University Press, Cambridge, UK., 454 p.

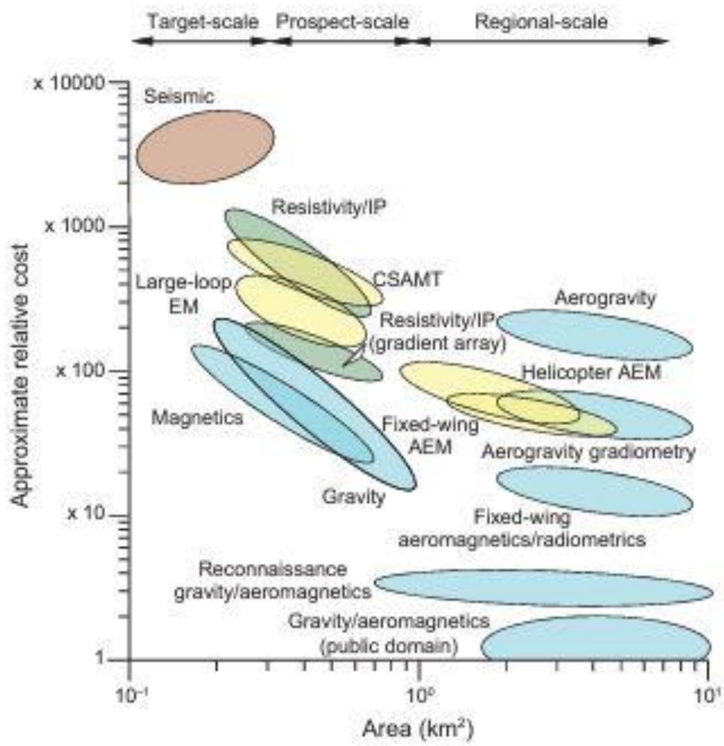


Figure 1.2 Approximate relative costs per square kilometre of different kinds of geophysical surveys and the approximate variation with size of the survey area. AEM – airborne electromagnetics, CSAMT – controlled source audio-frequency magnetotellurics, EM – electromagnetics, IP – induced polarisation. Redrawn with additions, with permission, from Fritz (2000).

Figure 8. Approximate relative costs per square kilometre of different kinds of geophysical surveys.

Geophysical System Configurations

It is possible to customize and tailor the geophysical methods in the acquisition platform to suit exploration goals. Common configurations and platforms include:

- Magnetic gradiometry and radiometrics – fixed wing and helicopter
- TDEM and magnetics – helicopter
- FDEM and magnetics – helicopter
- Gravity and magnetics – fixed wing
- Gravity gradiometry and magnetics – fixed wing

Magnetics is common to all platforms due to the relative ease, reliability and low cost. VLF instrumentation is just a receiver (no transmitter required) and could be easily added to a fixed wing or helicopter platform for a nominal cost.

Most TDEM and FDEM surveys are conducted on a helicopter platform. With regards to TDEM, the amount of power that is pulsed into the ground is dependent upon the dipole moment of the transmitter which is proportional to the number of turns, area and current of the transmitter (referred to as a system's NIA). Since the transmitter and receiver are towed beneath the helicopter there are only weight and manoeuvrability issues with regards to the size of the transmitter. On a fixed wing aircraft, the size of the transmitter is dependent upon the size of the aircraft since the transmitter is looped around the nose, wingtips and tail.

Less common are the "all-in-one" systems which combine magnetics/radiometrics with an electromagnetic system (TDEM or FDEM) or gravity with a magnetics/radiometrics and electromagnetic system. Most electromagnetic systems are on helicopter platforms which limits space and weight. The additional weight of the spectrometer (~150 kg) and/or a gravimeter (~150 kg or more) in addition to the towed electromagnetic/magnetic system seriously diminishes the number of line kilometers that can be flown during one sortie.

For example, Sander Geophysics Limited (www.sgl.com) is an Ottawa based company that conducts geophysical surveys worldwide. Their fleet consists of twelve fixed wing aircraft and two helicopters. The aircraft can be outfitted in the following combinations:

- Magnetic gradiometry and radiometrics ± gravity – 11 fixed wing aircraft
- Magnetic gradiometry and FDEM ± radiometrics ± gravity – 1 fixed wing aircraft
- Magnetic and TDEM or FDEM ± Radiometric ± gravity – 2 helicopters

Geotech Ltd. (www.geotech.ca) is another Canadian geophysical survey company specializing in electromagnetic surveying. Their fleet consists of five fixed wing aircraft and twelve helicopters. The aircraft can be outfitted in the following combinations:

- Magnetic gradiometry and radiometrics – all 5 fixed wing aircraft
- Magnetic gradiometry and gravity – only 2 fixed wing aircraft
- Magnetic gradiometry and ZTEM – only 2 fixed wing aircraft
- Magnetic gradiometry and radiometrics ± TDEM – all 12 helicopters
- Magnetic gradiometry ± radiometrics ± ZTEM – all 12 helicopters
- Magnetic and gravity – only 2 helicopters
- Magnetic and gravity and ZTEM – only 2 helicopters

CCG (www.cgg.com) has the TEMPEST system that can be outfitted with TDEM, magnetic gradiometry, radiometrics and gravity. However, they have only two such aircraft in their world-wide fleet.

From this sampling, it can be seen that "all-in-one" geophysical systems are rare in the industry. It is more efficient to fly a magnetic gradiometry and radiometric survey first, review the results and decide upon follow-up surveys with a geophysical method targeted to the mineral deposit type and the location/depth of the target.

Other Considerations in Survey Planning

The purpose of a geophysical survey is to detect the geology below the surface cover, whether that cover be soil, sediments, water or man-made infrastructure. This is done by measuring changes in the physical properties of the rocks. The different methods, i.e., magnetic gradiometry, radiometric, electromagnetic, etc. measure different physical properties such as susceptibility, density and conductivity. The ultimate aim is to define the lithologies ("what type of rock is it?") and the structure (faults, folds, alteration, etc.). How well or precisely that can be determined is controlled by the resolution of the survey. The two factors that most affect the resolution of the final data is the flight line spacing and flying height. Each will be discussed in the following sections.

Resolution – Flight Line Spacing

The resolution of the final grids or images are defined by its "grid cell size". That is, the size of each "pixel" in the image or grid. A smaller grid cell will result in a higher resolution image which will be capable of defining smaller features. That detail may be an anomaly that would be undetected or missed by a lower resolution survey or it may be vague in character. For example, the location and/or character of a fault would be better defined in a survey with a small grid cell size. Current acceptable practice is the grid cell size of the final processed images be 1/5th of the survey flight line spacing.

The total flight line distance is a measurement from two sets of survey lines. Flight lines or "traverse lines" are the lines from which the final grids or images are calculated. However, a survey may take many weeks to complete. In that time the magnetic field does change in intensity, instruments may have been replaced, aircrafts replaced, etc. Thus, there can be an offset or shift in the data from line to neighbouring line due to the time elapsed or different instruments. To level the data from line to line, "tie lines" are flown perpendicular to the traverse lines. The tie lines are not flown at the same spacing as the traverse lines, but usually at about 10 times the traverse line spacing (see **Figure 9** for an example).

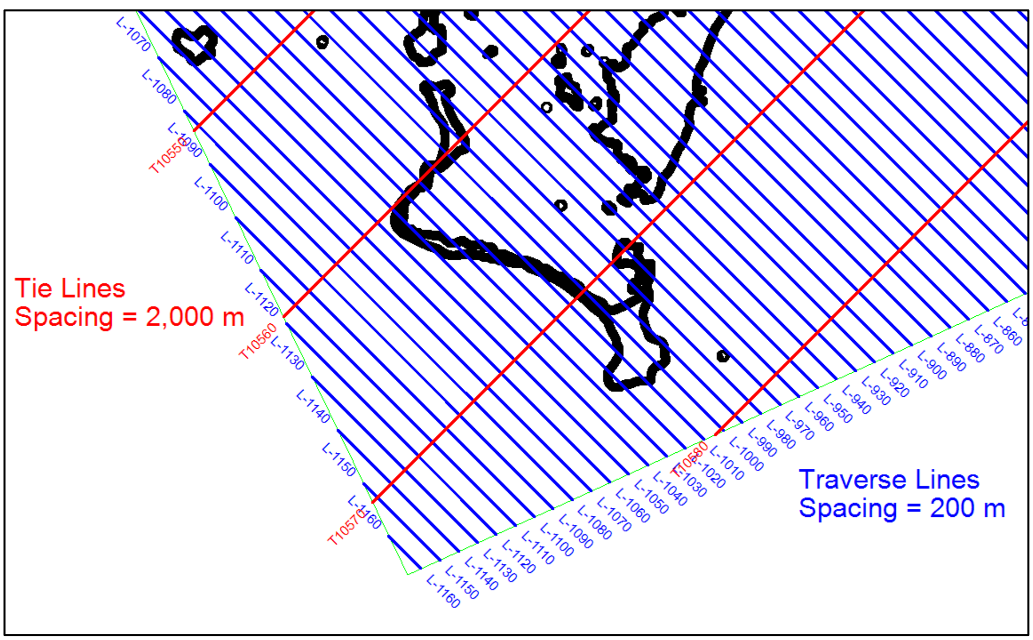
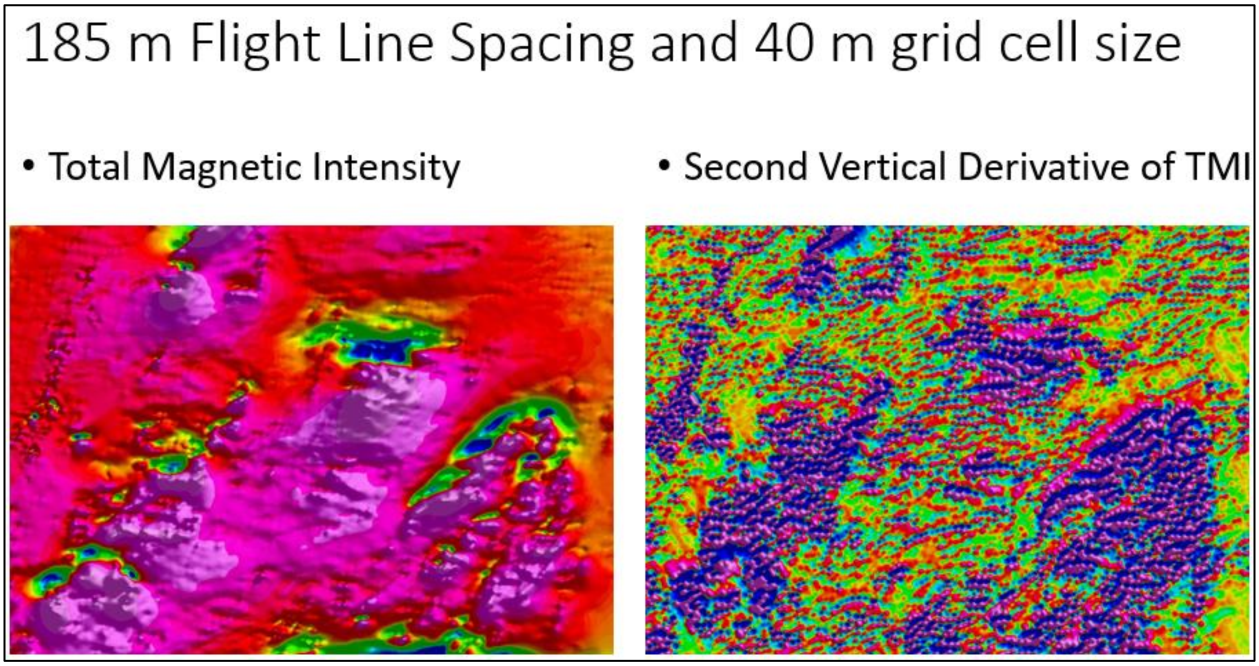
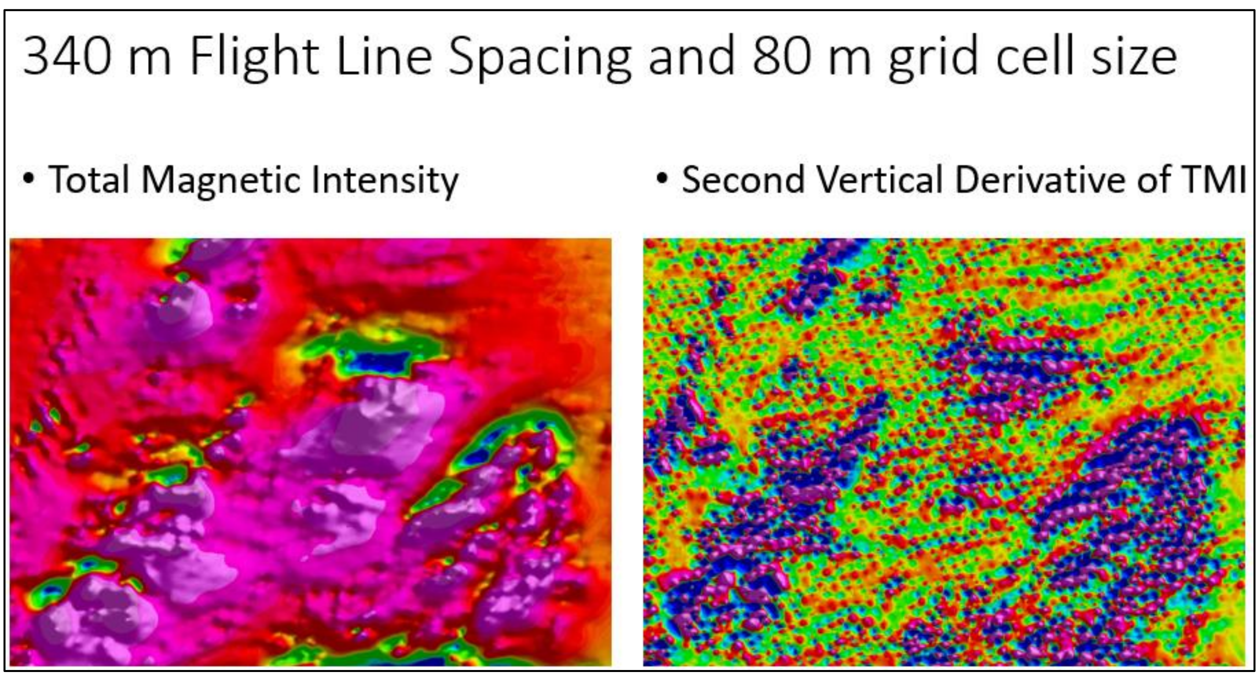


Figure 9. Traverse line and Tie line example.

In the following example in **Figure 10**, the degradation of the resolution related to the flight line spacing is illustrated by decimating a magnetic database from its original 185 m flight line spacing to 370 m, 555 m and 740 m. The grid cell size increases with increasing flight line spacing and the resolution decreases. The images represent the total magnetic intensity (left) and its second vertical derivative (right) which enhances short wavelength features near the surface. It is obvious from this example how much detail is lost as the line spacing and grid cell size are increased. The same loss of resolution with an increased flight line spacing occurs with radiometric, gravity and electromagnetic data as well.





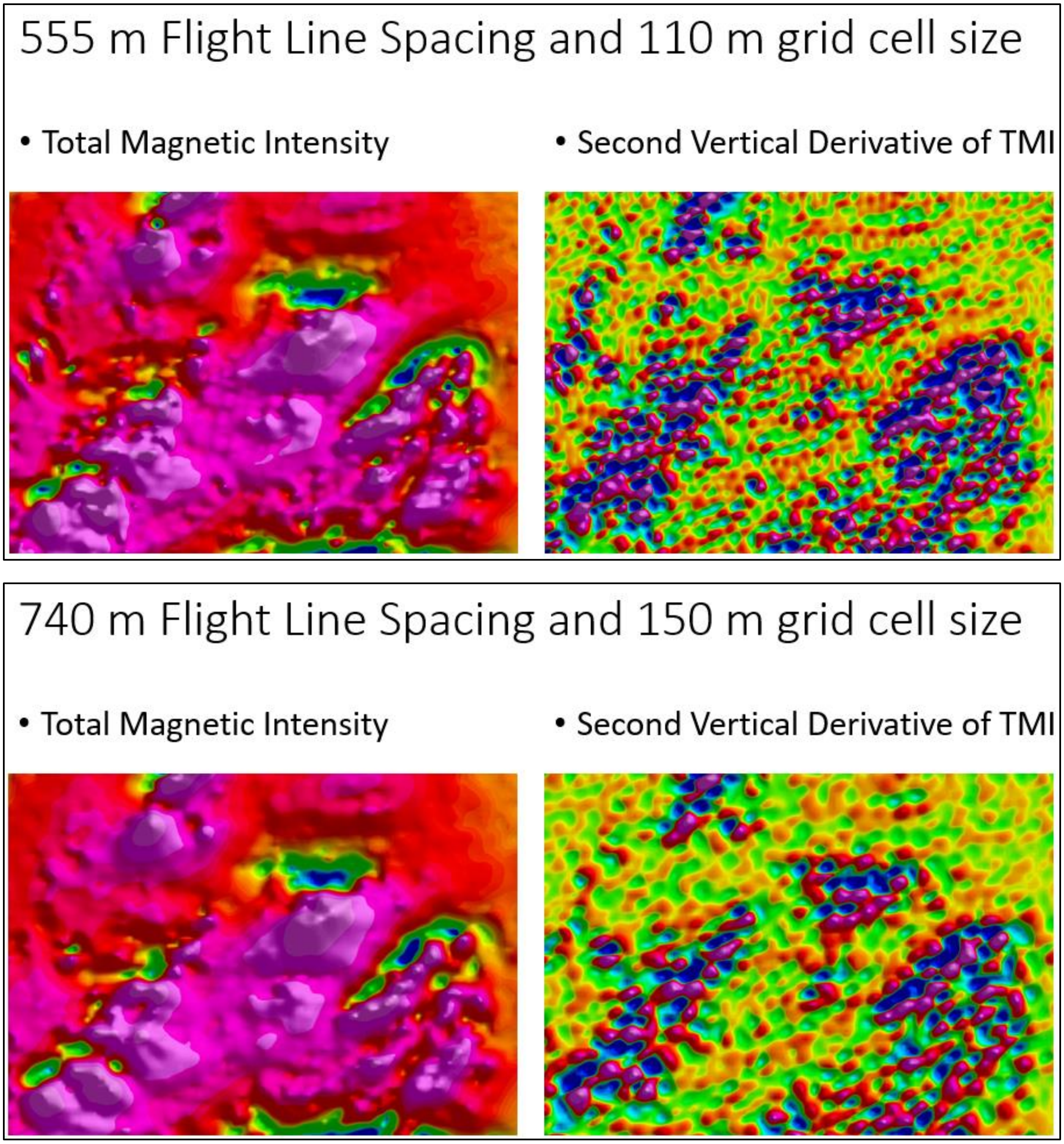
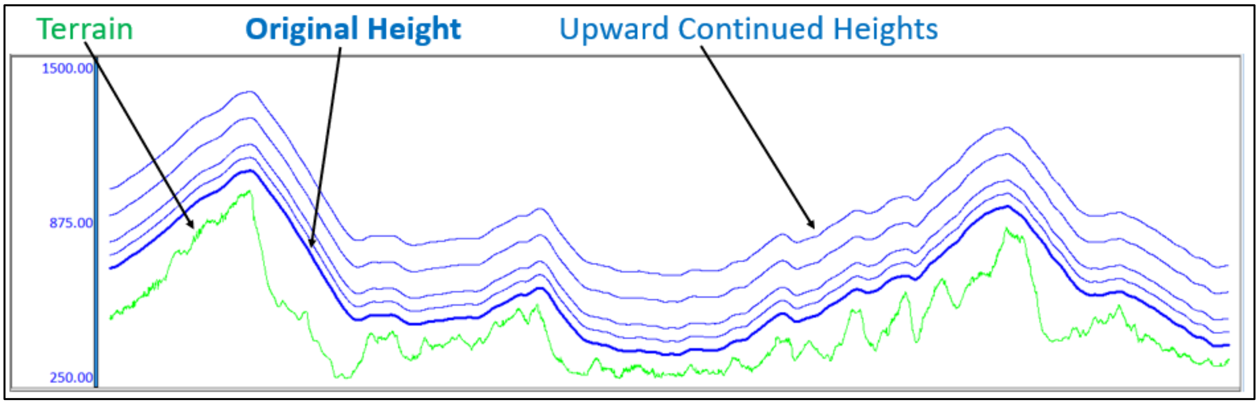


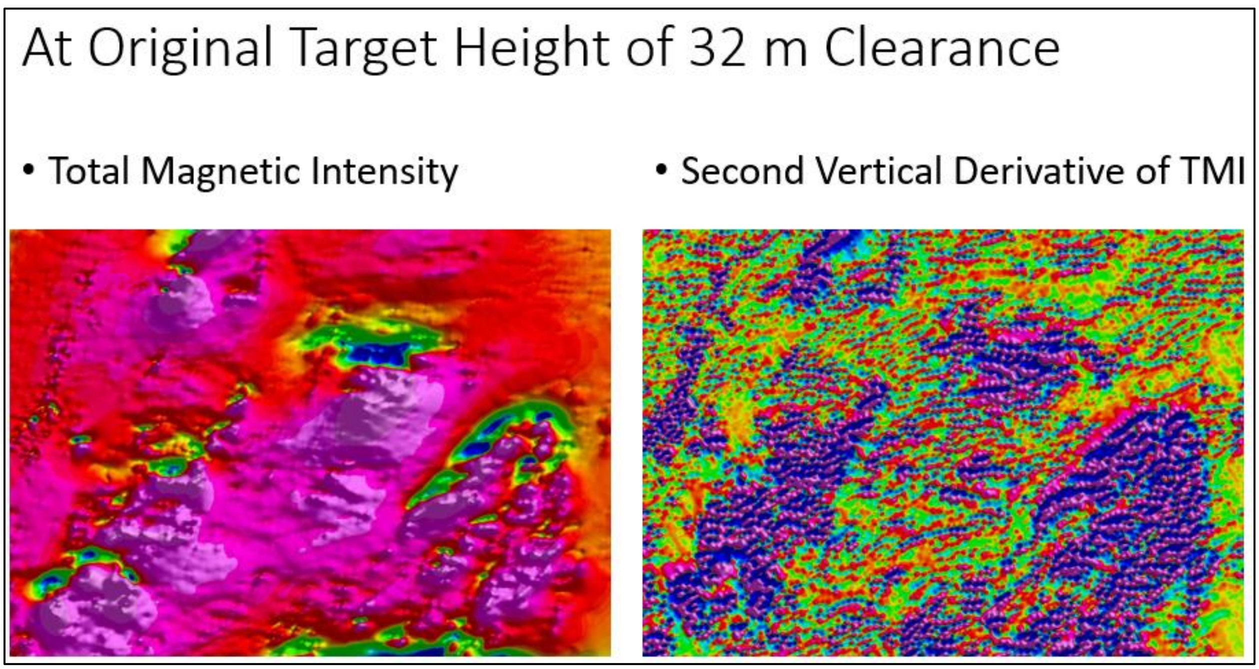
Figure 10. An example of the loss of resolution with increasing line spacing.

Resolution – Flying Height

Another factor that effects the resolution of the data is the height of the aircraft above ground. The closer the instrument is to the ground, the better the signal and ultimate resolution of anomalies whether they be magnetic, radiometric, gravity or electromagnetic. The same anomaly will reduce in amplitude and sharpness as signal attenuates with distance from source. Flying height must be balanced against safety concerns of fixed wing or helicopter aircraft flying at such low clearances, generally <100 m from ground.

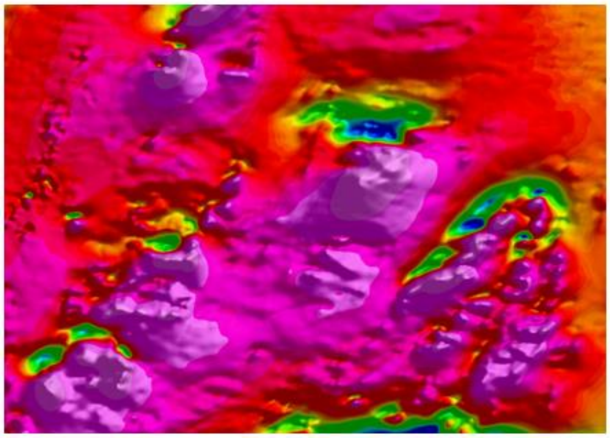
In the following example **Figure 11,** different flying heights can be simulated by upward continuing the data as though it was flown at a different heights. In this survey, the original sensor height was 32 m above the terrain since the magnetometer was towed below a helicopter. The data measured at this height was processed as though it was flown at 82 m, 132 m, 232 m and 332 m above ground. As in the previous example, the images represent the total magnetic intensity (left) and its second vertical derivative (right) which enhances short wavelength features near the surface. As with the previous example, resolution and fine detail are lost with an increase in survey height.

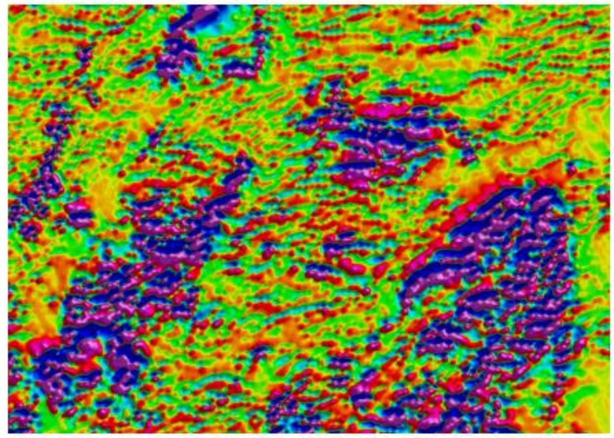




Upward Continued 50 m to 82 m Clearance

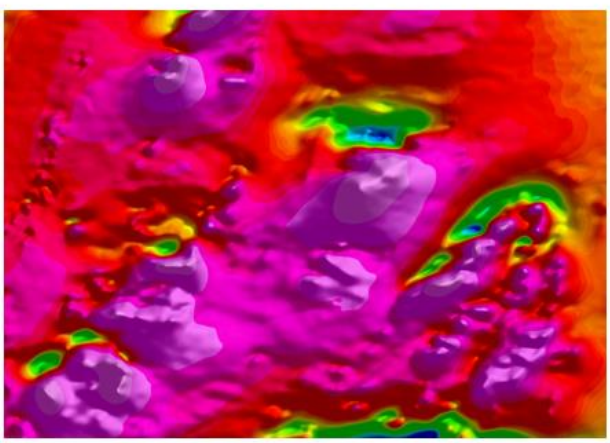
- Total Magnetic Intensity
- Second Vertical Derivative of TMI

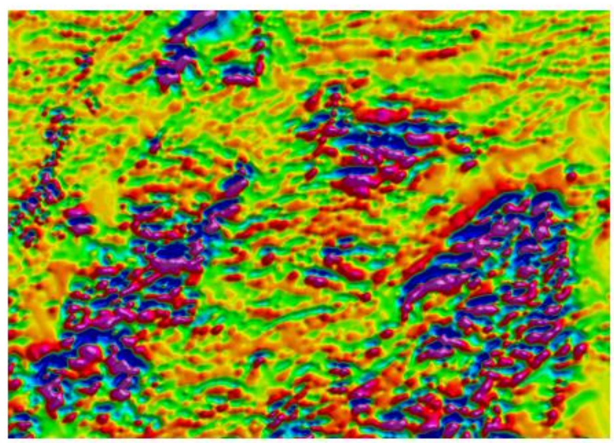




Upward Continued 100 m to 132 m Clearance

- Total Magnetic Intensity
- Second Vertical Derivative of TMI





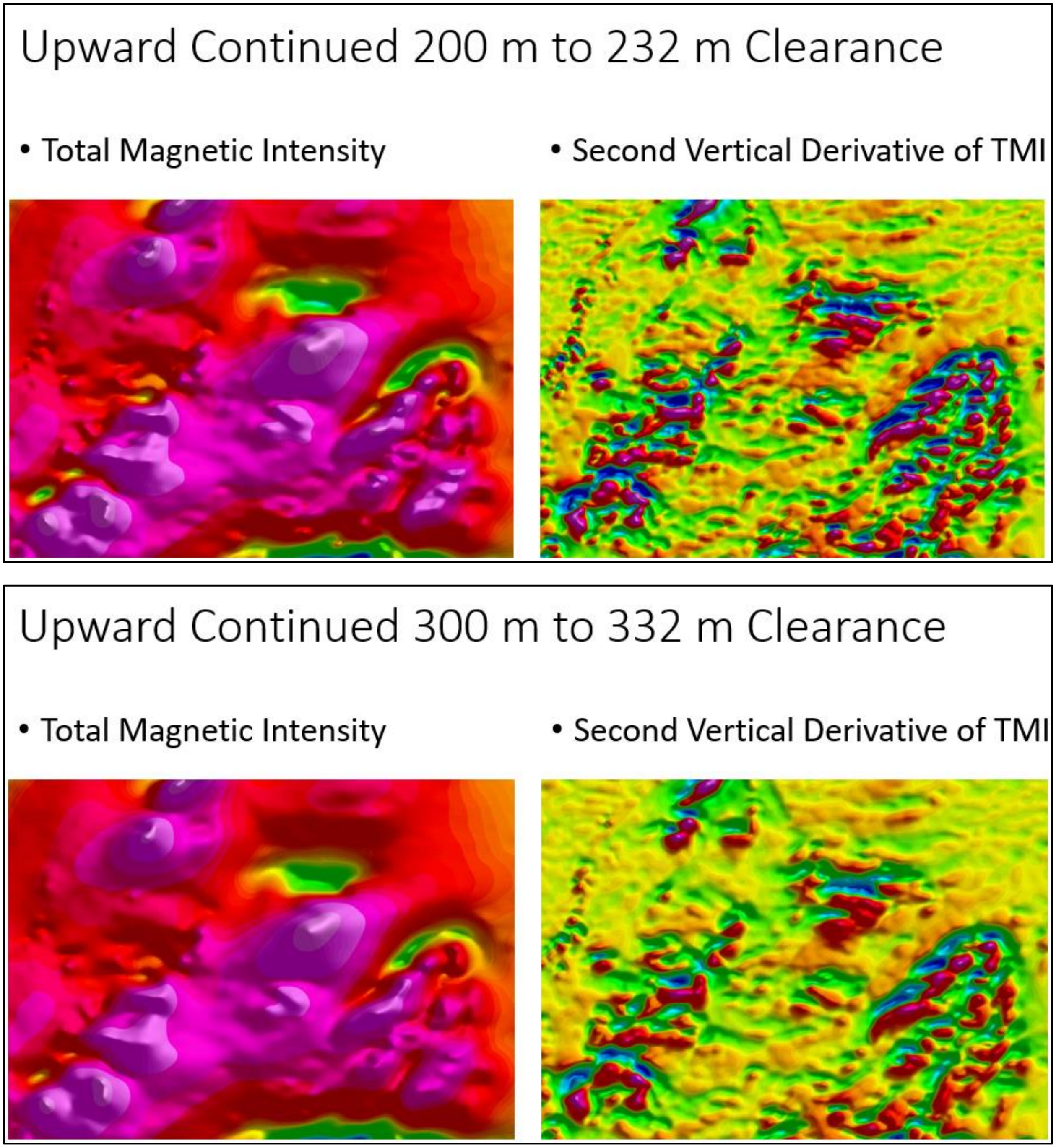


Figure 11. An example of the loss of resolution with increasing survey height.

A 100 m terrain clearance is standard amongst magnetic/radiometric surveys. However, that is not to say that the aircraft can always maintain an altitude of 100 m exactly and continuously. A fixed wing aircraft has a set rate of safe climb and descent rates. The topography of Nova Scotia varies from sea level to approximately 530 m above sea level (**Figure 12**). The surface topography undulates at a rate faster than a fixed wing aircraft can follow or mimic, thus there will be locations along the flight path where the aircraft will be at a height less or more than the specified 100 m. During the survey planning phase, the survey contractor will construct a planned survey height or “drape height” based upon the safe climb and descent rates of the aircraft and to allow the traverse line and tie lines to intersect at the same altitude. As well, pilots are given some leeway to deviate from this drape surface, i.e. usually a leeway of ± 15 m and even more if safety is a concern (cell towers, buildings, etc.). In **Figure 13** below, a profile of the topography is shown as the black profile. The red profile is the calculated drape height for the aircraft. It appears as a smoother version of the elevation raised approximately 100 m above the topography. There are locations, as shown on the right side, where the aircraft is incapable of following the steep terrain and the altitude of the aircraft will be much more than 100 m. For the magnetic and VLF data, large differences in survey height will degrade the resolution of the data since the instrument is further away from the source rocks, however there will still be a measurable signal. For radiometric data there can be some adjustment made for variations in altitude but only to a certain height above the ground. At altitudes of approximately 300 m or more, the radiometric signal is becoming overwhelmed with noise. At altitudes of more than 400 m, the radiometric signal from the ground are not useable.

In the survey planning phase of the project it is useful to prepare a drape surface and to compare with the topography to determine areas where data tolerances will be exceeded. A preliminary drape surface using standard climb and descent rates for a fixed wing aircraft was prepared. The estimated terrain clearance is calculated by subtracting the topography from the drape surface. An image of the clearance was created (**Figure 14**) and coloured so that areas in which the aircraft will be within the limits of 100 m ± 15 m are shown in blue. Areas in which the clearance is between 115 m and 300 m are shown in green. Areas in which the clearance is between 300 and 400 m are shown in orange and areas of more than 400 m is shown in red. For all areas, the magnetic and VLF data will be useable, but just at a lower resolution at the higher heights. For the radiometric data, the data in the blue and green areas will be useable while areas shown in orange will be problematic. In areas in red, the radiometric data will not be useable. Only 1% of the total area is over 300 m clearance and 0.1% of the area is over 400 m. Therefore, by this quick study, it can be seen that a provincewide survey will have almost completely useable radiometric data as well as complete coverage by magnetic data.

A helicopter, by its design, is more maneuverable and can maintain a clearance that mimics the topography more closely that a fixed-wing aircraft. As well, helicopters often tow sensors beneath on a long-line which result in a lower terrain clearance. Thus, a completely different drape surface would be calculated for a helicopter survey. The disadvantages of a helicopter survey are its high costs (9 to 10 times that of a fixed wing aircraft) and its lower weekly production rates.

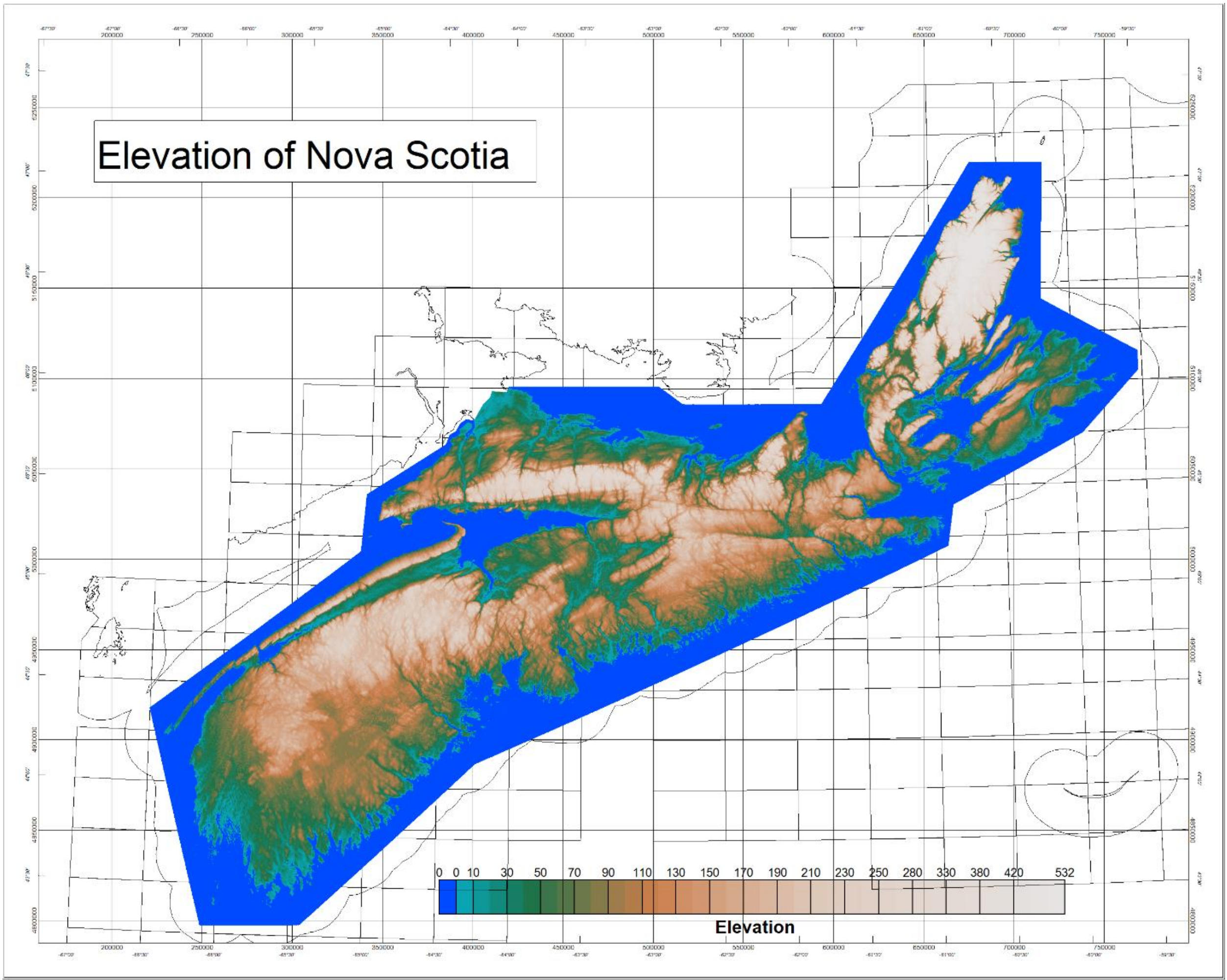
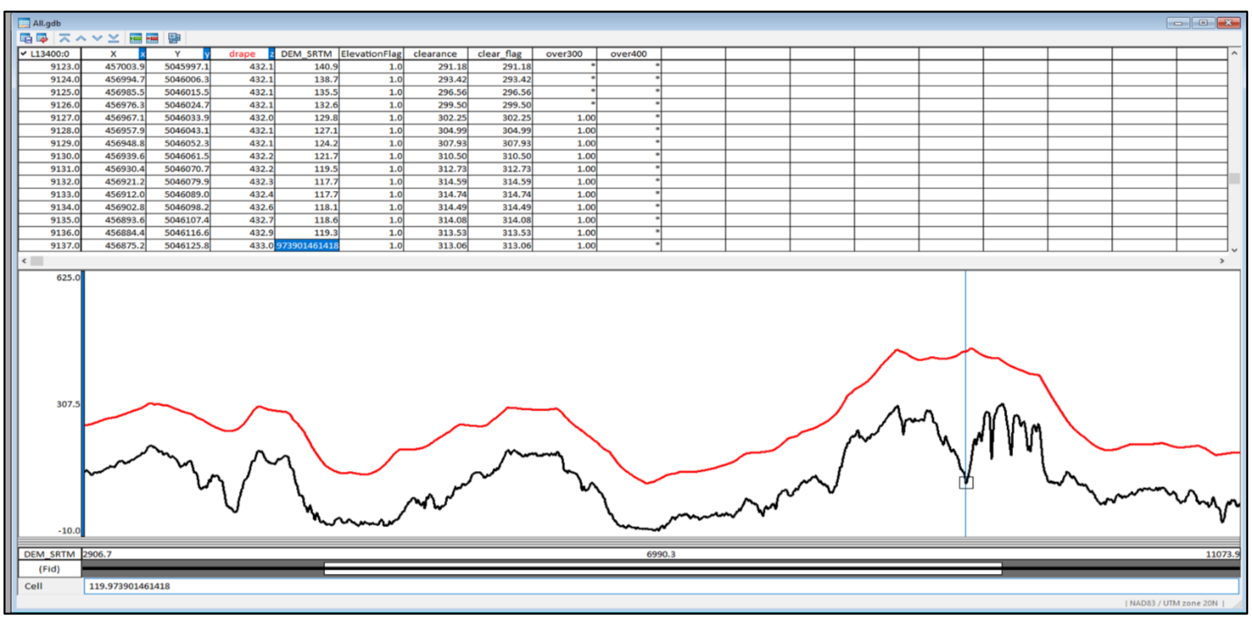


Figure 12. Elevation image of Nova Scotia.



L13400:0	X	Y	drape	DEM_SRTM	ElevationFlag	clearance	clear_flag	over300	over400
9123.0	457003.9	5045997.1	432.1	140.9	1.0	291.18	291.18	*	*
9124.0	456994.7	5046006.3	432.1	138.7	1.0	293.42	293.42	*	*
9125.0	456985.5	5046015.5	432.1	135.5	1.0	296.56	296.56	*	*
9126.0	456976.3	5046024.7	432.1	132.6	1.0	299.50	299.50	*	*
9127.0	456967.1	5046033.9	432.0	129.8	1.0	302.25	302.25	1.00	*
9128.0	456957.9	5046043.1	432.1	127.1	1.0	304.99	304.99	1.00	*
9129.0	456948.8	5046052.3	432.1	124.2	1.0	307.93	307.93	1.00	*
9130.0	456939.6	5046061.5	432.2	121.7	1.0	310.50	310.50	1.00	*
9131.0	456930.4	5046070.7	432.2	119.5	1.0	312.73	312.73	1.00	*
9132.0	456921.2	5046079.9	432.3	117.7	1.0	314.59	314.59	1.00	*
9133.0	456912.0	5046089.0	432.4	117.7	1.0	314.74	314.74	1.00	*
9134.0	456902.8	5046098.2	432.6	118.1	1.0	314.49	314.49	1.00	*
9135.0	456893.6	5046107.4	432.7	118.6	1.0	314.08	314.08	1.00	*
9136.0	456884.4	5046116.6	432.9	119.3	1.0	313.53	313.53	1.00	*
9137.0	456875.2	5046125.8	433.0	973901461418	1.0	313.06	313.06	1.00	*

Figure 13. Comparison of Topography (black profile) and Drape Height (red profile) along a flight line.

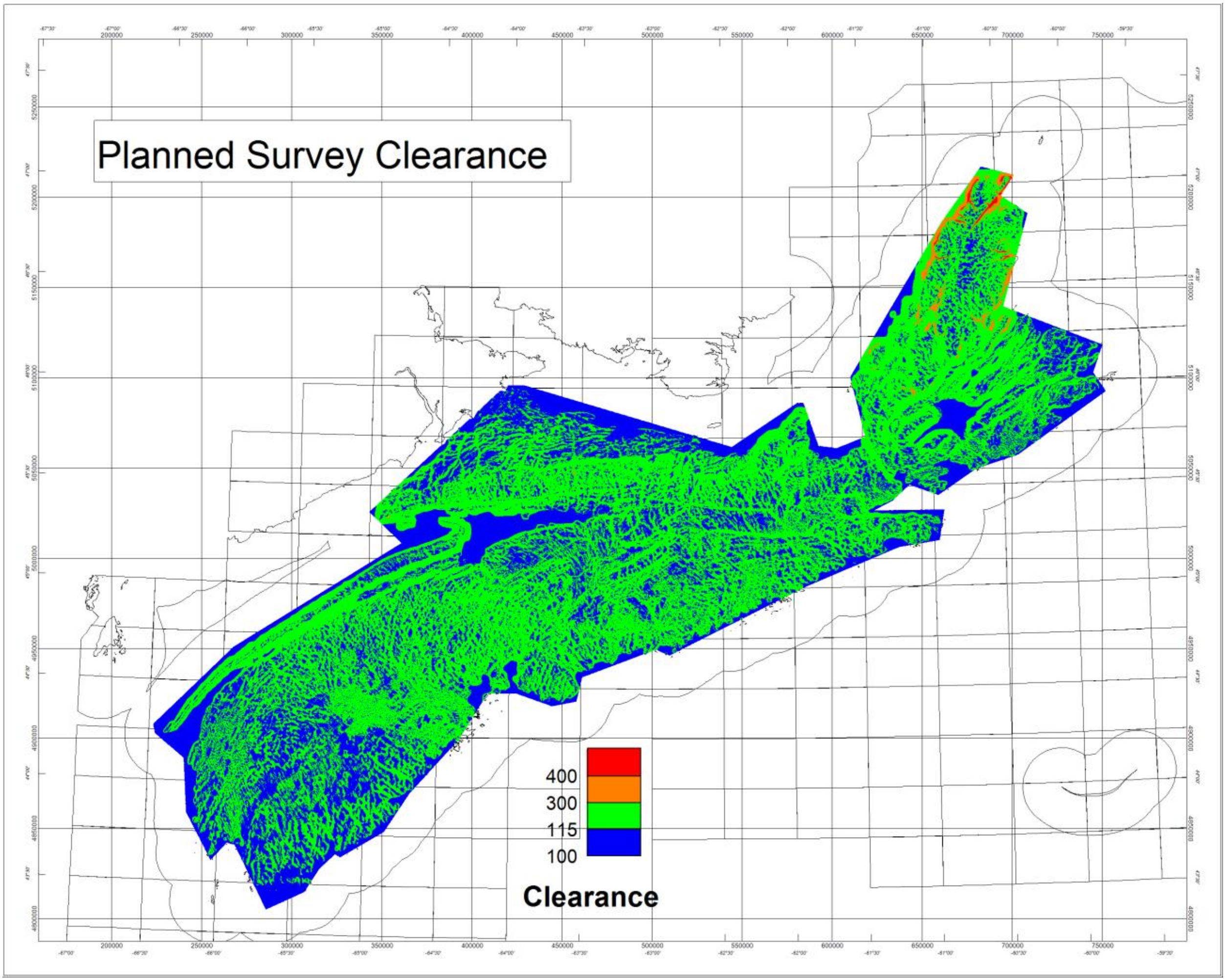


Figure 14. Aircraft clearance for a standard fixed wing aircraft.

Assessment of the Current State of the Government Data for Nova Scotia

There are two sources of geophysical data currently available for the province of Nova Scotia. They are: 1) Government funded, freely and publicly available data and 2) Proprietary data flown for mining companies and/or mineral exploration companies. The publicly available data was downloaded through the Web Map Services (WMS) server from Natural Resources Canada[9] or directly through a geophysical processing and mapping software package such as Geosoft™ Oasis Montaj.

The data was assessed by its quantitative and qualitative characteristics. The quantitative aspect is simply the coverage of the survey and the geophysical method used. Survey coverage also considers whether that coverage is continuous, i.e., with no holes or gaps within the survey area. Also, what general geophysical method was used for the survey, i.e., magnetics, radiometrics, gravity, Time Domain or Frequency Domain electromagnetics, VLF, etc. The qualitative character of the survey are those aspects that directly impact the quality of the final data. Such parameters can be the sensor instrumentation, single or multiple sensor configurations, survey height of the aircraft, survey speed of the aircraft, flight line spacing, processing of the data and grids, etc.

The data was evaluated by an examination the flight path and the creation of magnetic and radiometric grids from the profile data. Additional comments were noted, where applicable.

A "good" flight path is one that in which the flight line spacing was reasonably constant and flown with limited lateral or vertical deviations as in the example below and left (**Figure 15**). Flight lines that cross over one another or nearly touch can create artefacts that would need to be edited out of the database.

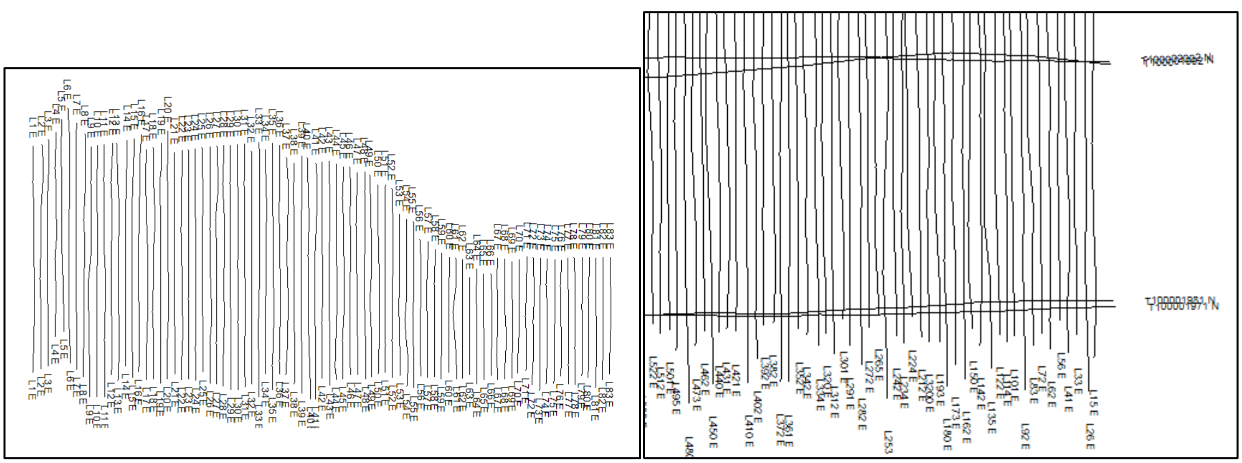


Figure 15. An example of good (left) and fair (right) flight path. Note the overlapping tie lines and the near touching flight lines in the fair example.

The magnetic and radiometric profile data was processed into grids or "images" using a grid cell size of 1/5th of the flight line spacing. The grids were reviewed to see whether further processing would be required. The amount of processing determined whether the quality was defined as "good", "fair" or "poor". Such processing may include editing, tie line levelling and microlevelling. Editing would be required to correct errors in the magnetic database. For example, flags for "no data" may have been

[9] http://gdr.agg.nrcan.gc.ca/gdrdap/dap/search-eng.php

designated with the numeral -9999, which would need to be removed before a grid could be created as it is not real data. Tie line leveling would shift neighbouring lines with respect to a tie line flown across them. Microlevelling can correct smaller shifts between lines that may have been due to different flying heights or level changes that were not corrected by tie line levelling. Tie lie and microlevelling problem areas are most easily observed by the creation of a sun shaded image in which the sun direction is perpendicular to the flight line direction. The shadows created by the simulated sun-shading highlight the areas where improvements could be made.

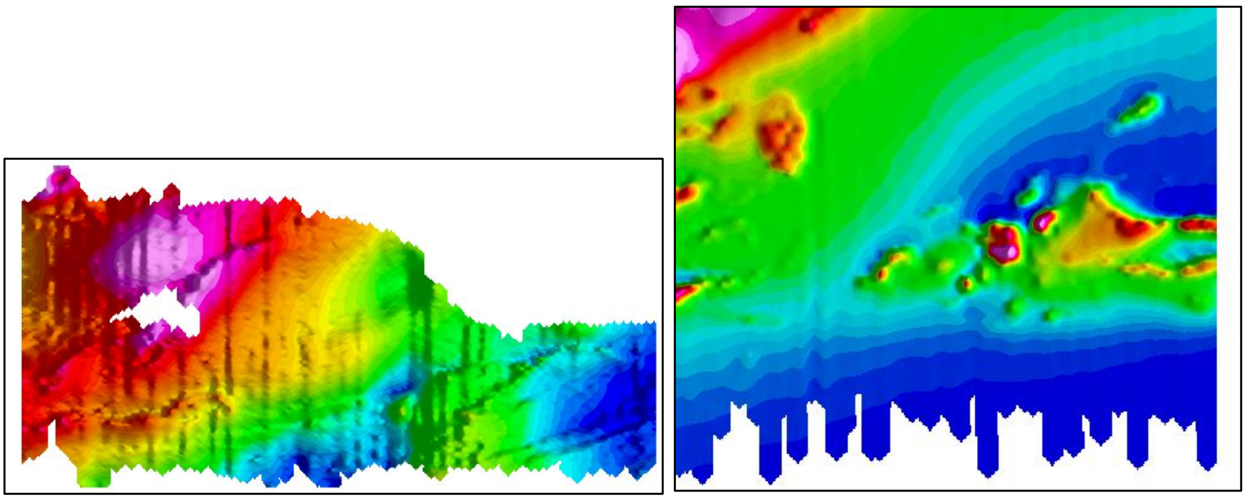


Figure 16. Magnetic data quality that is poor (left) and fair (right) for the same data sets are shown in the previous figure.

In **Figure 16** above, the survey (Amherst-Pugwash) which was deemed to have a “good” flight path but produced only a “fair” magnetic image. Tie line levelling of the data would be required, however the database does not contain any tie lines for this procedure to be completed. Microlevelling may assist in an improvement of the image. The survey (Antigonish) for which the flight path was considered only “fair”, produced a “good” quality image. The tie line levelling procedure produced a well levelled image and there are only a few instances where further processing by microlevelling would improve the image.

The radiometric data was good overall for its vintage. The dominant limiting factor for the radiometric data was its large grid cell size due to a flight line spacing at generally 1000 m and greater and the lack of intermediate processed channels in the profile database.

Data from the Geological Survey of Canada (GSC)

An assessment review of the available airborne geophysical survey data flown for the Geological survey of Canada was completed and is included in Appendix A. The airborne geophysical methods used in these surveys are one or a combination of magnetic, radiometric and VLF methods. There is no publicly available airborne gravity data in Nova Scotia. The surveys were funded by the GSC can be subdivided into two distinct groups.

Early Analogue GSC Data

There are 24 surveys flown for the GSC between 1953 and 1979. They are designated by the filename "Nova Scotia #xx" where xx is the survey number. All of these surveys were acquired using a single sensor magnetometer. The data was measured as analogue with chart recorders along a photographed flight path. Recorded chart values were transferred to the flight path and contoured manually. Subsequently the contours were digitized to produce the digital databases and grids. Digitized data is inherently lower quality than the original acquired data. The data is in a Geosoft™ database format and no grids or images are readily available from the individual surveys. However, a compiled magnetic grid is available with a grid cell size of 250 m that is downloadable from the GSC WMS server. The channels in the database contain location information in the form of Eastings and Northings and Latitude and Longitude in the NAD27 datum. The magnetic channel is only the final processed magnetic value from the contoured map that was digitized. No raw or intermediate magnetic channels are included. An additional residual magnetic channel has been calculated which has levelled the magnetic values to the surrounding surveys. The databases contain no recorded data with respect to the survey height, so it can only be assumed that aircraft was always at that prescribed survey height. Most survey heights were at 305 m (1000 feet) above ground level though some surveys were flown as low as 61 m (e.g. Nova Scotia #01 flown over the Atlantic Ocean) to as high as 1000 m (e.g. Nova Scotia #07 over southeastern Cape Breton Island).

As an aside, there are a number of surveys that have supplemental survey designated with the "(TO MERGE)" addition to their filename, for example, Nova Scotia #8 and Nova Scotia #8 (TO MERGE). The Canadian Aeromagnetic Data Base Project Number and Part Number are identical between the two surveys. The surveys were flown at the same time and have the same surveying parameters; thus, the data may just have been released at different times.

Quantitively, these GSC surveys cover most of the onshore portion of the province with the exception of the Bay of Fundy region that is north of 45° and west of -64° (covering parts of Kings, Hants, Colchester and Cumberland counties). **Figure 17.** Flight path (red) of the various Nova Scotia surveys flown for the GSC and digitized from hardcopy contour maps. illustrates the flight path coverage of these surveys. Some areas offshore to the west, north and south of Nova Scotia were also surveyed.

Qualitatively, the aeromagnetic data from these surveys is problematic due to a number of factors, of which the most important are:

a. old magnetometer instrumentation
b. wide flight line spacing of 805 m (half mile) and wider, for the most part
c. survey heights of 305 m or more, for the most part
d. poor positioning of the data locations (pre-GPS, mainly by air photo mosaic)

e. digitizing of the hand drawn contour data.

23 of the 24 survey were flown between 1953 and 1962. One survey in this series was flown in 1979. Needless to say, the magnetometers, data acquisition and storage systems have vastly improved since then in terms of sensor sensitivity, accuracy and sampling frequency. The flight line spacing ultimately controls the grid cell size of the resultant grids or images of the magnetic field and derivatives of that grid. Grid cell size is usually 1/4th to 1/5th of the flight line spacing. For surveys with a flight line spacing of 805 m (1/2 mile), the resultant grid will have a grid cell size of 200 m, thus each pixel of the image will have a size of 200 m and therefore impossible to resolve features that that are smaller than this. The images produced from these data sets are useful for regional studies, but not at the scale for mineral exploration. **Figure 18. Flight path of the various Nova Scotia surveys flown** for the GSC and digitized from hardcopy contour maps. Flight line spacings of 805 m shown in red, flight line spacings less than 805 m shown in blue and flight line spacings great than 805 m are shown in green.shows the same surveys as in **Figure 17**, but have been colour coded with respect to the flight line spacing. The most common line spacings of 805 m are shown in red. Flight line spacings less than 805 m shown in blue and flight line spacings greater than 805 m are shown in green. The wider line spacings for offshore surveys is reasonable due to the depth of basement rocks below water that is measured by the magnetometer. A majority of Cape Breton Island was flown at a narrower line spacing for increased resolution, but most of the rest of Nova Scotia was flown at the 805 m line spacing. The metadata for survey Nova Scotia #14 (parts of Halifax, Guysbourough and Pictou counties) indicates a flight line spacing of 1609 m (1 mile) but the digitized flight path shows otherwise at 805 m. It is unclear whether this is an error in the metadata or if the contours were digitized at half the flight line spacing.

The terrain clearance for most of these surveys is 305 m (1000 feet) with a few exceptions. That was the standard flying height at that time for safety since it was flown with visual flight rules only. The surveys were also flown in pre-GPS times, and the flight path was flown using radio beacons and the flight path was recorded on hand plotted on air photo mosaics. Thus, there would be some error in the actual location of the aircraft and the location of the data it recorded.

Finally, the fact that the original profile data does not exist is a major failing with these surveys. To prepare the published gridded data, the hand drawn contours were digitized along the flight path to reconstruct the profile data. Digitized data is inherently lower resolution than the original acquisition data, due to resolution differences between a grid's cell size (e.g. 200 m) and original data sampled along the flight lines (e.g. 1 Hz). It is also dependent on the contour interval on the published maps (e.g. 1 nT or 10 nT). In fact, PGW edited, gridded and merged these surveys under contract to the GSC in the 1980's as part of a systematic national magnetic compilation.

No grids were provided along with the individual databases. In addition to downloading the compiled grid from the GSC WMS server, a grid was created from the compiled 24 surveys consisting of 29 databases. The total magnetic intensity image, **Figure 19**, does show some good detail for a regional study. With a grid cell seize of 200 m it is useful at map scales down to 1:100,000 but not suitable for smaller scale mapping.

No radiometric data was acquired as part of these GSC Nova Scotia surveys.

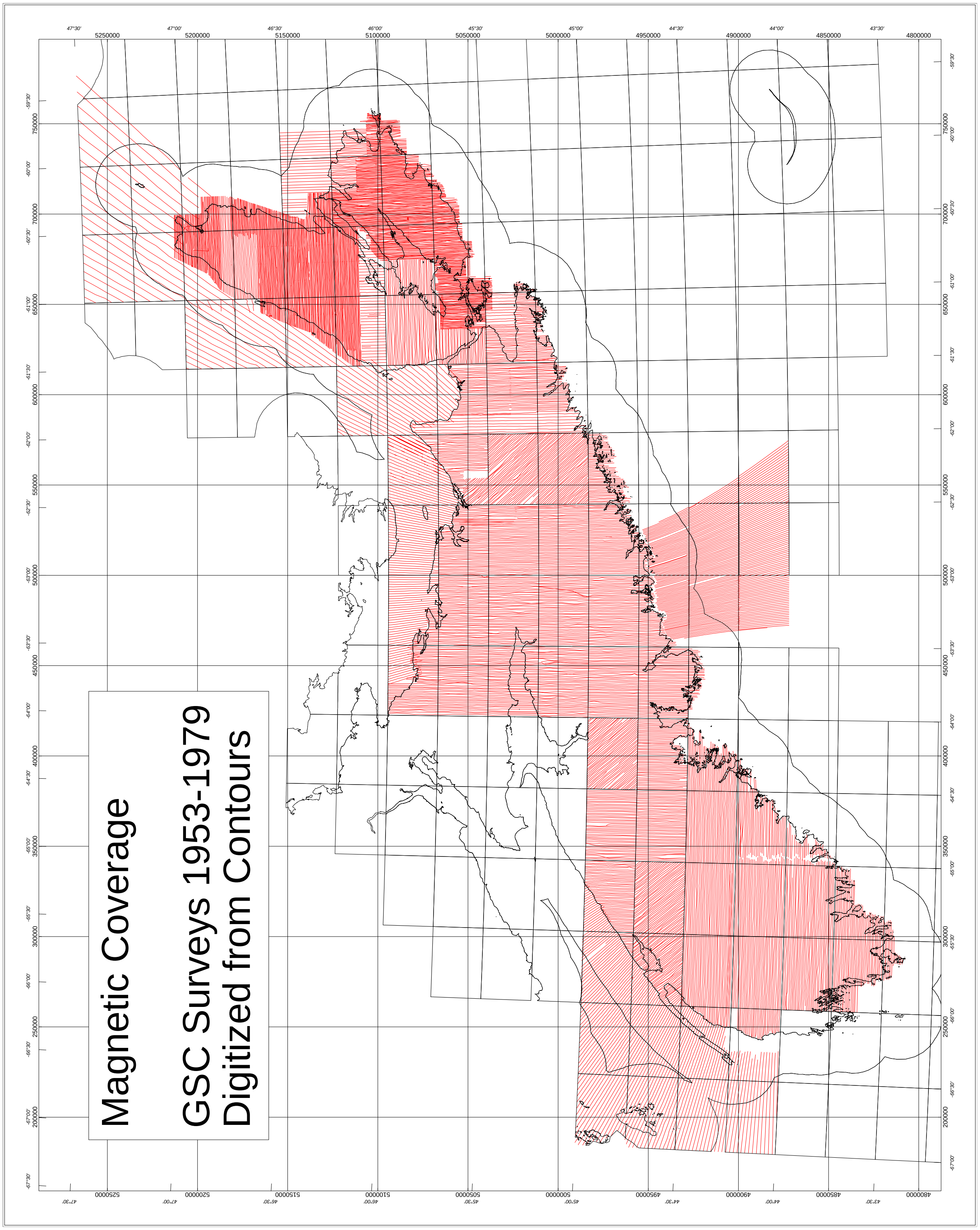


Figure 17. Flight path (red) of the various Nova Scotia surveys flown for the GSC and digitized from hardcopy contour maps.

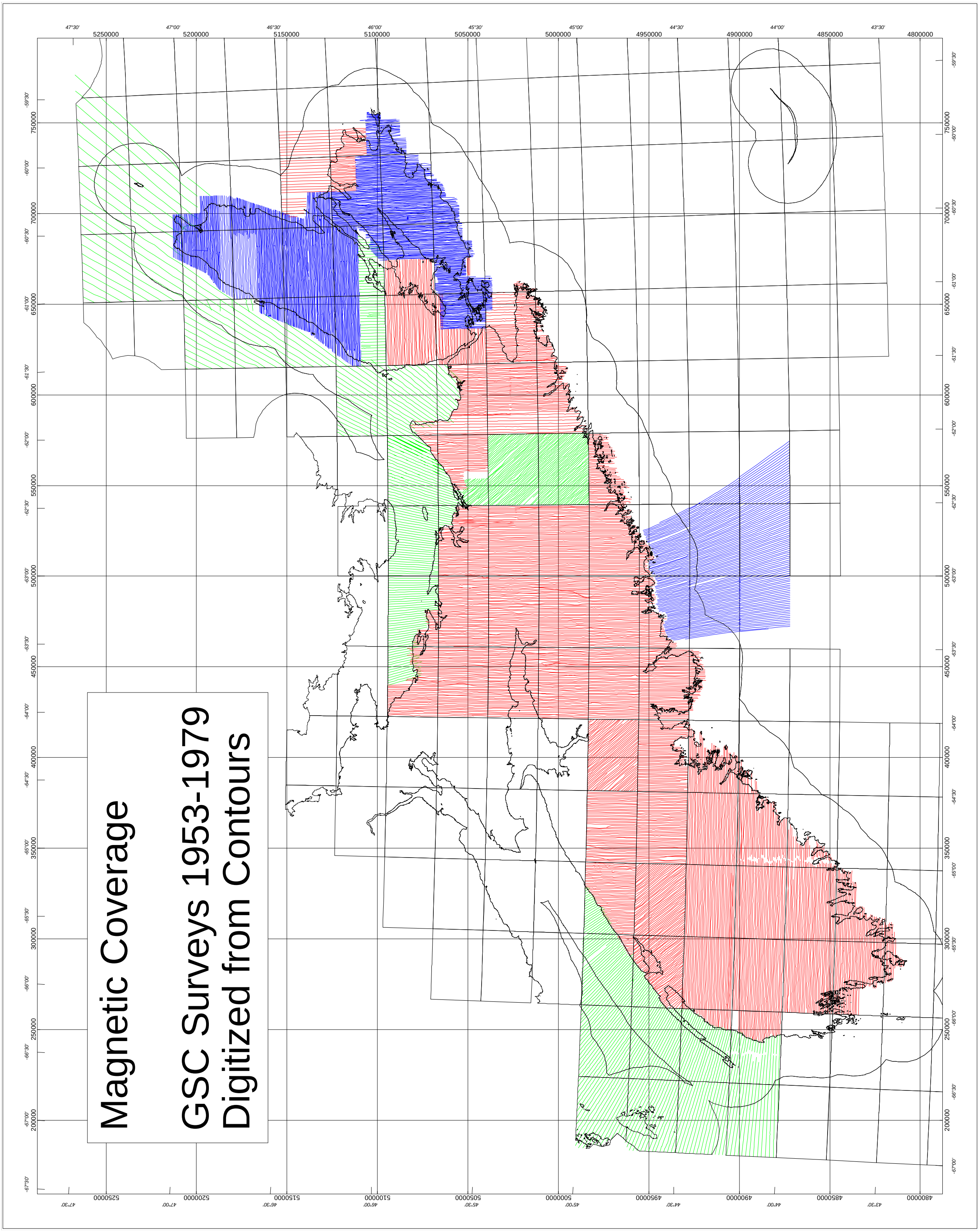


Figure 18. Flight path of the various Nova Scotia surveys flown for the GSC and digitized from hardcopy contour maps. Flight line spacings of 805 m shown in red, flight line spacings less than 805 m shown in blue and flight line spacings great than 805 m are shown in green.

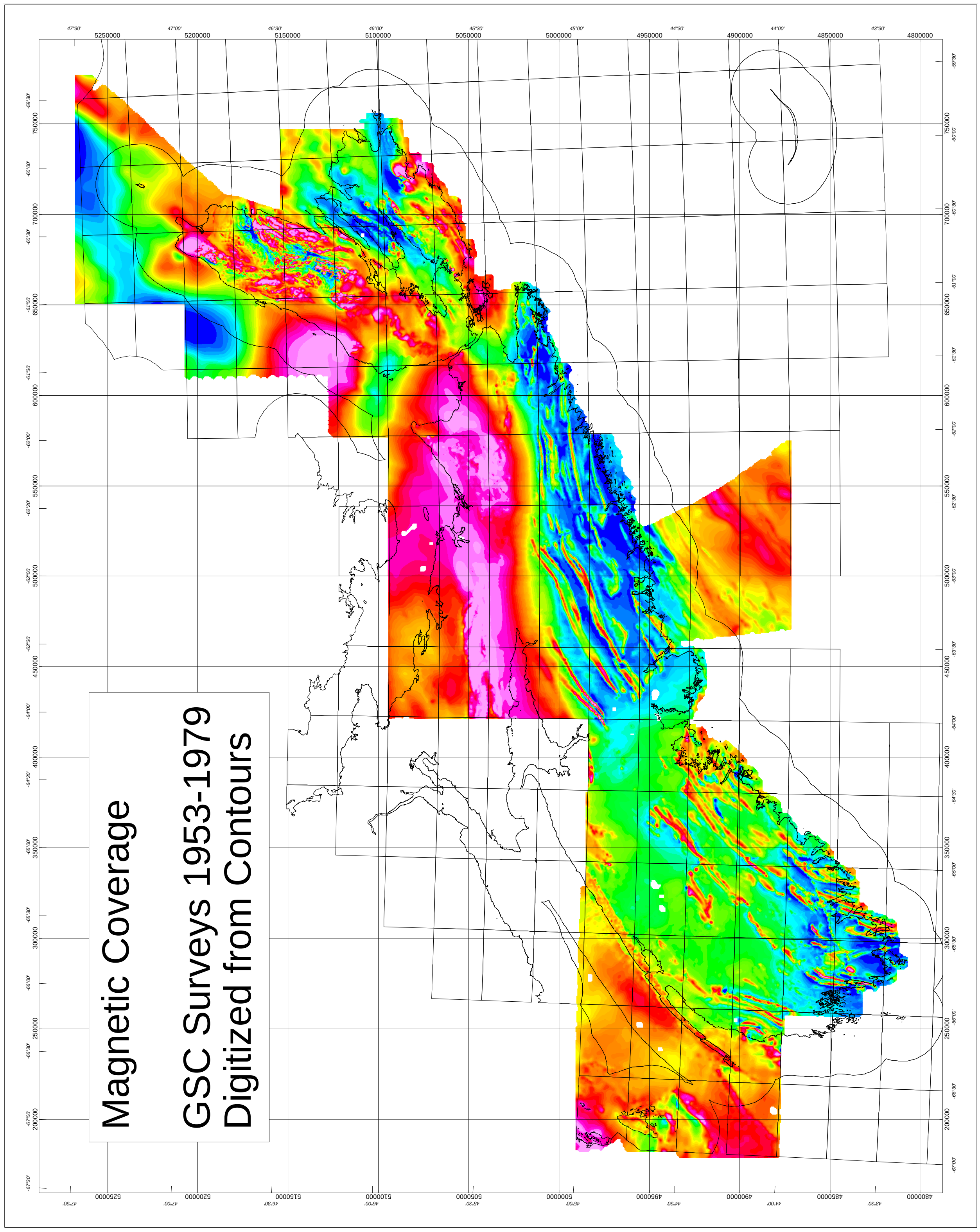


Figure 19. Image of the Total Magnetic Intensity of the various Nova Scotia surveys flown for the GSC surveys that were digitized from hardcopy contour maps. Blues are low magnetic values and reds/pinks are high magnetic values.

Digitally Acquired GSC Data

There are 47 surveys flown for the GSC between 1970 and 1995 (**Figure 20**). The data was acquired digitally, not in the analog mode as in the previous set of GSC data. For these surveys, the sensors are one or a combination of sensor types of magnetics, radiometrics and VLF numbering the following:

- Magnetic only – 7 surveys
- Radiometric only – 11 surveys
- Magnetic and Radiometric only – 3 surveys
- Magnetic and VLF only – 10 surveys
- Magnetic, Radiometric and VLF – 16 surveys

It is immediately apparent that there is a gap in coverage along the north shore of the province along the Bay of Fundy and inland through the Digby, Annapolis, Kings and Hants counties.

The majority of the data has a resolution of 200 m due to a survey flight line spacing of 1 km. If only the medium and high-resolution surveys (grid cell sizes of 75 m to 50 m) are considered (**Figure 21**), the coverage reduces further with some key areas in Cape Breton missing. As well, the offshore magnetic coverage is lost. Surveys with a 50 m resolution (**Figure 22**), which is typical for the resolution of modern regional scale surveys, the coverage further reduces to approximately 25% of the land area of the province.

The radiometric coverage of the province is complete, as shown in **Figure 23**. As with the magnetic data, a majority of the data has a resolution of 200 m due to a survey flight line spacing of 1 kilometer. If the low-resolution surveys are eliminated (**Figure 24)**, the remaining surveys cover less than 5% of the province's total land coverage.

There are a number of inadequacies of the existing data that does not make it fit for purpose for current exploration. As outlined above, most of the surveys were flown at flight line spacings too large for anything more than a regional interpretation and mapping at a scale of 1:100,000. Flight heights between the various surveys vary from 120 m to 609 m. To create a contiguous linked and levelled magnetic grid will require reprocessing to level to a common flying height and common grid cell size.

The resolution and sensitivity of the instrumentation of some of the surveys is very poor. Current magnetometers have a sensitivity of less than 0.001 nT and are sampled at the frequency of 10 Hz. Many of these GSC surveys have sensitivities of 1 or 10 nT and sampling frequencies of 1 Hz.

Few of the database contain intermediate processed channels. Thus, it is difficult to reprocess the data from its raw form to try to improve upon the final channels that were produced at the time.

All surveys, but one, are in the outdated datum of NAD27. All data and grids would have to be re-projected into the current NAD83 datum.

Airborne gravity was not an available technology at the time of the magnetic and radiometric GSC surveys in the period of 1974 to 1990. Ground gravity data is available with an average station spacing of 5 km, as shown by the red dots indicating the gravity station locations in **Figure 25** and with an image of the Bouguer gravity in **Figure 26**.

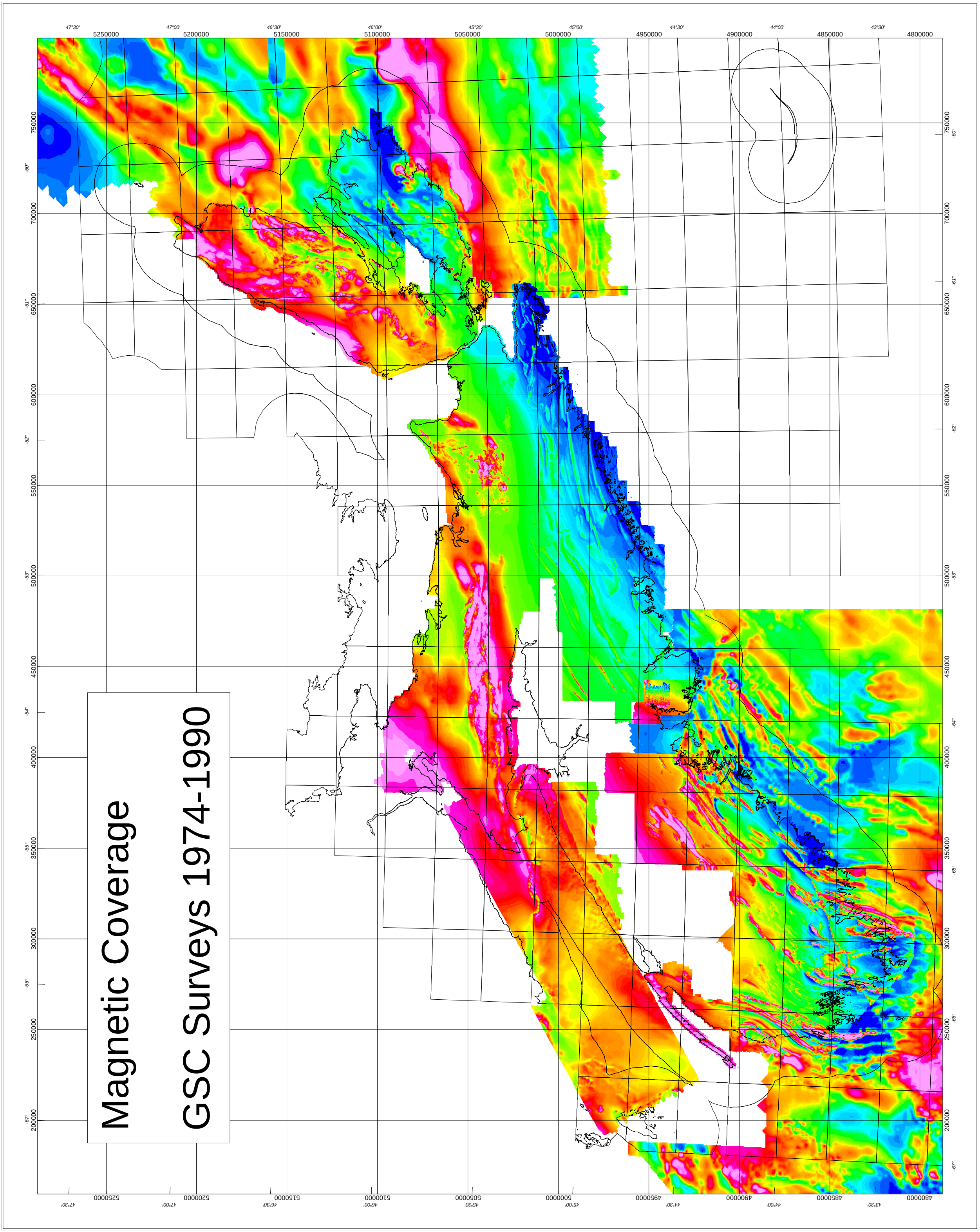


Figure 20. Image of the Total Magnetic Intensity surveys flown for the GSC surveys for which the original digital data is available. Blues are low magnetic values and reds/pinks are high magnetic values.

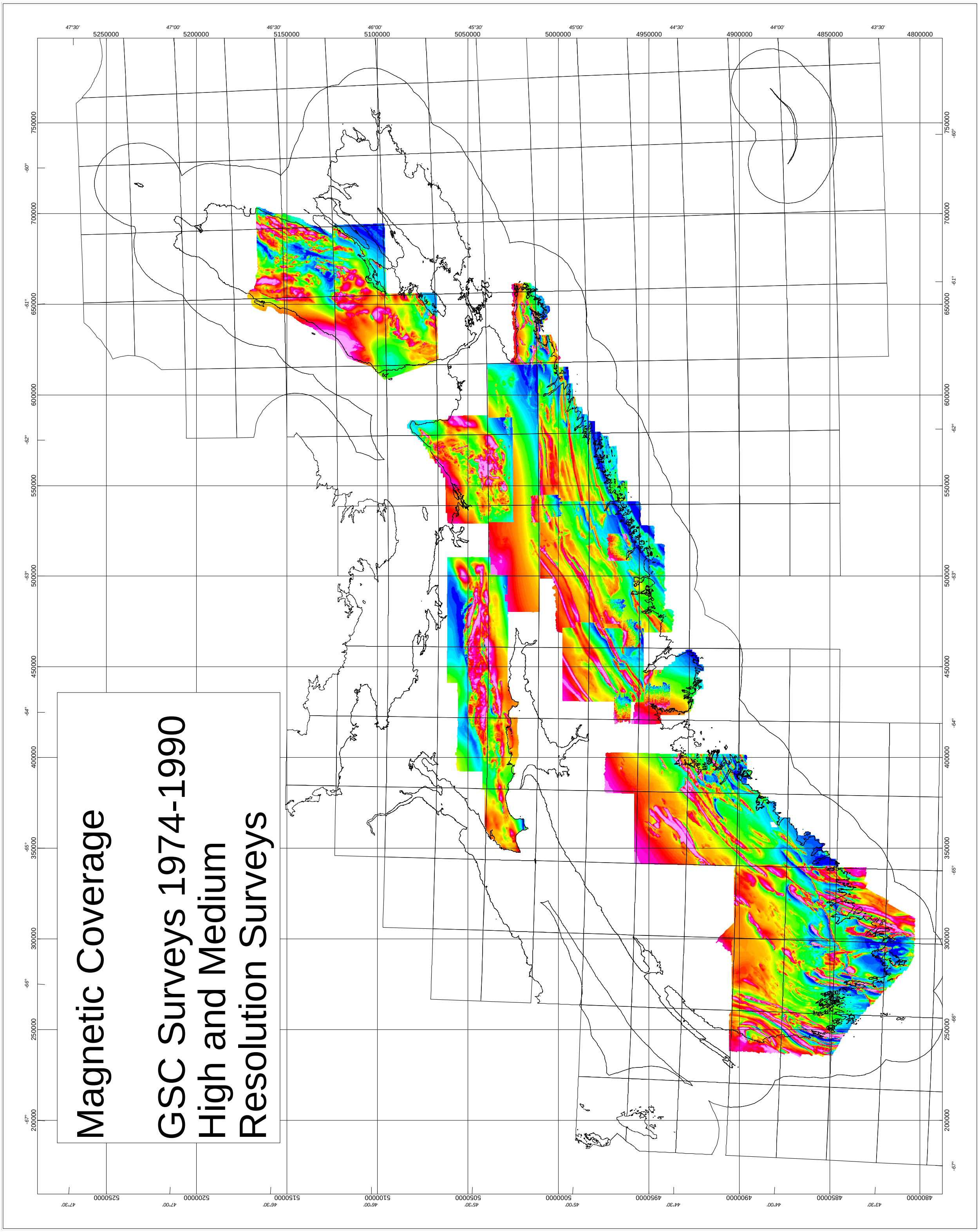


Figure 21. Image of the Total Magnetic Intensity surveys flown for the GSC surveys for which only the medium and high-resolution surveys (75 m to 50 m grid cell size) are included. Blues are low magnetic values and reds/pinks are high magnetic values.

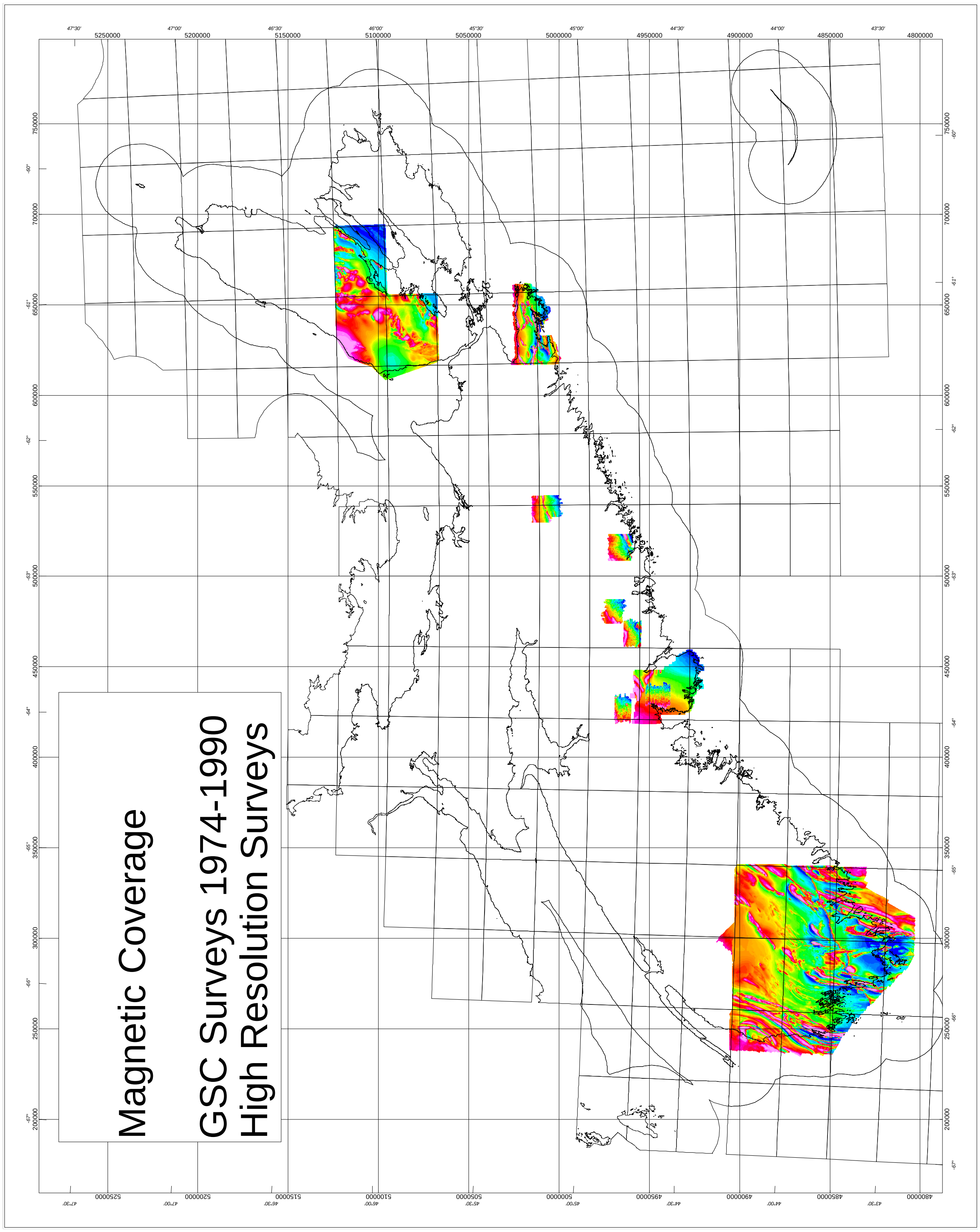


Figure 22. Image of the Total Magnetic Intensity surveys flown for the GSC surveys for which only the high-resolution surveys (50 m grid cell size) are included. Blues are low magnetic values and reds/pinks are high magnetic values.

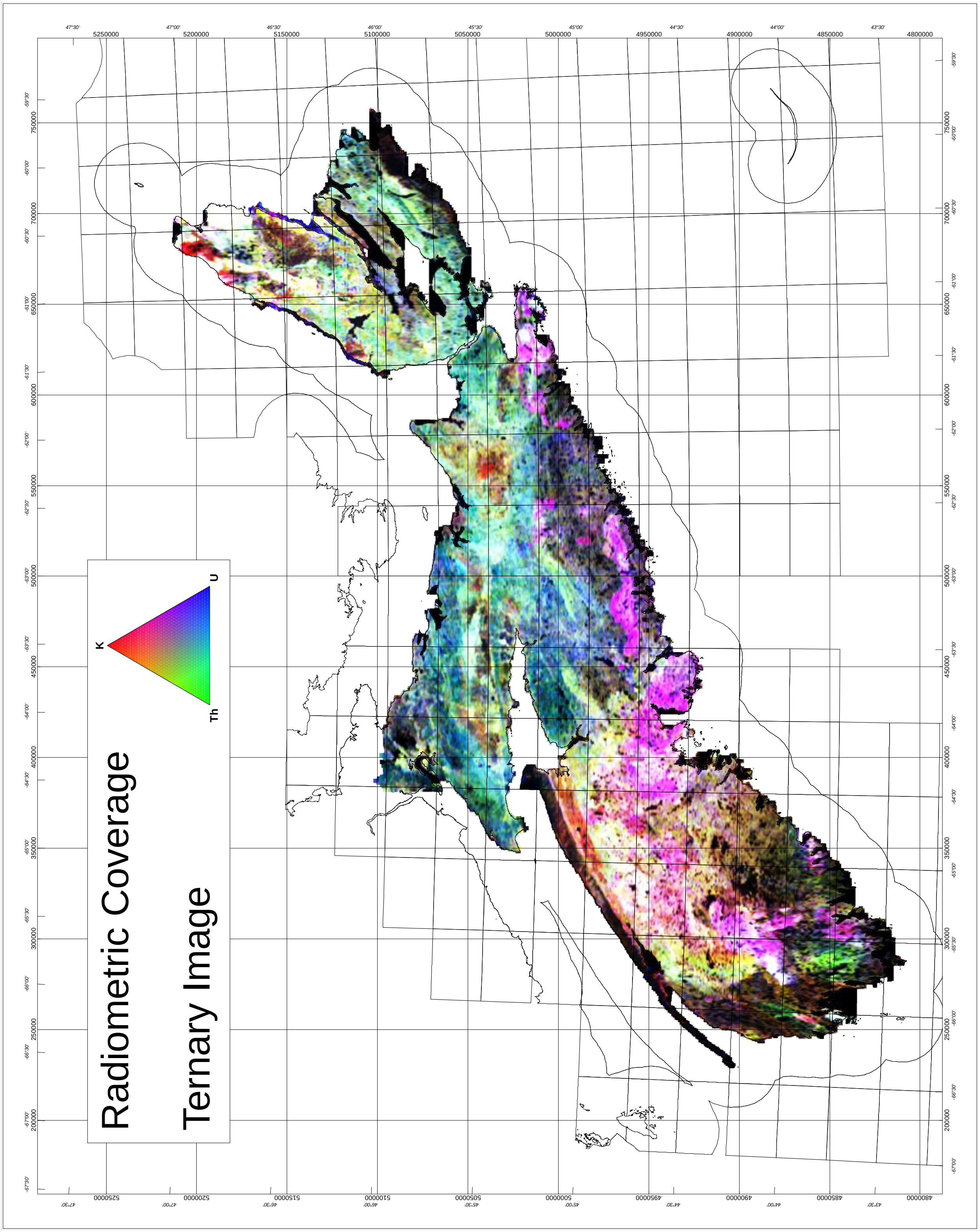


Figure 23. Ternary Image (K-Th-U) of the Radiometric surveys flown for the GSC surveys for which the original digital data is available. The colours represent various values and combinations of potassium, thorium and uranium (light colours indicate highest intensity).

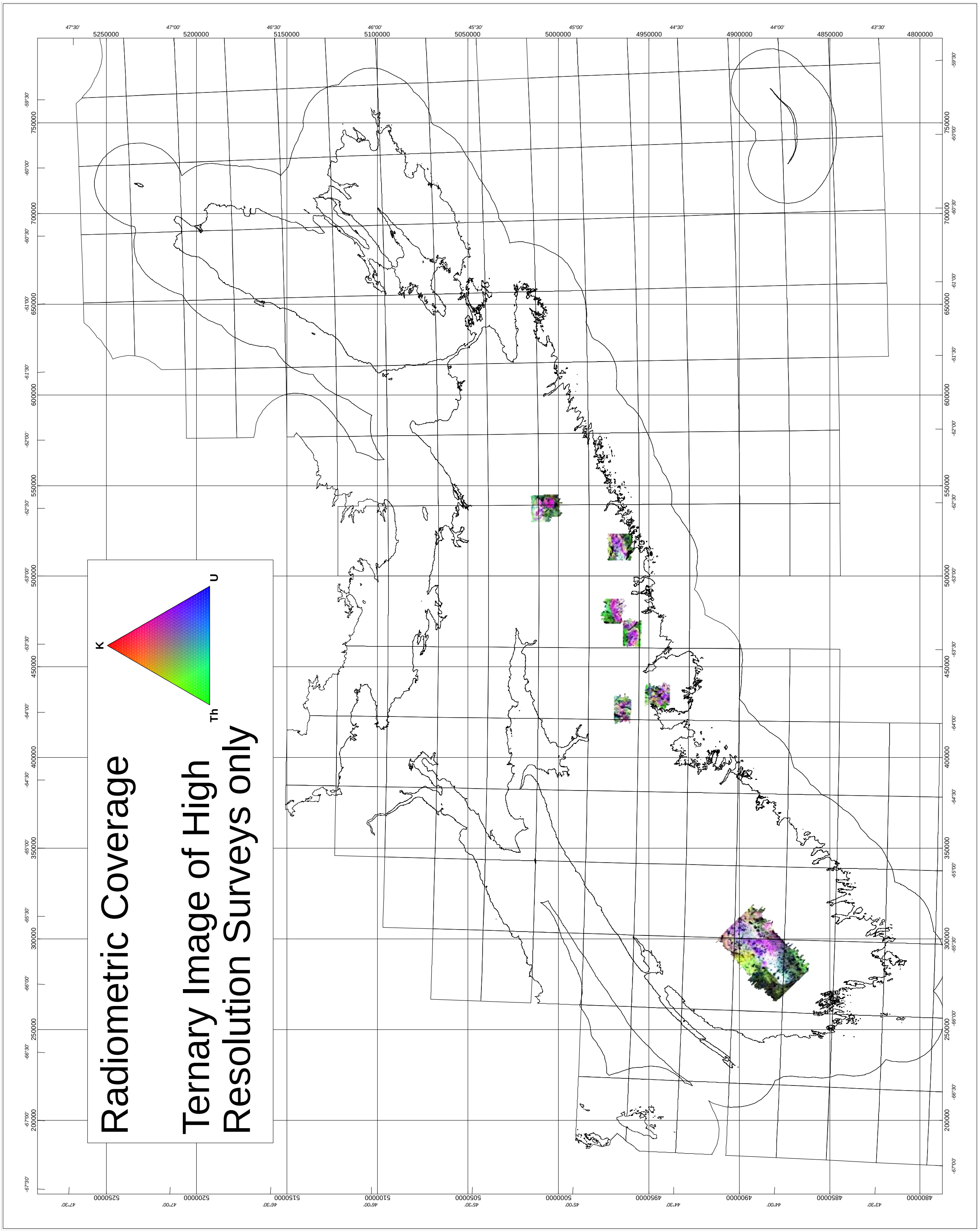


Figure 24. Ternary Image (K-Th-U) of only the 50 m resolutions Radiometric surveys flown for the GSC surveys for which the original digital data is available. The colours represent various values and combinations of potassium, thorium and uranium (light colours indicate highest intensity).

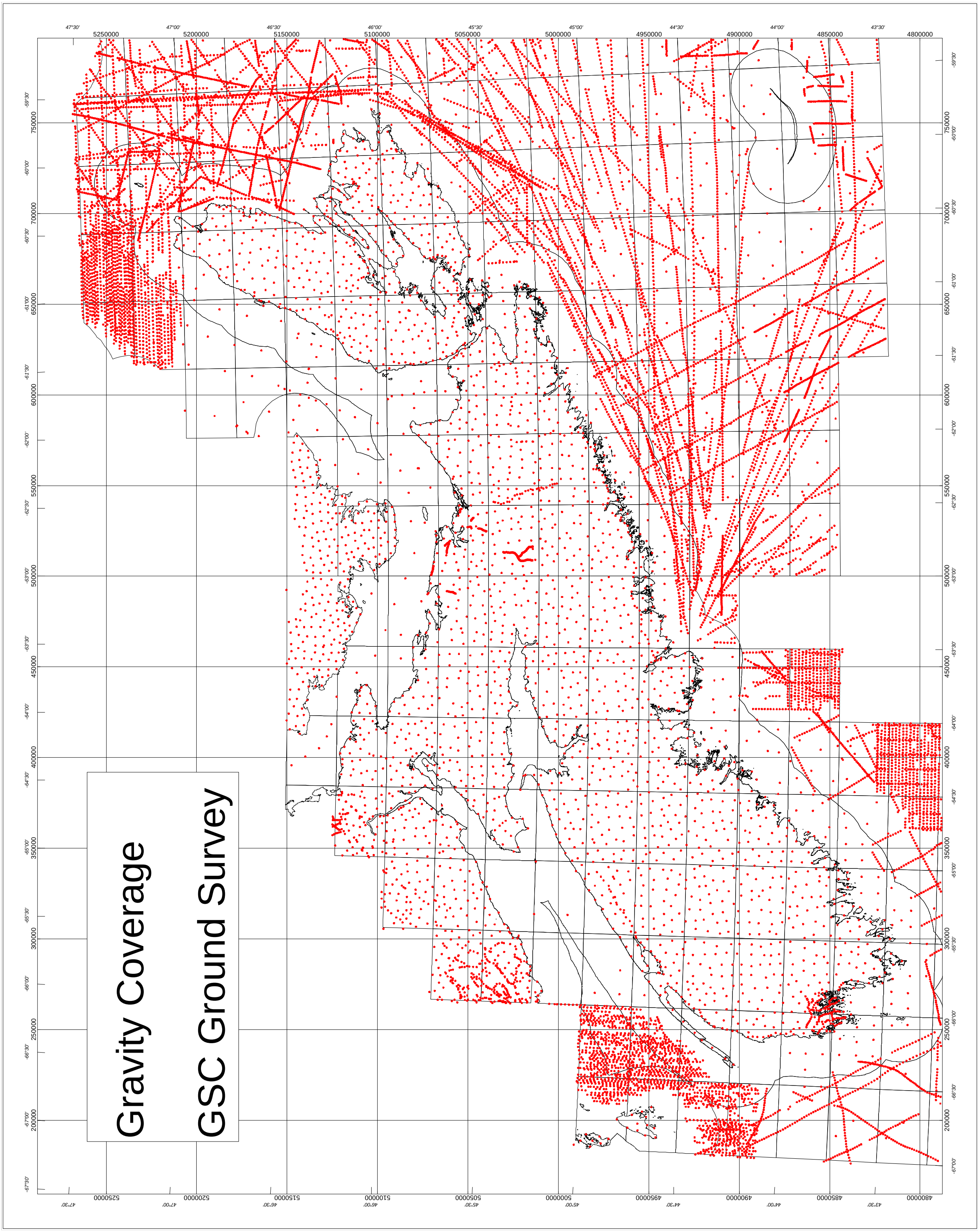


Figure 25. GSC Ground gravity measurement locations with an average station spacing of 5 km.

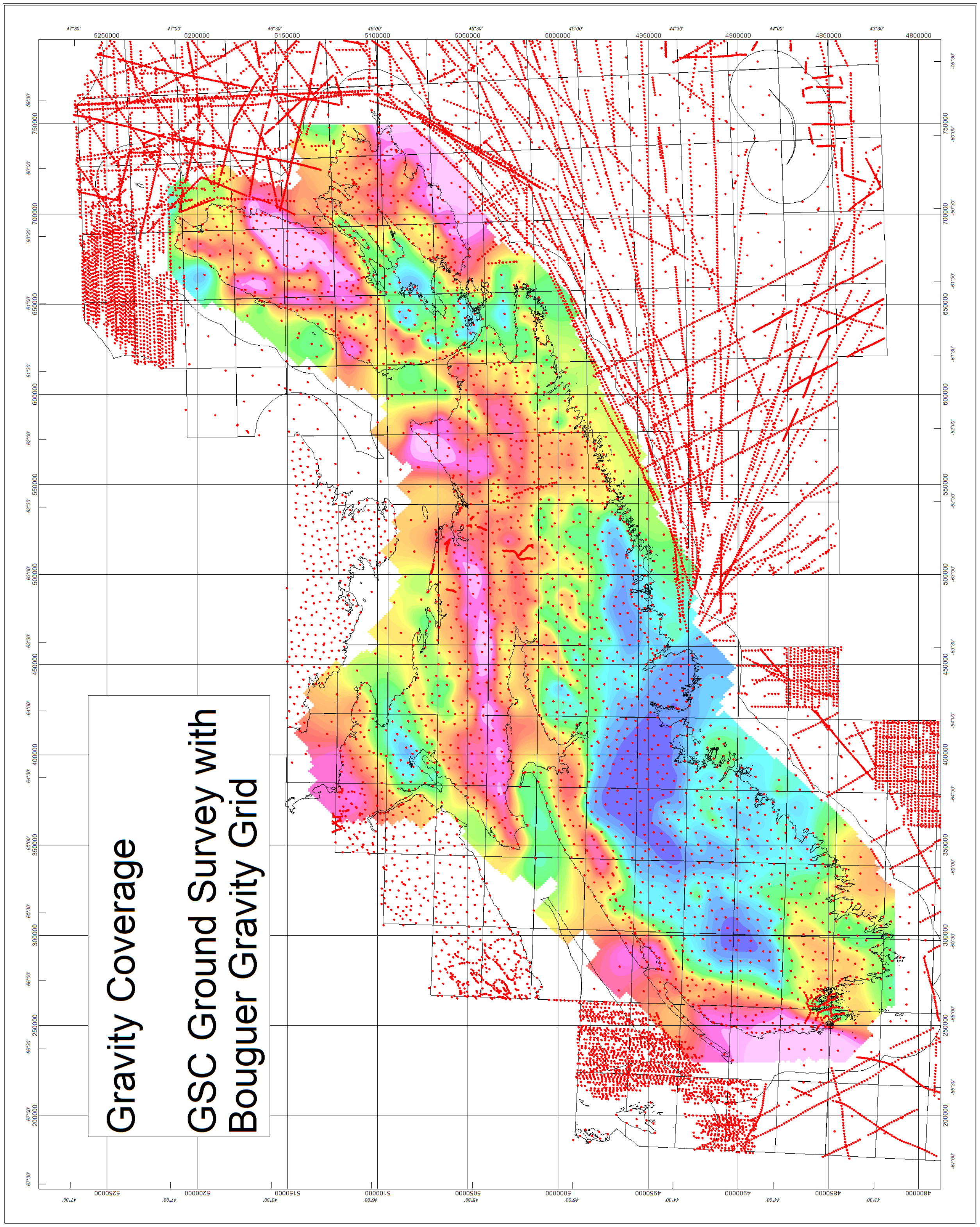


Figure 26. GSC Ground gravity measurement locations with am image of the Bouguer gravity grid (blue colours are low gravity values and red/pinks are high gravity values.)

Conclusions

Thus, what at first glance appears to be near complete magnetic and radiometric digital data coverage is low-resolution data not fit of propose for contemporary mineral exploration. The flight line spacing and flying height of the surveys are not adequate by current standards.

As with the previous set of analogue GSC surveys, the instrumentation of the magnetometers, spectrometers and electromagnetic equipment has improved within the last thirty years. Today, most magnetic surveys are conducted as a gradiometry survey. The extra data provided by the wingtip sensors helps to create a more accurate image of the magnetic field.

Radiometric instrumentation nowadays has much higher sensitivity and resolution. The detector crystal sizes have increased in the intervening years which has increased the sensitivity of signal to noise of the instrument to the radiation energies it detects. The instruments today can measure and record the entire gamma-ray energy spectrum rather than an output of just the specific energy windows related to concentrations of potassium, thorium and uranium. This allows for other uses of the radiometric data such as radon detection for health issues and environmental monitoring.

Modern electromagnetic data available from the GSC is only in the form of VLF data. Current electromagnetic instrument systems allow for greater energy input into the ground in the active Time Domain systems or deeper penetration using magnetotelluric methods such as ZTEM.

Airborne gravity has only been possible within the last twenty years. The resolution achieved approaches a high-resolution ground gravity survey at the fraction of the cost of a ground survey. More importantly it allows for acquisition in places where ground access is not possible or difficult.

Proprietary Data

A number of National Instrument (NI) 43-101 reports and Nova Scotia Assessment Reports were reviewed in order that a high-resolution survey could be potentially purchased from an exploration/mining company rather than the acquiring new geophysical data for its coverage area. The review is shown in Appendix B.

NI 43-101 Reports

Sixty-five (65) NI 43-101 reports from Nova Scotia were reviewed that spanned the years 2006 to 2018. Many were not relevant to the present assessment study since they referred to ground geophysical data or only used the publicly available GSC magnetic, radiometric and VLF data.

Only six reports reviewed relatively newly acquired airborne geophysical data. Of the six, five surveys were too small to consider or did not state the number of line kilometers of the survey. Only one survey, the Wentworth Property in Colchester and Cumberland counties, cited a 2007 magnetic and radiometric helicopter survey with a flight line spacing of 150 m. The survey totalled 4,470 line km. The data would be worth considering for purchase after a thorough review of the data quality and if a proposed new survey were not to cover the same area with the same type of instrumentation.

Nova Scotia Assessment Reports

A search was done through the assessment files and data through the NovaScan provincial database for geoscience publications. The search was likely not exhaustive of all the assessment files that referenced airborne geophysical data. A review through the assessment reports quickly concluded that most reports either referenced the publicly available GSC magnetic, radiometric and VLF data or reprocessed portions of that data. Any references to newly acquired data were for surveys of less than 1,500 line km. Such surveys are much too small to consider for purchase. None were of a regional size and were confined to the company's properties as a contiguous or non-contiguous series of surveys.

Other Data Sources

The existence of geophysical surveys through company web pages, news releases and "word of mouth" were reviewed. Some surveys such as Generation Mining 1,000 line km VTEM survey would be too small to consider. MegumaGold has acquired 12,342 line km of magnetic and radiometrics and 1,100 km^2 of LiDAR data within the Meguma gold belt. The quality and coverage of that data would have to be independently reviewed.

Proprietary Data Purchase

If any data is considered for purchase, an offer price for the survey must be calculated. Paterson, Grant & Watson Limited (PGW) created such a value point scheme during the Ontario government's geophysical acquisition program known as "Operation Treasure Hunt". As well as the procurement of 140,000 line km of new geophysical data, 105,000 line km of proprietary data was purchased. The point scheme included factors such as the age of the survey, survey area, flight line spacing, geophysical method or methods used, the inclusion of a technical survey report and whether the data had previously been filed for assessment. The estimated offer price was between 10 and 25% of the original acquisition cost of the survey. Of course, all of this is dependant upon the willingness of the exploration company to sell the data.

Proposal for New Geophysical Surveys of Nova Scotia

The current proposal to conduct a series of new airborne geophysical surveys consists of two phases. Phase 1 would be a provincewide survey measuring magnetic gradiometry, radiometrics and VLF with fixed wing aircraft. Concurrent with this survey would be an airborne gravity gradiometry survey. Phase 2 would target potential mineral systems with electromagnetic geophysical methods in focused regions.

Proposed Geophysical Surveys – Phase 1

The state of the current geophysical data in Nova Scotia is not fit for purpose for present day mineral exploration. The age and quality of the data requires a complete reset with a new and comprehensive geophysical data set. Thus, a provincewide survey is proposed using at least 3 fixed wing aircraft with a gradient magnetometer, spectrometer and VLF instrumentation. An airborne gravity gradiometry system, which also includes a magnetometer is proposed to be flown by a fixed wing aircraft concurrent with the magnetic gradiometry, radiometric and VLF survey or directly following that survey. Details for each of the proposed surveys is outlined in the following sections.

Magnetic Gradiometry, Radiometric and VLF Survey – Provincewide

Coverage

Onshore Nova Scotia has been generally outlined in the following **Figure 27** (blue outline with red fill). This outline covers all of onshore Nova Scotia including parts of the Bay of Fundy, St. Mary's Bay, Minas Basin, the Strait of Canso, Bras d'Or Lake and St. Andrews Channel. The survey reaches out to sea just enough to cover the bays and inlets. Note that there is no radiometric signal over water, but the magnetic data will be recorded regardless of water depth. The area of this provincewide survey is 66,250 km^2. Also, note that this includes areas that will eventually be trimmed or excluded in the final survey outline to be flown. Areas to be trimmed or excluded would be cities, major airports, military bases and potentially, some national or provincial parks. Thus, this area should be considered a maximum possible value.

This survey block could be further subdivided into smaller blocks based upon the flight line direction. Ideally, the flight line direction is perpendicular to the predominant geological strike. As shown in **Figure 28** , areas in western Nova Scotia and Cape Breton would be flown at approximately N45W (red fill) and areas in eastern and northern mainland Nova Scotia would benefit from being flown North-South (green fill). The flight line direction is shown as the solid black bar within each survey block. There would a margin of overlap (1 to 2 km) between any survey blocks to allow for the data to be merged into one continuous grid. The exact size, shape and flight direction will be refined at the flight planning stage or the project.

Flight Line Spacing

The flight line spacing directly impacts the total line kilometers of the survey which, in turn, affects the final survey cost and length of time it would take to complete the data acquisition. Generally, the cost of any geophysical survey, to a first approximation, is proportional to the total flight line distance. In the following table (**Table 1**) the total number of line kilometers is shown at various flight line spacings. These values were calculated using the one provincewide survey outline and a flight line direction of N45W

(**Figure 27**). Values for a provincewide survey at a line spacing of 150 m and 100 m are also provided for comparison.

Flight Line Spacing (metres)	Traverse Line Distance (km)	Tie Line Distance (km) with 2 km spacing*	Total Line kilometers (km)
200 m	331,234	33,118	364,352
150 m	441,644	33,118	474,762
100 m	662,467	33,118	695,585
* a 2 km tie line spacing for the survey area will result in the same number of km's regardless of the flight line spacing.			

Table 1. Proposed Phase 1 Magnetic/Radiometric/VLF survey line kilometers.

It is recommended that the provincewide survey be flown at a minimum of 200 m flight line spacing. This will produce grids with a resolution of 40 m. This would put the data quality at par with data from other Canadian provinces such as Ontario. Quebec's Ministère des Ressources naturelles (MRN) has conducted some of its airborne geophysical surveys down to a 100 m flight line spacing, but mainly in the 200 to 250 m range.

We would recommend a line spacing of 200 m to provide a "state of the art" geophysical data set to the mineral exploration community. Such a high quality and complete provincial geophysical coverage would make this data set stand out amongst other Canadian provinces and countries worldwide.

Flying Height, Speed and Sampling

A flying height of 100 m is recommended. This is a standard flying height for magnetic gradiometry and radiometric surveys. Surveys would be flown with a fixed wing aircraft which is able to cover large areas quickly and for substantially less money than a helicopter survey. A survey speed for a fixed wing aircraft is approximately 75 m/s (270 km/hr). Thus, with a recording frequency of 10 Hz for the magnetic and VLF sensors, the distance between individual sampling points along the flight line will be approximately 7.5 metres. Radiometric data is sampled at 1 Hz, approximately 75 m between sampling points.

Number of Aircraft

It is recommended that the chosen survey contractor commit at least three aircraft to the survey production. The survey can be conducted in a more efficient manner if more than one aircraft is deployed. If all three aircraft are based at the same location, they can share personnel such as aircraft mechanics and geophysical field processors. One set of magnetic and GPS base stations can be deployed as well as a common warehouse of instrument and aircraft spare parts. As an estimate, a fixed wing aircraft can survey 1,000 to 1,300 km per day when based near or within the survey block (little time and fuel are wasted ferrying to the survey site). Per week, one aircraft will collect approximately 5,000 km of data. There are always a few days lost for poor weather conditions, mandatory pilot rest days and routine or unexpected aircraft maintenance. With a recommended survey size of approximately 365,000 km, it will take three aircraft approximately 25 weeks (5.5 months) to complete the survey. Radiometric data can not be collected with snow cover, so the survey can not be flown during the winter months. As well, radiometric data can not be collected until 3 hours after an appreciable amount of precipitation and 12 hours after ground soaking precipitation. Under good conditions, three aircraft could complete the survey of Nova Scotia within one field season (spring, summer, autumn). The magnetic gradiometry, radiometric and VLF equipment is common, so it should be straightforward for the survey contractor to outfit three aircraft with identical instrumentation.

Summary – Magnetic Gradiometry, Radiometric and VLF Survey Specifications

- Flight Line Spacing – 200 m to result in a grid with a 40 m resolution
- Flying Height – 100 m mean terrain clearance
- Aircraft Type – Fixed wing aircraft
- Survey Speed – approximately 75 m/s
- Minimum of 3 aircraft surveying to complete survey in approximately 25 weeks.

Survey Cost Estimate

The cost estimate for the recommended survey comes from three sources:

1. Cost per line kilometer for the survey – costs include fuel, aircraft lease, insurance, field and office personnel, etc.
2. Mobilization/Demobilization – costs include ferrying aircraft, equipment and personnel to the base of operations, setup of base stations, permitting costs.
3. Project Management and Quality Control – costs for an independent geophysical consultant to manage and review the geophysical surveys. Duties would include:
    a. To write the RFP with the Terms of Reference for the survey contractors, i.e., technical specifications,
    b. Evaluation the contractor proposals using a point system based on technical merit and financial proposal,
    c. Assistance with preparation of the contract with the survey contractor,
    d. Quality Control of the pre-survey and post-survey calibration tests,
    e. On site visits to the contractors in the field to verify aircraft, instrumentation, procedures and field data,
    f. Weekly teleconferences with MANS as to the status of the various surveys,
    g. Periodic Quality Control of the field data, and
    h. Quality Control of interim and final deliverables.

Project management is necessary to ensure the surveys starts and ends in timely manner. Survey data is constantly reviewed to catch any problems before the aircraft demobilizes from the field and to require data to be re-flown if it is not up to contract standards. This ensures the highest possible quality of the field data. The review of the interim and final products is done to ensure that the data has been properly processed and are ready to be delivered to the public in a timely manner.

From recent experience, a magnetic gradiometry, radiometric and VLF survey for a survey of this size would be approximately $12 per km. Mobilization/Demobilization costs are approximately $20,000. Project Management and Quality Control would add another 10% to the survey cost for a fixed wing survey. All prices are quoted in Canadian dollars in the following **Table 2**.

Item	
Survey Cost for 365,000 km @ $12/km	$ 4,380,000
Mobilization/Demobilization	$ 20,000
Project Management and Quality Control	$ 438,000
Total	$ 4,838,000

Table 2. Cost Estimate of a provincewide magnetic gradiometry, radiometric and VLF survey.

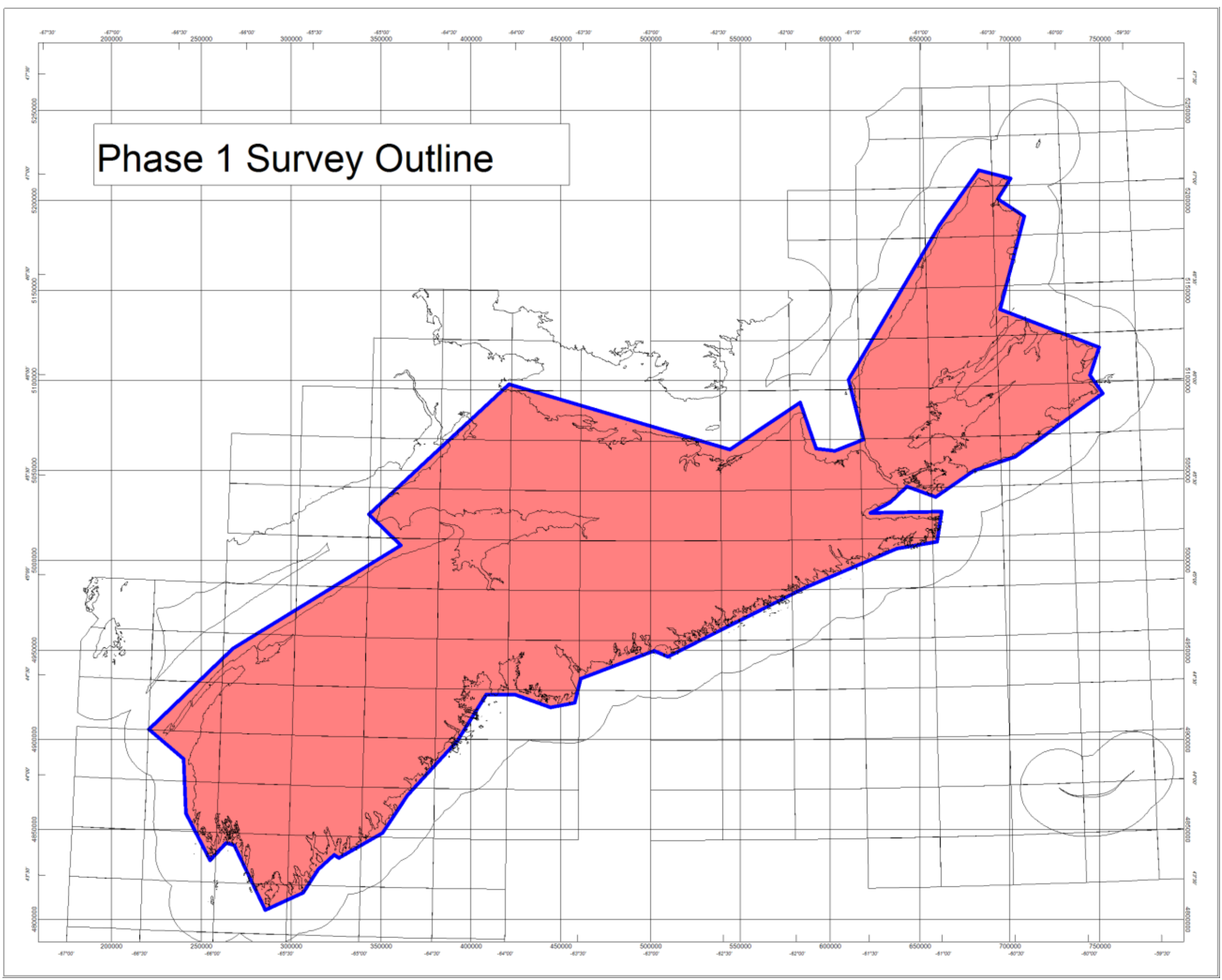


Figure 27. Proposed Phase 1 magnetic/radiometric/VLF outline.

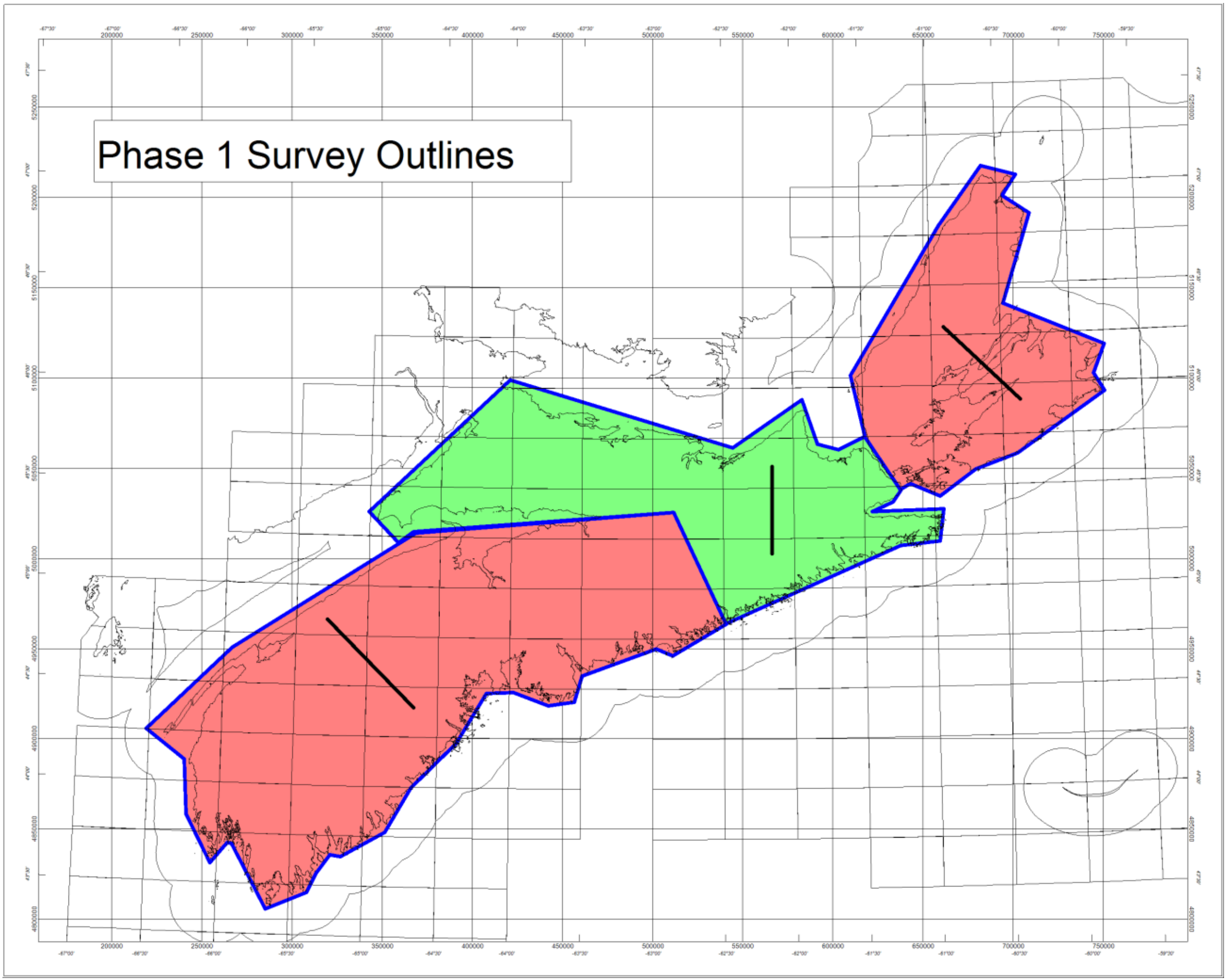


Figure 28. Proposed Phase 1 survey outline subdivided upon flight line direction.

Gravity Gradiometry Survey – Provincewide

A gravity gradiometry survey is recommended to follow the magnetic gradiometry, radiometric and VLF survey. The gravity gradiometry survey could commence before the end of the provincewide survey as long as care is taken not the schedule the surveys in the same area to avoid interaction between the aircraft. Also, a preliminary interpretation of the magnetic gradiometry, radiometric and VLF data may warrant adjustments to the boundaries of the gravity gradiometry survey to include geologically interesting areas that would benefit from additional coverage.

As with magnetics and unlike radiometrics, a gravity gradiometry survey is unaffected by the presence of water or snow. The survey could be conducted in the winter with snow cover on the ground. Thus, the timing of the gravity gradiometry survey is much more flexible.

The cost of a gravity gradiometry survey is approximately $100 per km. Though for a survey of such a large size, it may be possible to negotiate a reduction of approximately 25%, but at this stage of planning, the success of such a negotiation is unknown. An airborne scalar gravity (not gravity gradiometry) survey is approximately $75 per km. A gravity gradiometry survey is more sensitive to near surface geology (~ 2 km in depth), and so the increase in cost would be warranted for acquisition of such a high-resolution data set. The higher cost could be mitigated by increasing the line spacing to result in a lower total line distance. A gravity gradiometry and magnetic survey flown over the Chromium-PGE deposits in the "Ring of Fire" in northern Ontario (Rainsford et al.)[10] was able to delineate a broad package of mafic intrusive rocks and mafic to felsic metavolcanics rocks using a flight line spacing of 250 m. Estimates of the size and cost of a provincewide gravity gradiometry survey with a flight line spacing of 250 m is shown below. Values for a provincewide survey at a line spacing of 500 m are also provided for comparison (**Table 3**).

Flight Line Spacing (metres)	Traverse Line Distance (km)	Tie Line Distance (km)	Total Line kilometers (km)
500 m	132,499	13,235 (with a Tie Line Spacing of 5,000 m)	145,734
250 m	264,988	26,480 (with a Tie Line Spacing of 2,500 m)	291,468

Table 3. Proposed Phase 1 gravity gradiometry survey.

Surveys with a wider line spacing, i.e. 1 km line spacing, would be useful for a geoscience study of the province but will likely be of little help for direct targeting in mineral or hydrocarbon exploration.

Survey Cost Estimate

As with the previous survey, the cost would be a combination of the survey cost, mobilization/demobilization and project management and quality control. Only a fixed wing platform is being considered for a gravity gradiometry survey. All prices are quoted in Canadian dollars in the following **Table 4**.

Item	
Survey Cost for 291,500 km @ $100/km	$ 29,150,000
Mobilization/Demobilization	$ 40,000
Project Management and Quality Control	$ 750,000
Total	$ 29,940,000

Table 4. Cost Estimate of a provincewide gravity gradiometry survey.

[10] Rainsford, D.R.B., Dorio, P. A., Hogg, R. L. S. and Metsaranta, R.T. The use of Geophysics in the Ring of fire, James Bay Lowlands – The Chromite Story in: In "Proceedings of Exploration 17: Sixth Decennial International Conference on Mineral Exploration" edited by V. Tschirhart and M.D. Thomas, 2017, p. 649–662.

Note that the project Management and Quality Control costs have been capped at $750,000. Data acquisition rates for a gravity gradiometry system is comparable to that of the magnetic gradiometry, radiometric and VLF survey.

The gravity gradiometry survey will also include a magnetic survey (single or gradient system). The addition of the magnetic data acquisition basically comes at no extra cost to the survey. At least two aircraft would be required to carry out the provincewide gravity gradiometry survey. The estimated completion time for the data acquisition of the survey would be approximately 30 weeks.

Targeted Gravity Gradiometry Survey

Due to the costs estimated above, we believe that a provincewide gravity gradiometry survey would be prohibitively expensive. Alternately, the survey should focus on specific area such as the St. Mary's Basin and Cobequid-Chedabucto Fault System as shown as the blue hatched area in **Figure 29**. This area is approximately 30 km by 310 km with an area of 9,300 km^2. For a targeted area, a gravity gradiometry survey with a flight line spacing of <u>250 m</u> is proposed. Values for a targeted survey at a line spacing of 500 m are also provided for comparison in **Table 5**. The flight line direction is recommended to be North-South.

Flight Line Spacing (metres)	Traverse Line Distance (km)	Tie Line Distance (km)	Total Line kilometers (km)
500 m	18,565	1,845 (with a Tie Line Spacing of 5,000 m)	20,410
250 m	37,130	3,707 (with a Tie Line Spacing of 2,500 m)	40,837

Table 5. Proposed alternate Phase 1 gravity gradiometry survey.

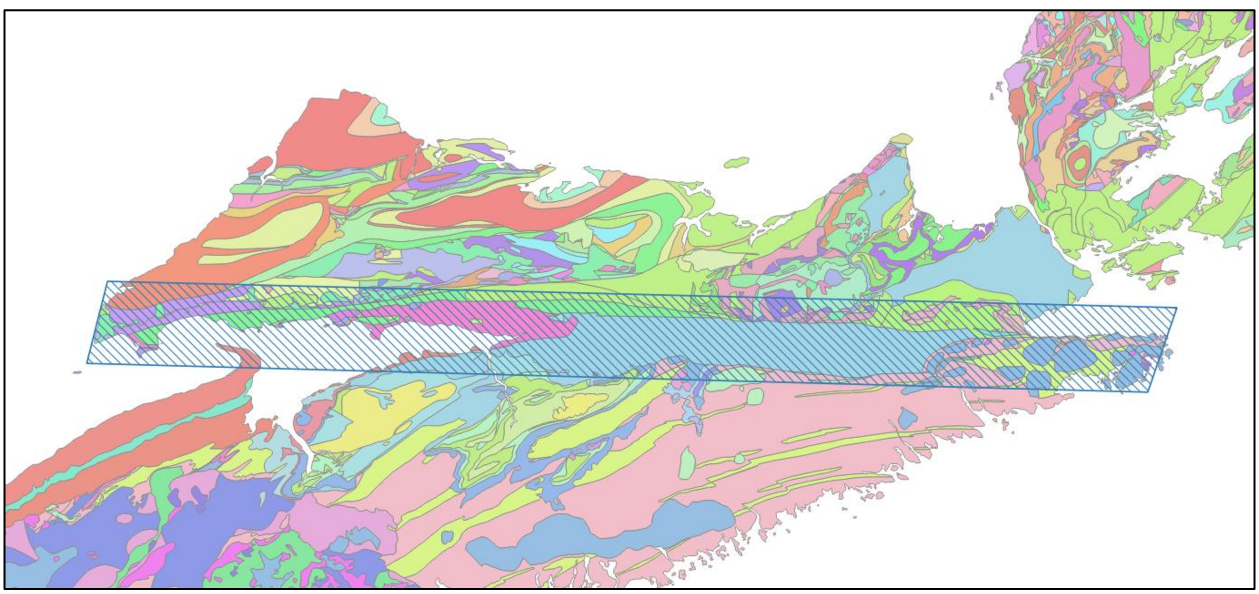


Figure 29. Targeted gravity gradiometry survey (blue hatched area) and geology in background.

Survey Cost Estimate

As with the previous survey, the cost would be a combination of the survey cost, mobilization/demobilization and project management and quality control. Project Management and Quality Control would add another 10% to the surveying cost for a fixed wing survey. Only a fixed wing platform is being considered for a gravity gradiometry survey. All prices are quoted in Canadian dollars in the following **Table 6**.

Item	
Survey Cost for 40,850 km @ $100/km	$ 4,085,000
Mobilization/Demobilization	$ 40,000
Project Management and Quality Control	$ 408,500
Total	$ 4,533,500

Table 6. Cost Estimate of a targeted gravity gradiometry survey.

The gravity gradiometry survey will also include a magnetic survey (single or gradient system). The addition of the magnetic data acquisition basically comes at no extra cost to the survey. It is recommended that one aircraft carry out the targeted gravity gradiometry survey. The estimated completion time for the data acquisition of the survey would be approximately 10 weeks.

Acquisition by Separate Surveys in Phase 1

Phase 1 of the project calls for two separate surveys:

- Magnetic gradiometry, radiometrics and VLF at 200 m line spacing, and
- Gravity gradiometry with magnetics at 250 m line spacing.

There are a number of reasons for conducting two separate surveys rather than an “all-in-one” survey. Most notably, is that multi-sensor aircraft that can measure the following combinations are very rare:

- Magnetic gradiometry, radiometrics, electromagnetics (TDEM or FDEM), or
- Magnetic gradiometry, radiometrics, gravity gradiometry.

The most common combinations are:

- Magnetic gradiometry and radiometrics ± VLF,
- Magnetic gradiometry and electromagnetics (TDEM or FDEM), and
- Magnetic gradiometry and gravity gradiometry

If the survey contractor only has one aircraft configured for a “all-in-one” survey, it will be difficult to schedule the aircraft for the Nova Scotia project due to the aircraft’s commitments elsewhere in the world. A single aircraft would not be able to carry out a provincewide survey in less than three years since the winter months will lost due to radiometrics being ineffective with snow cover.

It is actually less expensive to carry out two surveys rather than one "all-in-one" survey. We have estimated a magnetic gradiometry, radiometric and VLF survey to be $12 per kilometer and a gravity gradiometry survey to be $100 per km. We have seen estimates of "all-in-one" aircraft with gravity gradiometry, magnetic gradiometry and radiometrics at $120 per km or more and that would not include VLF.

Follow-Up Surveys – Phase 2

It is recommended that a number of follow-up surveys be conducted as part of Phase 2 of the project after Phase 1 is complete. These surveys will be electromagnetic surveys to detect near surface and deep conductors. Survey outlines are shown below in **Figure 30**.

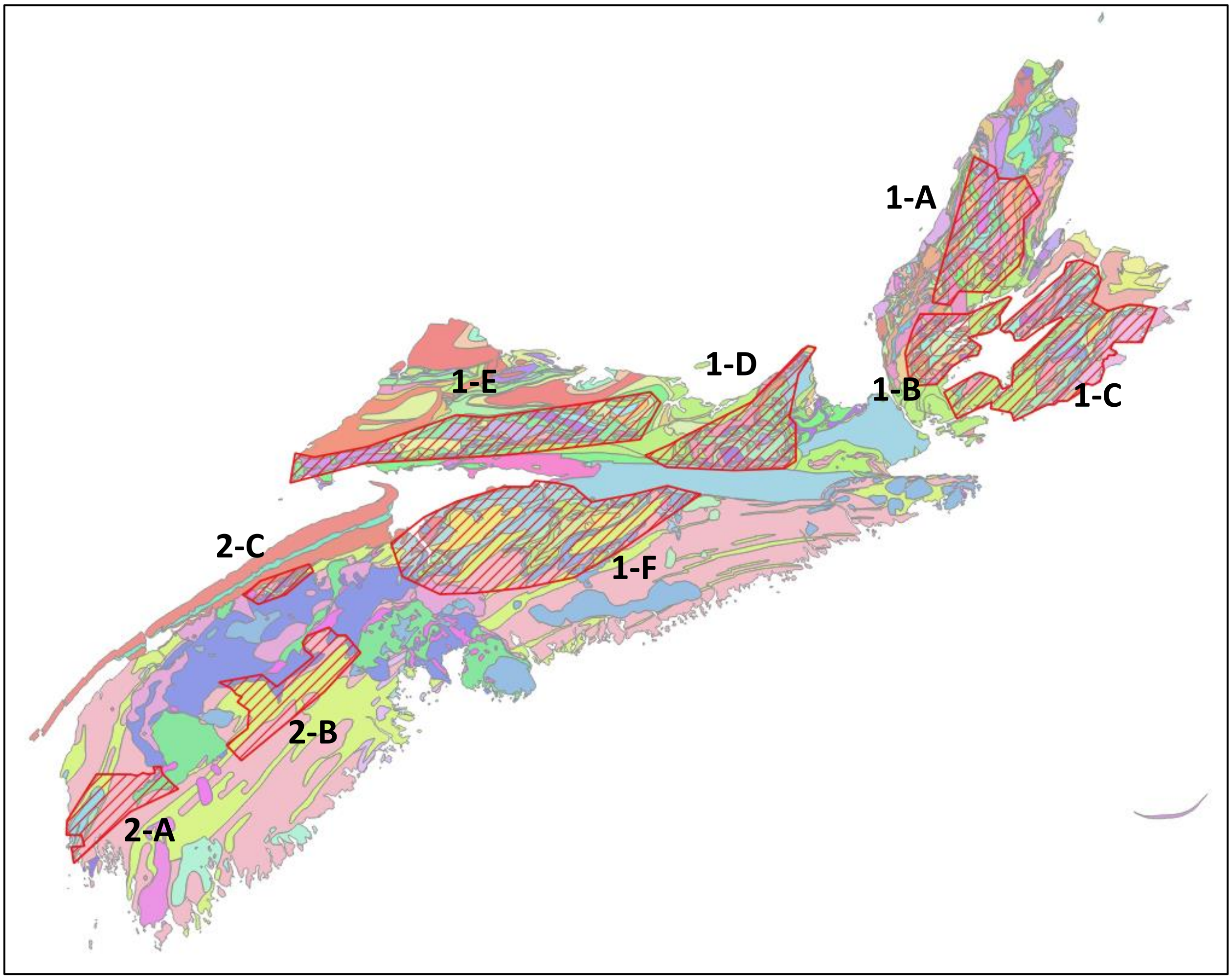


Figure 30. Proposed Phase 2 follow-up surveys.

The follow-up target surveys have been prioritized into primary and secondary targets, #1 and #2, in **Table 7.**

Survey #	Flight Line Spacing (metres)	Flight Line Direction	Traverse Line Distance (km)	Tie Line Distance (km) with 2000 m Spacing	Total Line kilometers (km)
Primary Target Areas					
1-A	200 m	EW	9,065	911	9,976
1-B	200 m	N45W	4,802	477	5,279
1-C	200 m	N45W	14,230	1,419	15,649
1-D	200 m	NS	8,435	845	9,280
1-E	200 m	NS	12,712	1,266	13,978
Alternate area combining 1-D and 1E, south to 1-F and extension to east.					
1-DE	200 m	NS	50,127	5,002	55,129
1-F	200 m	N45W	22,102	1,209	23,311
Secondary Target Areas					
2-A	200 m	N45W	4,557	459	5,016
2-B	200 m	N45W	6,625	657	7,282
2-C	200 m	N45W	1,220	120	1,340

Table 7. Proposed Phase 2 follow-up surveys.

The primary follow-up targets (1-A to 1-F) are relatively large in area for an electromagnetic survey. Thus, a ZTEM survey on a fixed wing or helicopter platform is recommended. A ZTEM survey "looks" deeper into the earth, up to 2 km. It will provide a more comprehensive picture of the conductivity from surface to depth. A helicopter platform is best suited for areas 1-A, 1-B and 1-C in Cape Breton due to the more rugged terrain and it will be able to maintain a constant terrain clearance, though the ZTEM system is less sensitive to variations in terrain clearance than other methods such as magnetic and radiometrics. However, if the budget allows, targets 1-D, 1-E (or 1-DE) and 1-F may also be acquired with a helicopter platform. The ZTEM instrumentation varies between the fixed wing and helicopter platforms. There are more frequencies available on the helicopter platform which allow it to have better resolution at the shallowest and deepest depths as well as penetrate a conductive surficial cover. The target area 1-DE (**Figure 31**) would be preferable to just areas 1-D and 1-E since it would complement the proposed gravity gradiometry survey. The potential interpretation of a combined magnetic gradiometry, gravity gradiometry and conductivity survey will provide a very good regional framework of the Cobequid-Chedabucto Fault System at depth and its associated mineral systems north and south of the fault zone.

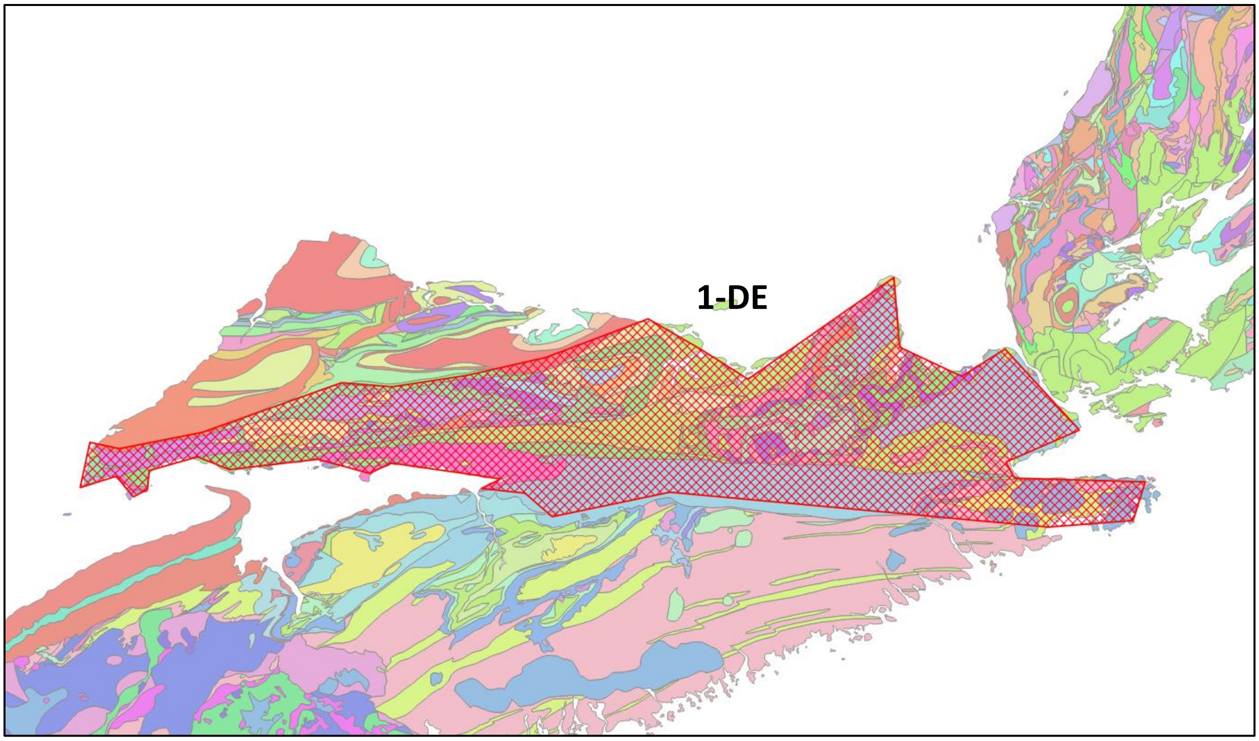


Figure 31. Alternate Phase 2 follow-up survey (1-DE) combining areas 1-D and 1-E, south to 1-F and extension to east.

Geological Background for the Phase 1 and 2 Surveys

Provincewide

Due to the poor resolution of most of the current magnetic and radiometric data in the province of Nova Scotia a compete update to the geophysical data set is recommended. This would act as a reset to the quality of the data available to the public and exploration companies/prospectors. The data will be consistent throughout the province with standard flight line spacing, flying height, instrumentation, processing and deliverables. It would give every prospector, large or small, in the province a "level playing field" with high quality data available everywhere. The instrumentation chosen for this survey (magnetic gradiometry, radiometrics and VLF) will deliver the most scientific impact from one survey.

Targeted Gravity Survey

A targeted airborne gravity gradiometry survey is recommended along the St. Mary's Basin and Cobequid-Chedabucto Fault Zone to assist in creating a geological framework of the fault system and basin along which there are found numerous deposits of Gold, Iron-Oxide-Copper-Gold (IOCG), Pb-Zn and rare earth elements (REE).

Ground gravity data is available along the north side (and some south side) of the fault zone [11] provided by Minotaur Atlantic Exploration Limited. However, the data is only available as 11,662 gravity station

[11] DP ME 509, Version 1, 2018, Ground Gravity Survey, Cobequid-Chedabucto Fault Zone, Northern mainland, Nova Scotia. https://novascotia.ca/natr/meb/download/dp509.asp

locations and a JGPs of the Bouguer gravity anomaly, residual gravity and vertical derivative of the residual gravity. An airborne gravity gradiometry survey will provide "state of the art" data that can be processed, enhanced, modelled and inverted to give details of the fault structure at depth and how it changes along the length of the fault. The airborne survey would also extend into Midas and Cobequid Bay to the west and Chedabucto Bay to the east.

Surveys 1-A, 1-B and 1-C

The Cape Breton Highlands have numerous mineral deposit targets for gold, IOCG and base metals. In addition to the magnetic gradiometry, radiometric and VLF survey, a recommended ZTEM surveys would further define the magmatic intrusions at depth by resistivity/conductivity mapping to depths of a few kilometers. The area has a very complex geology of metamorphosed sedimentary, granitic and volcanic terrains. These areas will be well mapped by the magnetic gradiometry, radiometric and VLF survey, but will be extended to depth, in part, by the ZTEM survey. There is much open ground in the survey areas for potential mineral exploration. If the budget would allow, the 1-A and 1-B surveys could be extended to the east and/or to the west.

Survey 1-DE

The provincewide magnetic gradiometry, radiometric and VLF survey, the gravity gradiometry survey and ZTEM survey (1-DE) all target the Cobequid-Chedabucto Fault Zone along which there are numerous IOCG, polymetallic mineralization (Pb, Zn, Ag, Sn, W, Mo) and rare-earth element (REE) deposits. The following map of IOCG type mineral occurrences along the Cobequid-Chedabucto Fault Zone is taken from an assessment report AR2011-034 titled "Exploration for Iron Oxide Copper-Gold along the Cobequid-Chedabucto Structure, Nova Scotia – Geochemical, Geophysical and Geology Assessment Report Licence 6914"[12]. Furthermore, it states "The fault zone is host to >100 mineral occurrences and small deposits of Fe-oxide ±Cu ±Co ±Au ±Ni ±Ba and consisting of chalcopyrite and barite. Mineral occurrences (**Figure 32**) range from single veins to breccia systems and are associated with widespread carbonate alteration (ankerite, siderite and calcite) along with silica and sericite alteration."[13]

Coverage by the provincewide magnetic gradiometry, radiometric and VLF survey of this fault system will provide detailed information as to the lithology and structure along the fault of the sedimentary and metavolcanics units at surface and to depth. The addition of the gravity gradiometry data and magnetotelluric data (ZTEM) will aid in the definition of the fault system and the magmatic sources of these deposits at depth. As shown by the matrix of geophysical methods and mineral deposit types (**Figure 7**), IOCG deposits (Olympic Dam Type deposits are an example) can be well defined in a geological framework and for direct targeting by the geophysical methods proposed in Phase 1 and 2.

[12] Belperio, T. (2011) Exploration for Iron Oxide Copper-Gold along the Cobequid-Chedabucto Structure, Nova Scotia – Geochemical, Geophysical and Geology Assessment Report Licence 6914 – Blackfly Exploration & Mining Option, Copper Lake, Nova Scotia, Antigonish County. Assessment Report AR2011-034, p.4.
[13] Ibid, p.4.

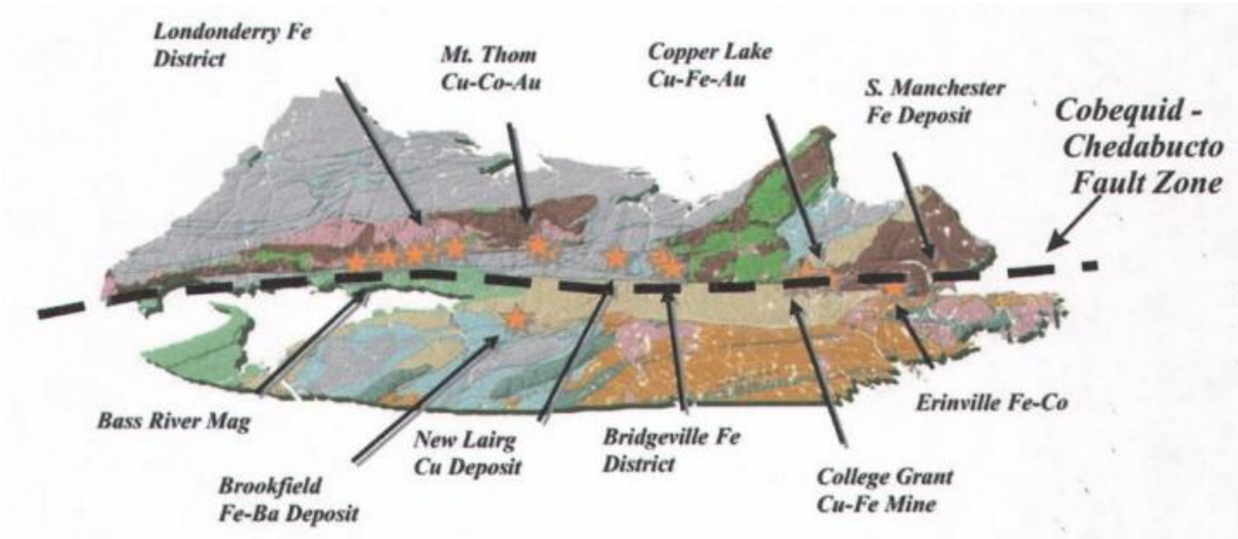


Figure 32. IOCG type mineral occurrences along the Cobequid-Chedabucto Fault Zone (Belperio, 2011).

Survey 1-F

This area encompasses the Windsor and Shubenacadie Basins that hosts a number of gold, sedex (sedimentary exhalative deposits dominant in Zn and Pb) and gas resources. These two basins are adjacent to the gold bearing Meguma Group. A ZTEM survey will provide a resistivity/conductivity image of the area at surface and at depth. It would add valuable information as to the structural connection between these to juxtaposed terrains. As for the basin structure, the aeromagnetic survey may provide further information as to the stratigraphy, basin architecture, depth and fault structures in the area. ZTEM has not been applied in solely hydrocarbon terrains, however it will provide further structural information at depths of a few kilometers. The depth information may complement the seismic data available in the area.

Surveys 2-A, 2-B and 2-C

Secondary follow-up targets (2-A to 2-C) are all located in the western portion of the province. All are less then 7,500 line km in size. They were chosen based upon metallic indicator minerals, interesting geology that could be better delineated and open ground, i.e., relatively few mining claims staked. Due to their small size, an electromagnetic system such as VTEM could also be considered as an alternative to ZTEM, especially for the smallest survey 2-C. ZTEM is a deep looking geophysical method and the small footprint of these areas may not provide a suitable "big picture" of the conductivity at very large depths (~ 2 km or more). A shallower looking method such as VTEM can detect conductive units at depths up to 800 m, in ideal geological conditions, with a resolution higher than that of ZTEM at those depths.

2-A would cover a northeast trending series of gold and base metal occurrences from Yarmouth to the Tobeatic Wilderness area. Also, within the area is a north-north-east trending metavolcanic unit (White Rock Formation) with some Li, Ta, Nb, Sn mineral occurrences. There are already some mining claims in the area, but also some potential open ground for further exploration. 2-B continues the northeast trend from 2-A on the northeast side of the Tobeatic Wilderness area and Kejimkujik National Park into the Meguma Group.

The target 2-C lies between the South Mountain Batholith and North Mountain Basalt. There are some small granite intrusions and mineral indicators for U, Fe, Mn but also one indicator of Co, Ni, As and Au.

Areas Not Covered for Follow-up Surveys

Notable areas not covered by follow-up surveys are the many gold deposits along the synclinal folds of the Meguma Group east of Halifax. The proposed high resolution magnetic gradiometry, radiometric and VLF survey for the province should be sufficient to further refine and delineate these structures and spur further brownfields exploration. The area is already well populated with mining claims.

Neither are there recommendations for follow-up surveys over the South Mountain Batholith and North Mountain Basalt since it is thought that the provincewide survey data should be sufficient in these areas. Areas 2-A, 2-B and 2-C border onto the South Mountain Batholith.

Survey Cost Estimate

As with the previous survey, the final cost would be a combination of the survey cost, mobilization/demobilization and project management and quality control. Costs for 1-D and 1-E are shown in the following table, though a combined large survey of 1-DE would be preferable. Costs per survey kilometer are shown in **Table 8**.

Aircraft Platform and EM System	Surveying Cost ($/km)	Mobilization/Demobilization (Mob/Demob) Cost ($)
Fixed Wing ZTEM	$ 80/km*	$ 20,000
Helicopter ZTEM	$ 100/km**	$ 20,000
Helicopter VTEM	$ 75/km	$ 20,000

Table 8. Estimated surveying and mobilization/demobilization costs.

*Fixed Wing ZTEM costs are not exactly known since those exact figures would not be divulged by Geotech. Previously known quotations from a large survey in India were used and modified for the scale and location of a survey in Nova Scotia. We would estimate that the cost per km could still vary by ± $10 per km.

**Helicopter ZTEM are also not exactly known since those exact figures would not be divulged by Geotech. Previously known quotations from a large survey in India were used and modified for the scale and location of a survey in Nova Scotia. We would estimate that the cost per km could still vary by ± $20 per km.

Project Management and Quality Control would add another 4% to the surveying cost for a fixed wing or helicopter electromagnetic platform for these follow-up target areas. The reduction from 10% for a magnetic gradiometry, radiometric and VLF survey is due to the higher surveying cost per kilometer of an electromagnetic system, thus the Project Management and Quality Control cost would be reduced to 4% of the total surveying cost. All prices are quoted in Canadian dollars in the following **Table 9**.

Survey #	Total Line kilometers Approximated (km)	Aircraft Platform and EM System	Cost per km ($)	Surveying Cost plus Mob/Demob ($)	Project Management and Quality Control	Total Cost ($) per Survey
Primary Target Areas						
1-A	10,000	Helicopter ZTEM	$100/km	$ 1,020,000	$ 40,000	$ 1,060,000
1-B	5,300	Helicopter ZTEM	$100/km	$ 550,000	$ 21,200	$ 571,200
1-C	15,650	Helicopter ZTEM	$100/km	$ 1,585,000	$ 62,600	$ 1,647,600
1-D	9,280	Fixed Wing ZTEM	$80/km	$ 762,400	$ 29,700	$ 792,100
1-E	14,000	Fixed Wing ZTEM	$80/km	$ 1,160,000	$ 44,800	$ 1,204,800
Alternate area combining 1-D and 1E, south to 1-F and extension to east.						
1-DE	55,130	Fixed Wing ZTEM	$80/km	$ 4,430,400	$ 176,400	$ 4,606,800
1-F	23,310	Fixed Wing ZTEM	$80/km	$ 1,884,800	$ 74,600	$ 1,959,400
Or						
1-DE	55,130	Helicopter ZTEM	$100/km	$ 5,533,000	$ 220,500	$ 5,753,500
1-F	23,310	Helicopter ZTEM	$100/km	$ 2,351,000	$ 93,200	$ 2,444,200
Secondary Target Areas						
2-A	5,015	Helicopter ZTEM	$100/km	$ 521,500	$ 20,000	$ 541,500
2-B	7,280	Helicopter ZTEM	$100/km	$ 748,000	$ 29,100	$ 777,100
2-C	1,340	Helicopter VTEM	$75/km	$ 120,500	$ 4,000	$ 124,500

Table 9. Survey costs associated with various target and alternative areas.

Admittedly, the above table has many variations, alternatives and secondary target areas. If we had to narrow our choices to the most important target areas and electromagnetic methodologies, we recommend trimming this list to the following **Table 10**.

Survey #	Total Line kilometers Approximated (km)	Aircraft Platform and EM System	Cost per km ($)	Surveying Cost plus Mob/Demob ($)	Project Management and Quality Control	Total Cost ($) per Survey
Primary Target Areas						
1-A	10,000	Helicopter ZTEM	$100/km	$ 1,020,000	$ 40,000	$ 1,060,000
1-B	5,300	Helicopter ZTEM	$100/km	$ 550,000	$ 21,200	$ 571,200
1-C	15,650	Helicopter ZTEM	$100/km	$ 1,585,000	$ 62,600	$ 1,647,600
1-DE	55,130	Fixed Wing ZTEM	$80/km	$ 4,430,400	$ 176,400	$ 4,606,800
1-F	23,310	Fixed Wing ZTEM	$80/km	$ 1,884,800	$ 74,600	$ 1,959,400
	109,390 km					**$ 9,845,000**

Table 10. Proposed Phase 2 follow-up survey costs.

An updated map of the follow-up targets areas is shown in **Figure 33** below.

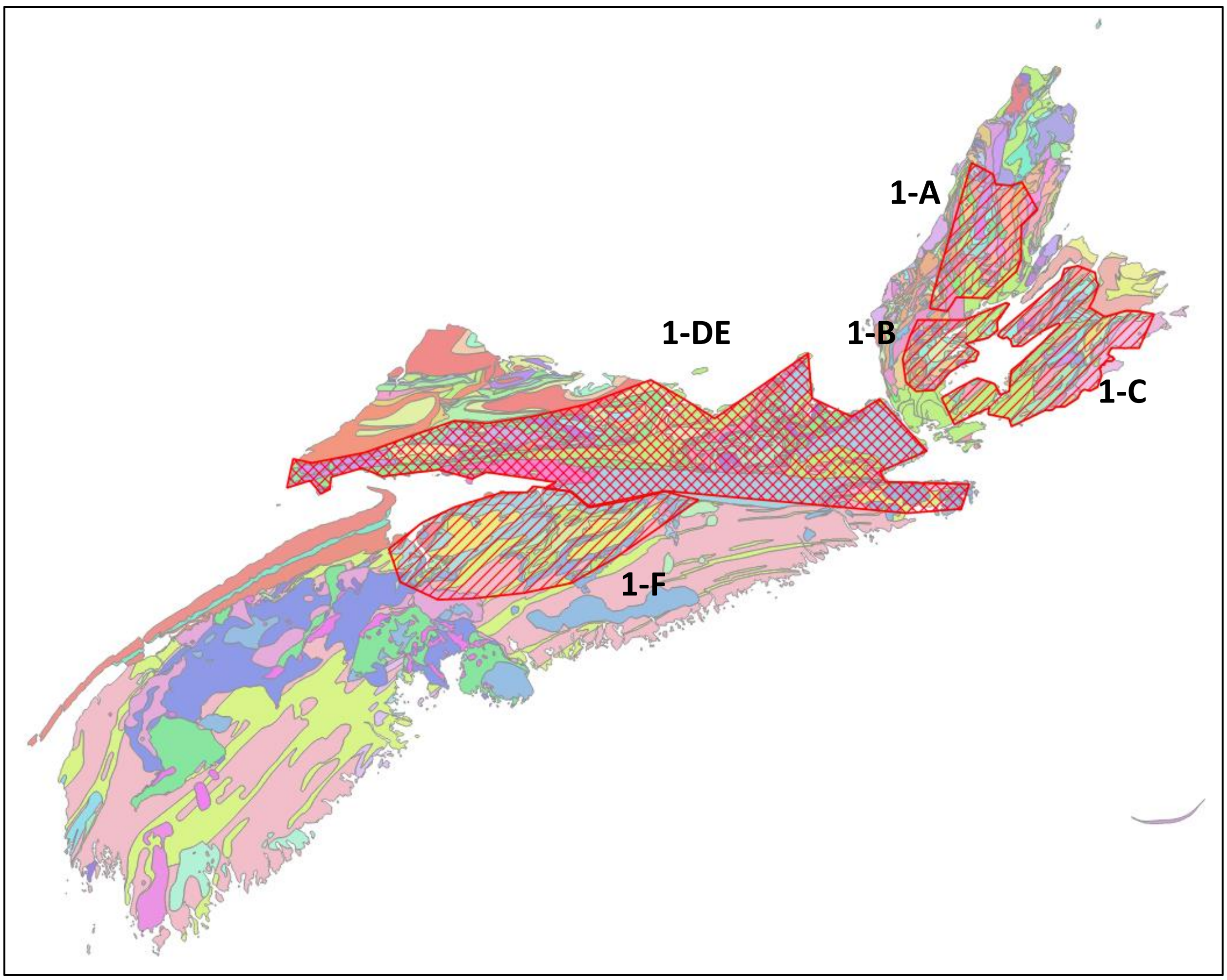


Figure 33. Proposed Phase 2 follow-up survey areas.

The ZTEM survey will also include a magnetic survey (single or gradient system). The addition of the magnetic data acquisition basically comes at little extra cost to the survey. Flying heights of the fixed wing aircraft is 100 m mean terrain clearance. Helicopter aircraft will fly at a higher height, but the sensor will be on a tow cable below the aircraft. Final sensor heights of the electromagnetic receiver and magnetometer(s) will vary between different electromagnetic systems.

It is recommended that one aircraft (helicopter) carry out the smaller (less than 16,000 km) ZTEM surveys. The larger surveys (greater than 20,000 km) may have one or two dedicated aircraft (fixed wing). Fixed wing survey aircraft have a production rate similar to that of the magnetic gradiometry, radiometric and VLF survey, i.e., 5,000 km per week per aircraft. Helicopter surveys have an average production rate of approximately 400 km per day or 2,000 km per week. Thus, the estimated time for data acquisition would be as follows in **Table 11**.

Survey #	Total Line kilometers Approximated (km)	Aircraft Platform and EM System	Number of Dedicated Aircraft	Production Rate per Week (km)	Approximate Weeks to complete Data Acquisition
Primary Target Areas					
1-A	10,000	Helicopter ZTEM	1	2,000 km / week	5
1-B	5,300	Helicopter ZTEM	1	2,000 km / week	2.75
1-C	15,650	Helicopter ZTEM	1	2,000 km / week	8
1-DE	55,130	Fixed Wing ZTEM	1	5,000 km / week	11
1-F	23,310	Fixed Wing ZTEM	1	5,000 km / week	5

Table 11. Estimated time for data acquisition.

As with magnetic or gravity surveys, an electromagnetic survey can be conducted throughout the year and is not dependent on snow cover or water saturated ground. However, due to the conductivity of seawater, an electromagnetic survey will be confined to the on-shore areas of Nova Scotia, though the aircraft could traverse some areas of open sea (inlets, bays, etc.) to take advantage of the most efficient flight path.

Survey Summary – Follow-Up Survey Specifications

- Flight Line Spacing – 200 m to result in a grid with a 40 m resolution
- Flying Height – 100 m mean terrain clearance, sensor heights to be determined.
- Aircraft Type – Mix of fixed wing and helicopter aircraft
- Survey Speed – approximately 75 m/s for Fixed wing and 25 m/s for Helicopter
- 3 surveys with one helicopter with a total data acquisition of approximately 16 weeks and a fixed wing aircraft with a total data acquisition of approximately 16 weeks.

Phase 1 and 2 Survey Final Summary Costs

Final summary costs for Phase 1 and 2 geophysical surveys are summarized in **Table 12**.

Survey Description	Total Line Kilometers (km)	Flight Line Spacing (m)	Estimated Total Survey Cost ($)
Phase 1			
Provincewide magnetic gradiometry, radiometric and VLF survey	365,000 km	200 m	$ 4,838,000
Targeted gravity gradiometry and magnetic survey	40,850 km	250 m	$ 4,533,500
Phase 2			
Five follow-up electromagnetic (ZTEM) surveys	109,390 km	200 m	$ 9,845,000
Total	515,240 km		**$ 19,216,500**

Table 12. Phase 1 and 2 survey final summary costs.

Survey Deliverables

Industry standard deliverables in the form of a database, grids and report would be produced by the survey contractor. Additional deliverables, inversions and interpretations may be generated after negotiations with the survey contractor and/or a geophysical consultant. The deliverables will be in a form so that they will be useful for years to come by students, prospectors, geoscientists, exploration managers, etc.

Standard contractor deliverables are:

Profile Database - Geosoft® binary database (*.gdb) which is an industry standard format. It can be viewed and processed within the Geosoft® Oasis Montaj software package as well as other mapping software packages. An ASCII equivalent version of the database is provided as an *.XYZ file compatible with legacy software. Raw and processed channels will be included for all traverse and tie lines. The coordinate system for Eastings and Northings will be in NAD83 and UTM zone 20 and Longitude and Latitude in the NAD83 datum. A list of typical channels for magnetic gradiometry, radiometric, electromagnetic and gravity gradiometry surveys is given in Appendix C.

Grids - Geosoft® binary grid (*.grd) which is an industry standard format. It can be viewed and processed within the Geosoft® Oasis Montaj software package as well as other mapping software packages. An ASCII equivalent version of the grid is provided as an *.GXF file compatible with other legacy software. The coordinate system for all grids will be NAD83 and UTM zone 20. A list of typical grids for magnetic gradiometry, radiometric, electromagnetic and gravity gradiometry surveys is given in Appendix C.

Report – a complete logistics and processing report describing all the aircraft, personnel, instrumentation, pre-survey and post-survey calibration tests, field acquisition, office processing and preparation of final deliverables.

Benefit - Cost of Publicly Available Geoscience Data

There has been a number of studies as to the tax revenue generated or benefit - cost ratio of publicly available geoscience data. This sometimes referred to as "pre-competitive geodata" meaning that the exploration is still in its early stages where competitors often collaborate and it is aimed as an incentive for exploration investment. Anthony Benham, Principle Exploration Geologist at SRK Exploration Services, an international mining consulting firm, presented a talk at The Mining Show in Dubai (October 2018) as to the importance of geoscience data to government in stimulating investments in the mining sector. Some examples given were a thirty-year study in Chile which concluded that for each dollar spent on acquiring geoscience data there was $11.5 returned in tax revenue. The geoscience data published by the Geological Survey of Western Australia (GSWA) estimates a benefit - cost ratio between 5.2 and 9.0 and that "companies really do form and raise funds for exploration based on information published by GSWA".

To cite some government of Australia statistics[14] as to the value of pre-competitive data (collection, collation and integration of basic geoscience data):

"The South Australian Government estimates that its investment in the acquisition of pre-competitive geoscientific data directly stimulated private exploration investment by a factor of 3 - 5 times the cost of providing core data."

"The Queensland Government estimates that for every dollar spent on initiative work, explorers spent another $15. Geoscience Australia cites studies that each pre-competitive dollar generated on average $5 of private exploration expenditure."

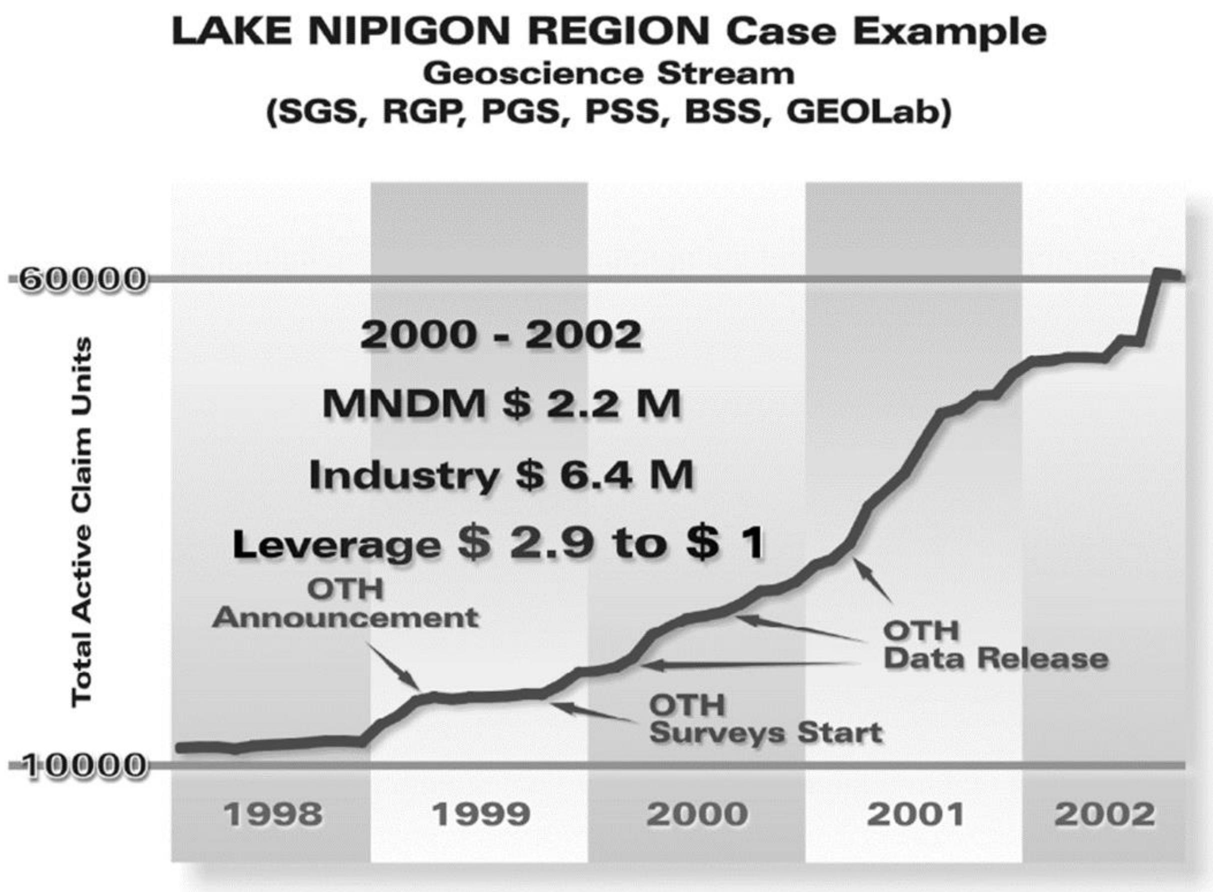


Figure 34. Total active mining claims west of the Lake Nipigon survey region pre- and post- release of the geoscience data.

In Canada, the Ontario Geological Survey (OGS) reviewed more than fifteen impact studies of geoscience initiatives in Canada and worldwide before their geoscience program named "Operation Treasure Hunt" (OTH) in began in 1999 (Reford et al., 2001)[15]. They concluded that "the leverage of private sector to

[14] Exploring: Australia's Future - impediments to increasing investment in minerals and petroleum exploration in Australia (2003) House of Representatives, Standing Committee on Industry and Resources.
[15] Reford, S., Rudd, J. and Churchill, L. (2001) Operation Treasure Hunt – Does the Ontario model work for you? Extended Abstracts, ASEG 15th Geophysical Conference and Exhibition, Brisbane, Australia.

public sector investment in exploration is typically in the 2:1 to 5:1 range. These figures increase by an order of magnitude if mine discovery can be attributed to the initiative." The OGS tracked the impact of their geoscience initiative by the number of mining claims staked and a poll of 180 of its geoscience clients (Fyon et al., 2002)[16]. In the example cited, the change in total active mining claims for the west side of the Lake Nipigon region showed an increase from 10,000 to 60,000 mining claims following the publication of the geoscience data (geophysical survey, lake sediment survey and bedrock mapping) in the region (**Figure 34**). The Ministry of Northern Development and Mines (MNDM) invested $2.2 million into the Lake Nipigon surveys, but realized an industry investment of $6.4 million shortly following the publication of the data. This resulted in a cost – benefit ratio of 2.9. Their clients were satisfied with the geoscience products produced in that it provided new and relevant data, increased investment in prospecting and exploration and contributed to job creation in their geoscience industry.

Environmental Impact of the Proposed Surveys

The proposed geophysical surveys will have little or no environmental impact. We would not foresee any impact other than brief disturbances to wildlife and residents due to the sound and appearance of the low flying aircraft. To mitigate this impact, it is standard surveying procedure to fly at a higher height of approximately 300 m over populated regions and other sensitive areas. Also, an awareness campaign for the public and police services would help stem any fears due to the low flying aircraft.

All of the proposed methods: magnetics, radiometrics, gravity and magnetotellurics (ZTEM) are passive geophysical methods. That is, they measure naturally occurring energy in the environment. Only the active electromagnetic methods, such as VTEM, pump energy into the ground and that is only for brief moments in time. It is more likely that the electromagnetic receivers will measure noise from power lines and other types of electromagnetic transmitters in the area.

During the planning stages of the survey, the schedule of certain areas of the survey can be timed around factors such as bird or animal migrations and hunting seasons to avoid impact on those activities.

Fuel handling is done by trained airport personal and not by the survey crew. In case of a fuel spill, spill kits are and will be required to be mandatory at the base airports. The pilots and ground crew are trained in health, environmental and safety issues. The survey contractor is partially chosen on the basis of their experience and safety record to minimize potential in flight and on ground accidents.

[16] Fyon, J. A., Churchill, L. L. and Baker, C. L. (2002) Project Unite 00-029. Measuring the Results of Ontario Geological Survey Projects: Impact of Operation Treasure Hunt, in Summary of Field Work and Other Activities 2002, Ontario Geological Survey, Open File Report 6100, p. 3-1 to 3-5.

Conclusions

Mineral deposit discoveries at surface are becoming more and more rare. Geophysical techniques can provide data that can look at the surface in detail and under the cover of overburden (soils, rocks) to the depths of many kilometers. The use of a variety of geophysical methods that measure the magnetic field, gravity, naturally occurring radiation, and electromagnetic energy, will allow for a three-dimensional geological framework or model to be constructed from the geoscience data. Major and local structures such as faults, folds, shear zones and intrusions can be defined. Lithology or "rock type" can be determined from combination of the physical properties measured. All combined, a "big picture" of the geology is created at or near the surface to depth, often to several kilometres. Coupled with our understanding of the different mineral deposit types in Nova Scotia, a high-resolution geophysical data set would guide further exploration in the province.

After a review of the current state of the publicly available geophysical data in the province of Nova Scotia it was concluded that the present state of the data is of too low a quality for modern mineral exploration and only fit for broad regional studies. It is the recommended that:

1) A survey of the entire province of Nova Scotia be conducted at flight line spacing of 200 m with a magnetic gradiometry, radiometric and VLF system with three fixed wing aircraft,

2) An airborne gravity gradiometry and magnetic survey be flown over the extents of the Cobequid-Chedabucto Fault Zone where there are numerous known mineral deposit types.

3) A second phase of the project would consist of a number of follow-up electromagnetic surveys to determine structure and conductivity targets at depth specifically targeted at metal bearing mineral deposits.

These new geophysical surveys would result in a "best in class" data set that would rival the data from any province in Canada and elsewhere in the world. The availability of high quality geoscience data reduces the exploration risk to the mining company. The cost - benefit ratio of the publication of geoscience data has varied around the world. But in all cases the benefits have been positive in industry investment and job creation.

Certificates of Qualification and Declaration

I, Edna Mueller-Markham, P.Geo., do hereby certify that:

1. I currently reside at 3315 – 81 Navy Wharf Court, Toronto, Ontario, M5V 3S2, Canada.
2. I am a graduate of the University of Toronto, Toronto, Ontario with an Bachelor of Science degree – Honours Physics, specialization in Geophysics, completed in 1988.
3. I am a graduate of McMaster University, Hamilton, Ontario with an Master of Science degree – Geology, completed in 1991.
4. I have worked as a geophysicist for a total of 21 years since my graduation, all of which has been with Paterson, Grant & Watson Limited.
5. I am currently Vice President and Senior Consulting Geophysicist for Paterson, Grant & Watson Limited.
6. I am a Practising Member in good standing with the Association of Professional Geoscientists of Ontario, (APGO member #2185).
7. Paterson, Grant & Watson Limited has a Certificate of Authorization with the Association of Professional Geoscientists of Nova Scotia (APGNS). Our corporate registration number s CA-068.
8. I am responsible for all sections of the report “Assessment on the Current State of the Airborne Geophysical Data for Nova Scotia” and dated October 15, 2018.

Dated this 15th day of October 2018.

Edna Mueller-Markham, P.Geo.

Appendix A – Assessment of Geophysical Data from the GSC

Source	Survey Name	Year Flown	Grid Cell Size (m)	Survey Type	Flight Line Spacing (m)	Flight Height (m)	Geoid Used	Technical Report Included?	Profile Database Included?	Flight Path Quality	Tie lines Included	Mag Quality	Magnetic Sensor Resolution (nT)	Data Sampling Frequency (Hz)	Mag Data Gaps?	Levelling or Microlevlling or Filtering Required	Rad Quality	Rad Data Gaps?	Ternary Image Quality	Other Comments
GSC	Amherst-Pugwash	1990	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Fair	1	1	Yes	Yes	Good	No	Yes	
GSC	Annapolis-Shelburne	1974	1000	Rad	5000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Antigonish	1978	62.5	Mag	300	152	NAD27	No	Yes	Fair	Yes	Good	0.001	2	no	Yes	N/A	N/A	N/A	Some work needed on Magnetics channels
GSC	Antigonish Highlands	1986	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Good	10	1	No	Yes	Good	No	Yes	
GSC	Big Indian Lake	1986	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Fair	No	Fair	1	1	No	No	Good	No	Yes	Some filtering need on Magnetics and Radiometrics
GSC	Bras d'Or Lakes	1990	200	Mag/Rad	1000	400	NAD27	No	Yes	Good	No	Good	1	1	Yes	Yes	Good	Yes	Yes	Line gap in centre
GSC	Cape Breton	1979	1000	Rad	5000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Cape Breton (Queenair)	1980	62.5	Mag/VLF	400	609	NAD27	No	Yes	Fair	Yes	Good	0.01	2	No	Yes	N/A	N/A	N/A	
GSC	Cape Breton Highlands	1986	250	Mag/Rad	1000	125	NAD27	No	Yes	Fair	No	Good	0.1	1	No	Yes	Good	No	Yes	
GSC	Cape Breton Highlands (North)	1990	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Fair	No	Fair	1	1	Yes	Yes	Good	No	Yes	Magnetics noisy in north, f_mtf channel not final
GSC	Cape Breton Island	1991	62.5	Mag/VLF	300	150	NAD27	Yes	Yes	Fair	Yes	Good	0.01	4	No	Yes	N/A	N/A	N/A	
GSC	Chedabucto Bay	1979	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Cobequid Hills	1985	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Good	10	1	No	Yes	Good	No	Yes	
GSC	Digby	1990	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Good	1	1	No	Yes	Fair	No	Yes	Many short lines, little useful ternary information seen
GSC	East Kemptville, Davis Lake Complex	1987	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Fair	No	Good	1	1	No	Yes	Good	No	Yes	
GSC	Eastern Liscomb Pluton	1986	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Good	No	Good	10	1	No	No	Good	No	Yes	Some smoothing required
GSC	Georges Bank Area A B C	1982	500	Mag	2000	300	NAD27	Yes	Yes	Good	Some	Good	0.001	1	No	Yes	N/A	N/A	N/A	
GSC	Gibraltar Hill	1986	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Good	No	Good	1	1	No	Yes	Good	No	Yes	Some smoothing required
GSC	Granite Lake	1986	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Good	No	Good	10	1	No	Yes	Good	No	Yes	Some smoothing required
GSC	Greenwood	1990	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Good	1	1	No	Yes	Good	No	Yes	

GSC	Guysborough	1983	75	Mag/VLF	300	150	NAD27	No	Yes	Fair	Yes	Good	0.001	2	No	Yes	N/A	N/A	N/A	Errors in levelled Magnetic channels
GSC	Halifax Rad	1982	200	Mag/Rad	1000	120	NAD27	No	Yes	Good	Yes	Good	10	1	No	No	Good	No	Yes	Magnetic grid needs IGRF correction
GSC	Halifax Mag	1976	62.5	Mag	300	150	NAD27	No	Yes	Good	Yes	Good	0.001	2	No	Yes	N/A	N/A	N/A	Errors in levelled channels
GSC	Halifax (recon)	1978	1000	Rad	5000	120	NAD27	No	Yes	Good	Yes	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Lac Rossignol	1978	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Laurentian Channel	1985	250, 500 and 1000	Mag	1000, 2000 and 4000	305	NAD27	No	Yes	Good	No	Good	0.001	1	Yes	Yes	N/A	N/A	N/A	Line gap in centre of survey, several data sets that need to be merged
GSC	Liscomb	1981	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Liverpool	1985	62.5	Mag/VLF	300	150	NAD27	No	Yes	Fair	Yes	Good	0.01	1	Yes	Yes	N/A	N/A	N/A	Errors in levelled channels, small gaps in data
GSC	Lunenburg	1986	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Fair	10	1	No	Yes	Good	No	Yes	
GSC	Mahone Bay	1983	75	Mag/VLF	300	150	NAD27	Yes	Yes	Fair	Yes	Good	0.01	1	No	Yes	N/A	N/A	N/A	
GSC	Musquodoboit	1986	75	Mag/VLF	300	150	NAD27	Yes	Yes	Fair	Yes	Good	0.01	10	No	Yes	N/A	N/A	N/A	
GSC	North Mountain	1983	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Nova Scotia #01	1962	100	Mag	483	61	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #05	1958	400	Mag	1609	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #06	1958	400	Mag	1609	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #07	1953	100	Mag	400	1000	NAD27	No	Yes	Fair	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #08	1956	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #08 To Merge	1956	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #09	1954	200	Mag	805	137	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #10	1954	200	Mag	805	137	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #11	1953	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #12	1953	200	Mag	805	305	NAD27	No	Yes	Fair	No	Good	N/A	N/A	No	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #14	1954	400	Mag	1609	152	NAD27	No	Yes	Fair	No	Good	N/A	N/A	No	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #15	1953	400	Mag	1609	152	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #16	1979	100	Mag	400	610	NAD27	No	Yes	Fair	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #17	1958	1500	Mag	6950	305	NAD27	No	Yes	Poor	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #18	1958	100	Mag	500	305	NAD27	No	Yes	Fair	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #40	1958	200	Mag	805	305	NAD27	No	Yes	Fair	No	Good	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Digitized from contour maps

GSC	Nova Scotia #40 To Merge	1958	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	Yes	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #41	1958	200	Mag	805	305	NAD27	No	Yes	Fair	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #42	1958	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #43	1953	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #43 To Merge	1953	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #44	1962	200	Mag	805	305	NAD27	No	Yes	Fair	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #45	1953	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #45 To Merge	1953	200	Mag	805	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #51	1958	400	Mag	1609	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #52	1958	400	Mag	1609	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #53	1958	800	Mag	3218	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #61	1958	400	Mag	1609	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	Yes	No	N/A	N/A	N/A	Digitized from contour maps
GSC	Nova Scotia #61 To Merge	1958	400	Mag	1609	305	NAD27	No	Yes	Good	No	Good	N/A	N/A	No	No	N/A	N/A	N/A	Digitized from contour maps
GSC	NRC Bay of Fundy	1995	250	Mag	1000	152	NAD83	No	Yes	Fair	Yes	Good	0.01	2	No	No	N/A	N/A	N/A	
GSC	Parrsboro	1987	62.5	Mag/VLF	300	150	NAD27	Yes	Yes	Fair	Yes	Good	0.01	6	No	Yes	N/A	N/A	N/A	
GSC	Seabright (Canso Area)	1987	50	Mag/VLF	200	150	NAD27	Yes	Yes	Fair	Yes	Good	0.01	1	No	Yes	N/A	N/A	N/A	
GSC	Shearwater	1990	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Good	1	1	No	Yes	Good	No	Yes	
GSC	Ship Harbour	1986	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Good	No	Good	10	1	No	Yes	Good	No	Yes	
GSC	South Mountain	1980	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	St. Mary's River	1970	62.5	Mag	457	458	NAD27	No	Yes	Fair	Yes	Good	0.01	2	No	Yes	N/A	N/A	N/A	
GSC	Tantallon	1986	50	Mag/Rad/VLF	250	120	NAD27	No	Yes	Good	No	Fair	1	1	No	Yes	Good	No	Yes	
GSC	Uniacke and Kennetcook	1976	200	Rad	1000	120	NAD27	No	Yes	Fair	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Western Cape Breton Island	1994	50	Mag/VLF	300	150	NAD27	Yes	Yes	Good	Yes	Good	0.01	4	No	Yes	N/A	N/A	N/A	Error in Magnetic data in one line
GSC	Windsor Basin East	1980	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Windsor Basin West	1978	200	Rad	1000	120	NAD27	No	Yes	Good	No	N/A	N/A	1	N/A	N/A	Good	No	Yes	
GSC	Yarmouth	1989-1990	50	Mag/VLF	300	150	NAD27	Yes	Yes	Fair	Yes	Good	0.01	4	No	Yes	N/A	N/A	N/A	
GSC	Yarmouth	1983	200	Mag/Rad/VLF	1000	120	NAD27	No	Yes	Good	No	Good	10	1	No	Yes	Good	No	Yes	
GSC	Yarmouth	1976	62.5	Mag	300	150	NAD27	No	Yes	Good	Yes	Good	0.01	2	No	Yes	N/A	N/A	N/A	

Appendix B – Assessment of NI 43-101 Reports for Proprietary Geophysical Surveys

National Instrument 43-101								
Title of NI 43-101 Report	Report Date	Location	Deposit Type	New Airborne Geophysical Survey?	Date of Survey	Method Type	Line kms	Other comments
Atlantic Canada Project Newfoundland and Labrador, New Brunswick, Nova Scotia Canada-May 22 2007.pdf	04/2007	Millet Brook and Cobequid Claim Group	Uranium	None	N/A	N/A	N/A	No geophysical survey. Compilation and assessment of existing data recommended.
Atlantic Canada Project Newfoundland and Labrador, New Brunswick and Nova Scotia Canada-Jul 18 2007.pdf	04/2007	Millet Brook and Cobequid Claim Group	Uranium	None	N/A	N/A	N/A	Repeat of previous report.
Beaver Dam Property Halifax County Nova Scotia Canada-Sep 17 2007.pdf	09/2007	Beaver Dam, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Beaver Dam Gold Project Halifax County Nova Scotia Canada-Apr 16 2015.pdf	03/2015	Beaver Dam, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant
Brazil Lake Lithium-Bearing Pegmatite Property Nova Scotia Canada-Jun 17 2010.pdf	06/2010	Brazil Lake	Lithium Pegmatite	No, past ground surveys	N/A	N/A	N/A	Not relevant
Caribou Property Upper Musquodoboit Halifax County Nova Scotia Canada-Feb 21 2007.pdf	12/2006	Caribou Property, Upper Musquodoboit, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed

Caribou Gold Property Upper Musquodoboit Halifax County Nova Scotia Canada-Nov 30 2007.pdf	09/2007	Caribou Property, Upper Musquodoboit, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Caribou Gold Property Upper Musquodoboit Halifax County Nova Scotia Canada-Nov 28 2008.pdf	10/2008	Caribou Property, Upper Musquodoboit, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Christmas East Graphite Project Cape Breton County Nova Scotia Canada-Jan 28 2013.pdf	11/2012	Christmas East, Cape Breton County	Graphite	No, past ground surveys	N/A	N/A	N/A	Not relevant
Cochrane Hill Gold Property Guysborough County Nova Scotia Canada-Nov 30 2007.pdf	09/2007	Cochrane Hill, Guysborough County	Gold	No, past airborne survey and ground surveys	1979	Fixed wing magnetic and VLF	N/A	Not relevant
Cochane Hill Gold Project Nova Scotia Canada-May 22 2014.pdf	04/2014	Cochrane Hill, Guysborough County	Gold	No, past airborne survey and ground surveys	1979	Fixed wing magnetic and VLF	N/A	Not relevant
Cochrane Hill Gold Project Nova Scotia Canada-Aug 14 2014.pdf	08/2014	Cochrane Hill, Guysborough County	Gold	No, past airborne survey and ground surveys	1979	Fixed wing magnetic and VLF	N/A	Not relevant

Coxheath Copper Project Cape Breton Island Nova Scotia Canada-Apr 3 2008.pdf	10/2007	Coxheath Project, Cape Breton County	Copper	No, past airborne survey and ground surveys	1987	Fixed wing magnetic and VLF	N/A	Not relevant
Donkin Coal Project Cape Breton Nova Scotia Canada-May 14 2007.pdf	04/2007	Donkin Project, Cape Breton County	Coal	No, past seismic and logging surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Donkin Coal Project Nova Scotia Canada-Nov 26 2007.pdf	11/2007	Donkin Project, Cape Breton County	Coal	No, past seismic and logging surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Donkin Coal Project Cape Breton Nova Scotia Canada-Jun 30 2011.pdf	06/2011	Donkin Project, Cape Breton County	Coal	No, past seismic and logging surveys	N/A	N/A	N/A	Not relevant
Donkin Coal Project Cape Breton Nova Scotia Canada-Oct 1 2012.pdf	06/2011	Donkin Project, Cape Breton County	Coal	No, past seismic and logging surveys	N/A	N/A	N/A	Identical to previous report
Donkin Coal Project Cape Breton Nova Scotia Canada-Nov 9 2012.pdf	11/2012	Donkin Project, Cape Breton County	Coal	No, past seismic and logging surveys	N/A	N/A	N/A	Not relevant
Dufferin Property Nova Scotia Canada-Jun 15 2009.pdf	06/2009	Dufferin Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant

Dufferin Property Nova Scotia Canada-Jun 6 2012.pdf	07/2012	Dufferin Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant
Dufferin Gold Deposit Nova Scotia Canada-Jan 24 2017.pdf	12/2016	Dufferin Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant
Dufferin Property Dufferin Gold Deposit Nova Scotia Canada-Apr 11 2017.pdf	12/2016	Dufferin Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant
Fifteen Mile Stream Gold Property Halifax County Nova Scotia Canada-Jul 4 2008.pdf	05/2008	Fifteen Mile Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant
Fifteen Mile Stream Property Halifax County Nova Scotia Canada-Sep 4 2012.pdf	08/2012	Fifteen Mile Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Fifteen Mile Stream Gold Project Halifax County Nova Scotia Canada-Apr 2 2015.pdf	02/2015	Fifteen Mile Property, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Not relevant
Forest Hill Gold Property Nova Scotia Canada-Apr 26 2017.pdf	04/2017	Forest Hill Property, Guysborough County	Gold	No	N/A	N/A	N/A	Not relevant
Gay’s River and Getty Deposits Nova Scotia Canada-Jul 8 2011.pdf	07/2011	Gay's River and Getty Deposit, Halifax County	Zinc-Lead	No	N/A	N/A	N/A	Not relevant
Gays River and Getty Deposits Halifax Regional Municipality Nova Scotia Canada-Oct 9 2012.pdf	10/2012	Gay's River and Getty Deposit, Halifax County	Zinc-Lead	No	N/A	N/A	N/A	Not relevant

Gays River and Getty Deposits Nova Scotia Canada-Jun 12 2013.pdf	06/2013	Gay's River and Getty Deposit, Halifax County	Zinc-Lead	No	N/A	N/A	N/A	Not relevant
Getty Zinc-Lead Depositgays River Area Halifax County Nova Scotia Canada-Mar 27 2008.pdf	12/2007	Getty Deposit, Halifax County	Zinc-Lead	No	N/A	N/A	N/A	Government geophysical data was reviewed
Getty Zinc-Lead Deposit Gays River Area Halifax County Nova Scotia Canada-Nov 17 2008.pdf	11/2008	Getty Deposit, Halifax County	Zinc-Lead	No	N/A	N/A	N/A	Not relevant
Getty Zinc-Lead Deposit Gays River Area Halifax County Nova Scotia Canada-May 5 2011.pdf	03/2011	Getty Deposit, Halifax County	Zinc-Lead	No	N/A	N/A	N/A	Not relevant
Goldboro Property Guysburough County Nova Scotia Canada-Sep 16 2009.pdf	09/2009	Goldboro Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1987	Helicopter magnetic and EM	N/A	Not relevant
Goldboro Property Guysborough County Nova Scotia Canada-Apr 17 2013.pdf	04/2013	Goldboro Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1987	Helicopter magnetic and EM	N/A	Not relevant
Goldboro Property Goldboro Nova Scotia Canada-Apr 24 2014.pdf	04/2014	Goldboro Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1987	Helicopter magnetic and EM	N/A	Not relevant

Goldboro Property Guysborough County Nova Scotia Canada-Apr 3 2017.pdf	04/2015	Goldboro Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1987	Helicopter magnetic and EM	N/A	Not relevant
Goldboro Property Guysborough County Nova Scotia Canada-Aug 25 2017.pdf	02/2017	Goldboro Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1987	Helicopter magnetic and EM	N/A	Not relevant
Goldboro Project Nova Scotia Canada-Mar 2 2018.pdf	03/2018	Goldboro Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1987	Helicopter magnetic and EM	N/A	Not relevant
Goldenville Property Guysborough County Nova Scotia Canada-Mar 2 2017.pdf	02/2017	Goldenville Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1981	Fixed wing magnetic and VLF	N/A	Government geophysical data was reviewed
Goldenville Project Guysborough County Nova Scotia Canada-Apr 28 2017.pdf	04/2017	Goldenville Property, Guysborough County	Gold	No, past airborne survey and ground surveys	1981	Fixed wing magnetic and VLF	N/A	Government geophysical data was reviewed

Hants County Property Nova Scotia Canada-Feb 14 2008.pdf	01/2008	Hants County Property	Gold, Lead-Zinc	No, past airborne survey and ground surveys	2001	Fixed wing magnetic	N/A but 900 km^2 in size	Data processing by the Nova Scotia Department of Energy
Harrigan Cove Property Halifax County Nova Scotia Canada-Jul 29 2011.pdf	06/2011	Harrigan Cove, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Harrigan Cove Property Halifax County Nova Scotia Canada-Aug 29 2011.pdf	08/2011	Harrigan Cove, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Harrigan Cove Property Halifax County Nova Scotia Canada-Apr 27 2012.pdf	02/2012	Harrigan Cove, Halifax County	Gold	No, past ground surveys	N/A	N/A	N/A	Government geophysical data was reviewed
Jubilee Zinc-Lead Deposit Victoria County Nova Scotia Canada-Feb 15 2008.pdf	11/2007	Jubilee Deposit, Victoria County	Zinc-Lead	No, past airborne survey and ground surveys	1987	N/A	N/A	Government geophysical data was reviewed
Jubilee Zinc-Lead Deposit Exploration Properties Inverness and Victoria Counties Nova Scotia Canada- Mar 31 2009.pdf	02/2009	Jubilee Deposit, Inverness and Victoria County	Zinc-Lead	No, past airborne survey and ground surveys	1987	N/A	280 km	Government geophysical data was reviewed

Jubilee Zinc Project Victoria County Nova Scotia Canada-Dec 23 2009.pdf	10/2009	Jubilee Deposit, Victoria County	Zinc-Lead	No, past airborne survey and ground surveys	1987	N/A	N/A	Government geophysical data was reviewed
Meaghers Property Halifax County Jul 26 2018.pdf	07/2018	Meaghers Property, Halifax County	Gold	No, past airborne survey and ground surveys	1980	magnetic and VLF	N/A	Government geophysical data was reviewed. Further airborne and ground geophysics was recommended.
Mill Village Gold Property Queens County Nova Scotia Canada-Dec 8 2010.pdf	12/2010	Mill Village Property, Queens County	Gold	No	N/A	N/A	N/A	Not relevant
Millen Mountain Property Middle Musquodoboit Halifax and Colchester Counties Nova Scotia Canada-Jun 15 2017.pdf	05/2017	Middle Musquodoboit, Halifax and Colchester Counties	Gold	No, new ground geophysical survey	N/A	N/A	N/A	Government geophysical data was reviewed
Millen Mountain Property Middle Musquodoboit Halifax and Colchester Counties Nova Scotia Canada-Aug 9 2017.pdf	08/2017	Middle Musquodoboit, Halifax and Colchester Counties	Gold	No, new ground geophysical survey	N/A	N/A	N/A	Government geophysical data was reviewed
Moose River Consolidated Project Nova Scotia Canada-Aug 13 2015.pdf	08/2015	Moose River Project, Halifax County	Gold	No, past airborne survey and ground surveys	2010	magnetic	N/A	100 and 50 m line spacing, line km unknown

Moose River Consolidated Phase 2 Project Nova Scotia Canada-Sep 1 2017.pdf	07/2017	Moose River Project, Halifax County	Gold	No, past airborne survey and ground surveys	2010	magnetic	N/A	
Moose River Consolidated Project Nova Scotia Canada-Mar 15 2018.pdf	01/2018	Moose River Project, Halifax County	Gold	No, past airborne survey and ground surveys	2010	helicopter magnetic gradiometry and VLF	940 and 1600 km	This report had the survey line km and methods from the 2010 survey.
Mooseland Gold Property Halifax County Nova Scotia Canada-Jun 4 2010.pdf	04/2010	Mooseland Property, Halifax County	Gold	No, past airborne survey and ground surveys	1986, 1997	magnetic and VLF	N/A	Government geophysical data was reviewed
Mooseland Gold Property Halifax County Nova Scotia Canada-Jun 17 2011.pdf	06/2011	Mooseland Property, Halifax County	Gold	No, past airborne survey and ground surveys	1986, 1997	magnetic and VLF	N/A	Government geophysical data was reviewed
Mooseland Gold Property Halifax County Nova Scotia Canada-Sep 26 2011.pdf	08/2011	Mooseland Property, Halifax County	Gold	No, past airborne survey and ground surveys	1986	magnetic and VLF	N/A	Government geophysical data was reviewed
Mooseland Gold Property Halifax County Nova Scotia Canada-Jul 20 2012.pdf	07/2012	Mooseland Property, Halifax County	Gold	No, past airborne survey and ground surveys	1986	magnetic and VLF	N/A	Government geophysical data was reviewed

Scotia Mine Nova Scotia Canada-May 17 2011.pdf	05/2011	Scotia Mine, Gay's River	Lead-Zinc	No	N/A	N/A	N/A	Not relevant
Scozinc Mine Gays River Nova Scotia Canada-Oct 7 2011.pdf	10/2011	Scozinc Mine, Gay's River	Lead-Zinc	No	N/A	N/A	N/A	Not relevant
Scozinc Mine ScoZinc Property Gays River Deposit Nova Scotia Canada-Dec 21 2012.pdf	12/2012	Scozinc Mine, Gay's River	Lead-Zinc	No	N/A	N/A	N/A	Not relevant
ScoZinc Mine Nova Scotia Canada-Feb 2 2018.pdf	02/2018	Scozinc Mine, Gay's River	Lead-Zinc	No, past airborne survey	2012	helicopter magnetic gradiometer and VTEM	56 km	
Tangier Gold Property Nova Scotia Canada-Apr 26 2017.pdf	04/2017	Tangier Property, Halifax County	Gold	No, past airborne survey	1987	magnetic and VLF	95 km	200 m line spacing
Touquoy Gold Project Nova Scotia Canada-Aug 14 2014.pdf	08/2014	Touquoy Project, Halifax County	Gold	No, past airborne survey	1987	magnetic and VLF	N/A	Not relevant
Wentworth Property Colchester and Cumberland Counties Nova Scotia Canada-Jun 8 2012.pdf	01/2012	Wentworth Property, Colchester and Cumberland Counties		No, past airborne survey and ground survey	2007	helicopter magnetic and radiometric	4,470 km	Mag/Rad survey with 150 m line spacing. Helicopter magnetic and EM survey recommended.

Appendix C – Examples of Deliverables

Database Channels

Magnetic Deliverables - Database Channels

The following are typical channels delivered as part of a magnetic gradiometry database sampled at 10 Hz.

Channel	Name	Description Units
gps_x_raw	raw GPS X	metres
gps_y_raw	raw GPS Y	metres
gps_z_raw	raw GPS Z	metres
gps_base_x	GPS base station X	decimal-degrees
gps_base_y	GPS base station Y	decimal-degrees
gps_base_z	GPS base station Z	metres
gps_x_final	differentially corrected GPS X (NAD83 datum)	decimal-degrees
gps_y_final	differentially corrected GPS Y (NAD83 datum)	decimal-degrees
gps_z_final	differentially corrected GPS Z (NAD83 datum)	metres above sea level
x_nad83	easting in UTM co-ordinates using NAD83 datum	metres
y_nad83	northing in UTM co-ordinates using NAD83 datum	metres
lon_nad83	longitude using NAD83 datum	decimal-degrees
lat_nad83	latitude using NAD83 datum	decimal-degrees
radar_raw	raw radar altimeter	metres above terrain
radar_final	corrected radar altimeter	metres above terrain
dem digital	elevation model	metres above sea level
fiducial	fiducial	
flight	flight number	
line_number	full flightline number (flightline and part numbers)	
line	flightline number	
line_part	flightline part number	
time_utc	UTC time	seconds
time_local	local time	seconds after midnight
date	local date	YYYY/MM/DD
height_mag	magnetometer height	metres above terrain
mag_base_raw	raw magnetic base station data	nanoteslas
mag_base_final	corrected magnetic base station data	nanoteslas
fluxgate_x	X-component field from the compensation fluxgate magnetometer	nanoteslas
fluxgate_y	Y-component field from the compensation fluxgate magnetometer	nanoteslas
fluxgate_z	Z-component field from the compensation fluxgate magnetometer	nanoteslas
mag_raw_left	raw magnetic field from left wingtip sensor	nanoteslas
mag_comp_left	compensated magnetic field from left wingtip sensor	nanoteslas
mag_lag_left	comp'd, edited and lag corrected magnetic field from left wing sensor	nanoteslas
mag_raw_right	raw magnetic field from right wingtip sensor	nanoteslas
mag_comp_right	compensated magnetic field from right wingtip sensor	nanoteslas
mag_lag_right	comp'd, edited and lag corrected mag. field from rt. wingtip sensor	nanoteslas
mag_raw_tail	raw magnetic field from tail sensor	nanoteslas
mag_comp_tail	compensated magnetic field from tail sensor	nanoteslas
mag_lag_tail	compensated, edited and lag corrected mag. field from tail sensor	nanoteslas
mag_diurn_tail	diurnally-corrected magnetic field from tail sensor	nanoteslas
igrf	local IGRF field	nanoteslas
mag_igrf_tail	IGRF-corrected magnetic field from tail sensor	nanoteslas

mag_lev_tail	levelled magnetic field from tail sensor	nanoteslas
mag_final_tail	micro-levelled magnetic field from tail sensor	nanoteslas
mag_gsclevel_tail	GSC levelled magnetic field from tail sensor	nanoteslas
mag_grad_lat_raw	raw lateral horizontal mag. gradient (from wingtip sensors)	nanoteslas/metre
mag_grad_lat_cor	microlevelling correction for lateral horizontal mag. gradient	nanoteslas/metre
mag_grad_lat_final levelled	lateral horiz. mag. gradient (from wingtip sensors)	nanoteslas/metre
mag_grad_long_raw raw	longitudinal horizontal magnetic gradient	nanoteslas/metre
mag_grad_long_cor	microlevelling correction for longitudinal horiz. mag. gradient	nanoteslas/metre

Electromagnetic Deliverables - Database Channels

The following are typical channels delivered as part of a magnetic and electromagnetic database, both sampled at 10 Hz. The delivered channels are system dependent. The following channels would be typical of a VTEM survey.

Channel name	Units	Description
gps_x_raw	metres	raw GPS X
gps_y_raw	metres	raw GPS Y
gps_z_raw	metres	raw GPS Z
gps_x_final	decimal-degrees	differentially corrected GPS X (NAD83 datum)
gps_y_final	decimal-degrees	differentially corrected GPS Y (NAD83 datum)
gps_z_final	metres ASL	differentially corrected GPS Z (NAD83 datum)
x_nad83	metres	easting in UTM co-ordinates using NAD83 datum
y_nad83	metres	northing in UTM co-ordinates using NAD83 datum
lon_nad83	decimal-degrees	longitude using NAD83 datum
lat_nad83	decimal-degrees	latitude using NAD83 datum
radar_raw	metres above terrain	raw radar altimeter
radar_final	metres above terrain	corrected radar altimeter
dem	metres ASL	digital elevation model
fiducial		Fiducial
flight		flight number
line_number		full flight line number (flight line and part numbers)
line		flight line number
time_utc	seconds	utc time
date	YYYY/MM/DD	local date
height_mag	metres above terrain	magnetometer height
mag_base_final	nanoteslas	corrected magnetic base station data
mag_raw	nanoteslas	raw magnetic field
mag_diurn	nanoteslas	diurnally-corrected magnetic field
mag_lev	nanoteslas	levelled magnetic field
igrf	nanoteslas	local IGRF field
mag_igrf	nanoteslas	IGRF-corrected magnetic field
mag_final	nanoteslas	diurnally and IGRF-corrected magnetic field
cvg	nanoteslas per metre	calculated magnetic vertical derivative from mag_final
mag_gsclevel	nanoteslas	GSC levelled magnetic field
cvg_gsclevel	nanoteslas per metre	calculated magnetic vertical derivative from mag_gsclevel
height_em	metres above terrain	electromagnetic receiver height
em_z_raw_off	$(pV)/(A*m^4)$	raw (stacked) dB/dt, Z-component, off-time channels 4 to 46
em_z_final_off	$(pV)/(A*m^4)$	filtered and leveled dB/dt, Z-component, off-time channels 4 to 46
em_bz_raw_off	$(pV*ms)/(A*m^4)$	raw (stacked) B-field, Z-component, off-time channels 4 to 46

Channel name	Units	Description
em_bz_final_off	$(pV*ms)/(A*m^4)$	filtered and leveled B-field, Z-component, off-time channels 4 to 46
em_x_raw_off	$(pV)/(A*m^4)$	raw (stacked) dB/dT, X-component, off-time channels 20 to 46
em_x_final_off	$(pV)/(A*m^4)$	filtered and leveled dB/dT, X-component, off-time channels 20 to 46
em_fraserfilt_final_off	$(pV)/(A*m^4)$	Fraser filtered calculated from channel em_x_final_off, channels 20 to 46
em_bx_raw_off	$(pV*ms)/(A*m^4)$	raw (stacked) B-field, X-component, off-time channels 20 to 46
em_bx_final_off	$(pV*ms)/(A*m^4)$	filtered and leveled B-field, X-component, off-time channels 20 to 46
em_y_raw_off	$(pV)/(A*m^4)$	raw (stacked) dB/dT, Y-component, off-time channels 20 to 46
em_y_final_off	$(pV)/(A*m^4)$	filtered and leveled dB/dT, Y-component, off-time channels 20 to 46
em_by_raw_off	$(pV*ms)/(A*m^4)$	raw (stacked) B-field, Y-component, off-time channels 20 to 46
em_by_final_off	$(pV*ms)/(A*m^4)$	filtered and leveled B-field, Y-component, off-time channels 20 to 46
plm	microvolts	60 Hz power line monitor
taubf	microseconds	decay constant (tau) for B-field Z-component
tausf	microseconds	decay constant (tau) for dB/dt Z-component
nchan_bz		latest time channels of TAU calculation, B-field Z
nchan_z		latest time channels of TAU calculation, dB/dt Z
appcond	siemens per metre	apparent conductivity

As well, an EM anomaly data should be delivered.

Channel name	Units	Description
x_nad83	metres	easting in UTM co-ordinates using NAD83 datum
y_nad83	metres	northing in UTM co-ordinates using NAD83 datum
lon_nad83	decimal-degrees	longitude using NAD83 datum
lat_nad83	decimal-degrees	latitude using NAD83 datum
dem	metres asl	digital elevation model
fiducial		Fiducial
flight		flight number
line		flight line number
time_utc	seconds	utc time
date	YYYY/MM/DD	local date
em_z_final_off	$(pV)/(A*m^4)$	filtered and leveled dB/dt, Z-component, off-time channels 4 to 46
em_bz_final_off	$(pV*ms)/(A*m^4)$	filtered and leveled B-field, Z-component, off-time channels 4 to 46
tausf	microseconds	decay constant (tau) for dB/dt Z-component
appcond	Siemens per metre	apparent conductivity
height_em	metres above terrain	electromagnetic receiver height
anomaly_no		nth anomaly along the survey line
anomaly_ID		Alpha identifier
anomaly_type_letter		anomaly classification, “thick” (K) or “thin” (N) anomaly
anomaly_type_no		anomaly classification (i.e. anomaly grade), 1 to 6 from the weakest to the strongest
conductance_dBdt	Siemens	apparent conductance, calculated from dB/dt data
conductance_bfield	Siemens	apparent conductance, calculated from B-filed data

Channel name	Units	Description
depth_to_conductor	metres	Depth to conductor
heading	degrees	direction of flight
survey_number		Government survey number
nchan_z		Number of off-time channels deflected
cultural		Flagged channel for anomalies identified as cultural

Conductivity depth database (CDI) may also be delivered.

Channel name	Units	Description
x_nad83	metres	easting in UTM co-ordinates using NAD83 datum
y_nad83	metres	northing in UTM co-ordinates using NAD83 datum
dist	metres	distance from the beginning of the line
depth	metres	array channel, depth from the surface
z	metres	array channel, depth from sea level
appres	ohm.m	array channel, apparent resistivity
appcond	Siemens per metre	array channel, apparent conductivity
tr	metres	electromagnetic receiver height from sea level
topo	metres	digital elevation model
height_em	metres	electromagnetic receiver height
em_z_final_off	pV/(A*m^4)	array channel, filtered and leveled dB/dt, Z-component, off-time
mag_gsclevel	nanoteslas	GSC levelled magnetic field
cvg_gscl	nanoteslas per metre	calculated magnetic vertical derivative from mag_gsclevel
doi	metres	Depth of Investigation: a measure of VTEM depth effectiveness
power		60Hz power line monitor

Radiometric Deliverables - Database Channels

The following are typical channels delivered as part of a radiometric database sampled at 1 Hz.

Channel	Name Description	Units
gps_x_final	differentially corrected GPS X (NAD83 datum)	decimal-degrees
gps_y_final	differentially corrected GPS Y (NAD83 datum)	decimal-degrees
gps_z_final	differentially corrected GPS Z (NAD83 datum)	metres above sea level
x_nad83	easting in UTM co-ordinates using NAD83 datum	metres
y_nad83	northing in UTM co-ordinates using NAD83 datum	metres
lon_nad83	longitude using NAD83 datum	decimal-degrees
lat_nad83	latitude using NAD83 datum	decimal-degrees
radar_raw	raw radar altimeter	metres above terrain
radar_final	corrected radar altimeter	metres above terrain
dem digital	elevation model	metres above sea level
baro_press	barometric pressure	millibars
air_temp	outside air temperature	degrees Celsius
air_temp_f	low-pass filtered outside air temperature	degrees Celsius
fiducial	fiducial	
flight	flight number	
line_number	full flightline number (flightline and part numbers)	
line	flightline number	
line_part	flightline part number	

time_utc	UTC time	seconds
time_local	local time	seconds after midnight
date local	date	YYYY/MM/DD
height_rad	gamma-ray spectrometer height at STP	metres above terrain
live_time	gamma-ray spectrometer live time	milliseconds
cosmic_raw	raw cosmic window	counts per second
radon_raw	raw upward-looking uranium window	counts per second
radon_final	lag corrected upward-looking uranium window	counts per second
total_count_win	windowed total count	counts per second
potassium_win	windowed potassium	counts per second
uranium_win	windowed uranium	counts per second
thorium_win	windowed thorium	counts per second
total_count_corr	corrected total air-absorbed dose rate	nanograys per hour
potassium_corr	corrected potassium	percent
euranium_corr	corrected equivalent uranium	parts per million
ethorium_corr	corrected equivalent thorium	parts per million
dose_rate	natural dose rate	nanograys per hour
total_count_final	micro-levelled total air-absorbed dose rate	nanograys per hour
potassium_final	micro-levelled potassium	percent
euranium_final	micro-levelled equivalent uranium	parts per million
ethorium_final	micro-levelled equivalent thorium	parts per million
k_over_th	ratio of potassium over equivalent thorium	
spectrum_raw raw	256-channel gamma-ray spectrum (array channel)	counts per second

Gravity Deliverables - Database Channels

The following are typical channels delivered as part of a gravity gradiometry database sampled at 8 Hz.

Channel Name	**Description**	**Units**
gps_z_final	differentially corrected GPS Z	metres above sea level
x_nad83	easting in UTM co-ordinates using NAD83	metres
y_nad83	northing in UTM co-ordinates using NAD83	metres
long_nad83	longitude using NAD83	decimal-degrees
lat_nad83	latitude using NAD83	decimal-degrees
heading	line heading	degrees
drape	drape surface	metres
radar_raw	raw radar altimeter	metres
radar_final	corrected radar altimeter	metres
height	calculated laser scanner clearance	metres
dem	digital elevation model	metres
fiducial	fiducial	seconds
flight	flight number	–
line_number	full flight line number (flight line and part numbers)	–
line	flight line number	–
line_part	flight line part number	–
time_1980	UTC time since January 6, 1980	seconds
TURBULENCE	Estimated vertical platform turbulence (vertical acceleration Gal)	Gal
Err_NE	NE gradient uncorrelated noise estimate, after tie-line levelling	Eötvös
Err_UV	UV gradient uncorrelated noise estimate, after tie-line levelling	Eötvös

Channel Name	Description	Units
T_DD	Terrain effect calculated for DD using a density of 1 g/cc	Eötvös
T_NE	Terrain effect calculated for NE using a density of 1 g/cc	Eötvös
T_UV	Terrain effect calculated for UV using a density of 1 g/cc	Eötvös
A_SJT_0_NE	Self gradient, jitter corrected NE gradient, no terrain correction	Eötvös
A_SJT_0_UV	Self gradient, jitter corrected UV gradient, no terrain correction	Eötvös
B_SJT_0_NE	Self gradient, jitter corrected NE gradient, no terrain correction	Eötvös
B_SJT_0_UV	Self gradient, jitter corrected UV gradient, no terrain correction	Eötvös
A_SJT_2p2_NE	Self gradient, jitter & terrain corrected NE gradient, terrain correction density 2.2 g/cc	Eötvös
A_SJT_2p2_UV	Self gradient, jitter & terrain corrected UV gradient, terrain correction density 2.2 g/cc	Eötvös
B_SJT_2p2_NE	Self gradient, jitter & terrain corrected NE gradient, terrain correction density 2.2 g/cc	Eötvös
B_SJT_2p2_UV	Self gradient, jitter & terrain corrected UV gradient, terrain correction density 2.2 g/cc	Eötvös
A_SJT_2p67_NE	Self gradient, jitter & terrain corrected NE gradient, terrain correction density 2.67 g/cc	Eötvös
A_SJT_2p67_UV	Self gradient, jitter & terrain corrected UV gradient, terrain correction density 2.67 g/cc	Eötvös
B_SJT_2p67_NE	Self gradient, jitter & terrain corrected NE gradient, terrain correction density 2.67 g/cc	Eötvös
B_SJT_2p67_UV	Self gradient, jitter & terrain corrected UV gradient, terrain correction density 2.67 g/cc	Eötvös
gD_FOURIER_2p67	Fourier-derived vertical gravity, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	mGal
GEE_FOURIER_2p67	Fourier-derived G_{EE} gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
GNN_FOURIER_2p67	Fourier-derived G_{NN} gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
GDD_FOURIER_2p67	Fourier-derived vertical gravity gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
GED_FOURIER_2p67	Fourier-derived G_{ED} horizontal EW gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
GND_FOURIER_2p67	Fourier-derived G_{ND} horizontal NS gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
GNE_FOURIER_2p67	Fourier-derived G_{NE} curvature gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
GUV_FOURIER_2p67	Fourier-derived G_{UV} curvature gradient, terrain correction density 2.67 g/cc, 250 m cutoff wavelength	Eötvös
DRAPESURFACE_FOURIER	Drape surface for Fourier reconstruction, smoothed flight surface	metres
gD_FOURIER_2p2	Fourier derived vertical gravity, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	mGal

Channel Name	Description	Units
GEE_FOURIER_2p2	Fourier-derived G_{EE} gradient, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
GNN_FOURIER_2p2	Fourier-derived G_{NN} gradient,terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
GDD_FOURIER_2p2	Fourier-derived vertical gravity gradient, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
GED_FOURIER_2p2	Fourier-derived G_{ED} horizontal EW gradient, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
GND_FOURIER_2p2	Fourier-derived G_{ND} horizontal NS gradient, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
GNE_FOURIER_2p2	Fourier-derived G_{NE} curvature gradient, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
GUV_FOURIER_2p2	Fourier-derived G_{UV} curvature gradient, terrain correction density 2.2 g/cc, 250 m cutoff wavelength	Eötvös
gD_FOURIER_0	Fourier-derived vertical gravity, no terrain correction applied, 250 m cutoff wavelength	mGal
GEE_FOURIER_0	Fourier-derived G_{EE} gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
GNN_FOURIER_0	Fourier-derived G_{NN} gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
GDD_FOURIER_0	Fourier-derived vertical gravity gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
GED_FOURIER_0	Fourier-derived G_{ED} horizontal EW gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
GND_FOURIER_0	Fourier-derived G_{ND} horizontal NS gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
GNE_FOURIER_0	Fourier-derived G_{NE} curvature gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
GUV_FOURIER_0	Fourier-derived G_{UV} curvature gradient, no terrain correction applied, 250 m cutoff wavelength	Eötvös
gD_EQUIV_2p2	Equivalent source–derived vertical gravity, terrain correction density 2.2 g/cc	mGal
GDD_EQUIV_2p2	Equivalent source–derived vertical gravity gradient, terrain correction density 2.2 g/cc	Eötvös
GNE_EQUIV_2p2	Equivalent source–derived G_{NE} curvature gradient, terrain correction density 2.2 g/cc	Eötvös
GUV_EQUIV_2p2	Equivalent source–derived G_{UV} curvature gradient, terrain correction density 2.2 g/cc	Eötvös
DRAPESURFACE_EQUIV	Drape surface for equivalent source construction, 100 m above terrain	metres

Grids

Magnetic Deliverables - Grids

The following are typical grids delivered as part of a magnetic gradiometry survey.

- Digital Elevation Model
- Total Magnetic Field
- "GSC levelled" gradient enhanced Residual Magnetic Field
- Second Vertical Derivative of the "GSC levelled" gradient- enhanced Residual Magnetic Field
- Measured Lateral (across line) Horizontal Magnetic Gradient
- Measured Longitudinal (along line) Horizontal Magnetic Gradient
- Additional grids may be negotiated with the survey contractor

Electromagnetic Deliverables - Grids

The following are typical grids delivered as part of an electromagnetic survey, however the delivered grids are system dependent. The following grids would be typical of a VTEM survey.

- TDEM Decay Constant B field Z Component (µsec)
- TDEM Decay Constant dBz/dt Z Component (µsec)
- TDEM of B field Z component at index 36
- TDEM of dB/dt of Z component at index 10
- TDEM of dB/dt of Z component at index 25
- TDEM of dB/dt of Z component at index 40
- 60Hz powerline monitor

Conductivity depth images (CDI) may also be delivered.

Radiometric Deliverables - Grids

The following are typical grids delivered as part of a radiometric survey.

- Natural Air Absorbed Dose Rate (nGy/hr)
- Potassium (%)
- Equivalent Thorium (ppm)
- Equivalent Uranium (ppm)
- Potassium/equivalent Thorium ratio (%/ppm)
- Ternary image of Potassium, Thorium and Uranium

Gravity Deliverables - Grids

The following are typical grids delivered as part of a gravity gradiometry survey.

- Digital elevation model
- Drape surface for Fourier
- Drape surface for equivalent source
- Fourier-derived vertical gravity (no terrain correction)
- Fourier-derived vertical gravity (terrain corrected, conformed & not conformed)
- Equivalent source–derived vertical gravity (terrain corrected, conformed& not conformed)
- Fourier-derived GNE curvature gravity gradient (terrain corrected)
- Fourier-derived GUV curvature gravity gradient (terrain corrected)
- Fourier-derived GND horizontal NS gravity gradient (terrain corrected)

- Fourier-derived GED horizontal EW gravity gradient (terrain corrected)
- Fourier-derived GEE gravity gradient (terrain corrected)
- Fourier-derived GNN gravity gradient (terrain corrected)
- Fourier-derived GDD vertical gravity gradient (terrain corrected)
- Equivalent source–derived GDD vertical gravity gradient (terrain corrected)