Ontario's Operation Treasure Hunt: Stimulating Mineral Exploration in Ontario Through Airborne Geophysics

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1. Summary

The Ontario Government initiated the two-year Operation Treasure Hunt in 1999. This program is designed to stimulate mineral exploration in the Canadian province by collecting and releasing a large volume of new geoscience data. It incorporates a significant geophysical component, including more than 105,000 line-km of high-resolution airborne magnetic/electromagnetic surveys in the first year, and the procurement of proprietary data from industry, over strategically located areas.

2. Introduction

Geological surveys, aid agencies and similar government institutions worldwide have collected geophysical data, particularly gravity and airborne magnetics, for more than half a century, as a means of contributing to the geological infrastructure of a nation or state/province. In recent years, this approach has shifted towards focused efforts on geological domains of particular interest, with airborne surveys designed accordingly and strong partnerships with the exploration industry. The Ontario Geological Survey (OGS), Ontario Ministry of Northern Development and Mines, was a pioneer in the latter approach. In the mid-70's, the OGS recognized the value of high-resolution airborne magnetic and electromagnetic surveys as a means of stimulating exploration in the province's many Archean and Proterozoic greenstone belts, some of which were already prolific producers of gold (Red Lake camp, Kirkland Lake camp, Timmins camp) and base metals (Kidd Creek). These surveys continued to the early 90's, and in excess of 450,000 line-km were collected, split equally between time-domain (Input, Geotem) and frequency-domain (Tridem, Aerodat, Dighem) electromagnetic systems. These data were used extensively at all levels of the exploration chain, particularly the magnetic contour maps with superimposed EM anomalies. Advances in technology afforded the opportunity to transform all the legacy data sets to a common format, pick and describe EM anomalies, address some data inconsistencies, and enhance client access to these data, through a project in the mid-90's to reprocess all of these data and re-release them to the public in standard digital format (Gupta et al. 1998). The data are distributed on CD at nominal cost, and have proven extremely popular. These surveys remain unique in the world from the perspective of a government institution undertaking detailed airborne electromagnetic surveys (200 m line spacing). A by-product of this work was the improvement in electromagnetic acquisition, processing and interpretation technology that surveys of this magnitude afford.

During the 90's, the focused government exploration efforts worldwide, not only in airborne geophysics but also geochemistry and bedrock geology, have been accompanied by studies to measure the impact of these data collection exercises on the exploration industry and the economy in general (e.g. Robson and Lewis 1997). These studies go beyond a tabulation of the registered claims that follow the inevitable staking rush when a unique dataset is released. The short-term economic impact and the longer-term benefits are quantified. The ultimate impact will not be known until the data matures through a 15 to 20-year exploration cycle, and the newly discovered mineral deposits, if any, are brought into production. However, the preliminary analyses show that purely through the exploration activity generated by these initiatives, each $1 of government investment levers between $2 and $5 of exploration activity. Discovery of ore deposits contributes up to several $100 return per $1 on the initial government investment in geoscience. There are also the less quantifiable benefits from airborne surveys, including geological mapping, baseline studies, environmental applications, etc.

3. Operation Treasure Hunt

Recognising the value of geoscience data in reducing private sector exploration risk and investment attraction, the Ontario Government embarked on "Operation Treasure Hunt" (OTH). The OTH initiative comprises a two-year, $19 million program that commenced April 1, 1999. It incorporates:

- airborne geophysics (high-resolution magnetic/electromagnetic and some radiometric surveys)
- surficial geochemistry (lake sediments and indicator minerals)
- bedrock map compilation
- methods development (e.g. electro-geochemical modelling applied to exploration and 3-D geological/geophysical models)
- delivery of digital data product

Airborne Magnetics and Electromagnetics in Ontario

This paper concentrates on the airborne geophysical component of OTH.

The OGS was charged with the responsibility to manage OTH. The OGS sought advice about the mineral industry needs and priorities from its OGS Advisory Board – a stakeholder board including representatives from the Ontario Mining Association, Ontario Prospectors Association, Prospectors and Developers Association, Aggregate Producers Association of Ontario, Chairs of Ontario University Geology Departments, Canadian Mining Industry Research Organisation and Geological Survey of Canada. The OGS Advisory Board charged a Technical Committee to advise the OGS on geographic areas of interest within Ontario where collection of new data would make the greatest impact on reducing exploration risk. Various criteria were assessed, including:

- commodities and deposit types sought
- prospectivity of the geology
- state of the local mining industry and infrastructure
- existing, available data
- mineral property status.

4. Geophysical Management

Most of the airborne geophysical work was frontloaded into the first year of OTH. The OGS recognized that management of the airborne surveys was a critical success factor in the delivery of the OTH airborne geophysical projects. Therefore, the OGS contracted the function of "OTH Geophysicist" from the private sector. Paterson, Grant & Watson Limited was contracted in this role through a Request for Proposal and Contractor Selection process. The main functions of the OTH Geophysicist are as follows:

- manage the airborne surveys
- quality assurance/quality control (QA/QC) inspection of the data acquisition, compilation, digital and map products
- locate, review and recommend for purchase proprietary airborne surveys
- communicate results of OTH geophysics to end-users.

The airborne survey management initially involved the finalisation of the survey areas and the determination of appropriate survey methods, aircraft and specifications. The areas of interest were refined based on the quantity and quality of existing OGS airborne data, and the known or interpreted extent of geological units of interest. The appropriate survey methods in the first year were restricted to a choice between frequency-domain (FDEM) and time-domain (TDEM) electromagnetics. Radiometrics were not incorporated due to a four-month window to acquire data between November 1999 and February 2000, when snow cover would limit its effectiveness. FDEM was selected for areas where conductive overburden was limited, and anomaly resolution was more important than depth penetration. TDEM was selected where the opposite characteristics occurred. The choice of aircraft (fixed wing or helicopter) depended on the topography of each survey area and the survey method.

5. Airborne Survey Areas

Of 160,000 line-km originally proposed for the first year of OTH, MNDM was able to afford 105,000 line-km of high-resolution magnetic/electromagnetic surveys. Figure 1 shows the airborne survey areas for the first year. The Kirkland Lake, Cochrane, Temagami and Matheson blocks are located in a fairly mature exploration region, and in some cases overlap with older OGS surveys. These areas were designated for TDEM surveys, as it was felt that the latest generation of TDEM technology, with its increased resolution and depth penetration, would provide fresh insight into the geology and deposits of the region. The Schreiber, Garden-Obonga and Vickers blocks are located in areas that would be classified as under explored. In these areas, conductive overburden presents little difficulty and consequently, FDEM surveys were flown. The surveys were designed to address several potential deposit types, as follows:

- Kirkland Lake/Cochrane/Matheson – gold, komatiite copper-nickel, intrusion-related copper-nickel-platinum group elements, volcanogenic massive sulphides, and potential diamond-bearing kimberlites
- Temagami – silver-cobalt, gold, volcanogenic massive sulphides, iron formation (gold) and intrusion-related copper-nickel-platinum group elements
- Schreiber – gold, volcanogenic massive sulphides, intrusion-related nickel-platinum group elements and alkalic intrusion-related mineralization
- Garden-Obonga – intrusion-related platinum group elements, gold and volcanogenic massive sulphides
- Vickers – gold, volcanogenic massive sulphides, iron formation (gold) and komatiite copper-nickel-platinum group mineralization.

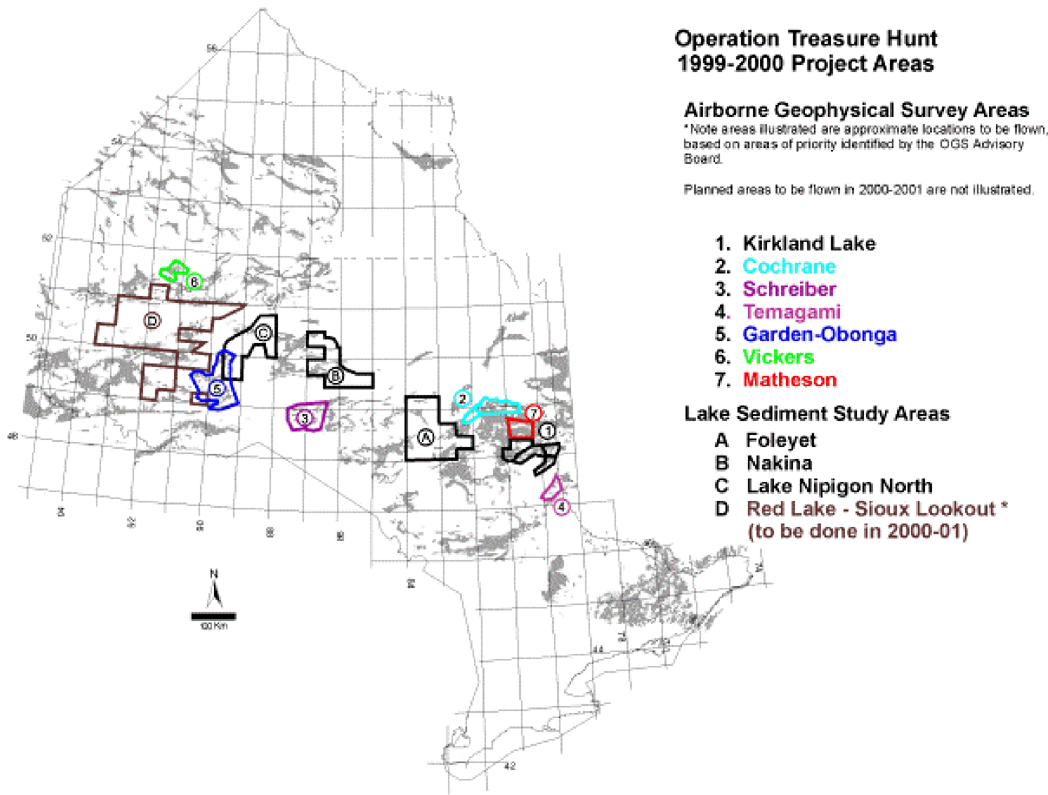

Figure 1. Operation Treasure Hunt Areas of Data Acquisition (1999-2000 fiscal year)

6. Airborne Survey Systems

The airborne survey contracts were awarded through a Request for Proposal and Contractor Selection process. The system and contractor selected for each survey area were judged on many criteria, including the following:

- applicability of the proposed system to the local geology and potential deposit types
- aircraft capabilities and safety plan
- experience with similar surveys
- QA/QC plan
- capacity to acquire the data and prepare final products in the allotted time
- price-performance.

The electromagnetic systems were chosen as follows:

- Kirkland Lake/Cochrane/Temagami – Geotem – a pulse-type, fixed wing TDEM system that acquires X, Y and Z-components of the secondary field
- Matheson – Spectrem$_{2000}$ – a full duty-cycle, fixed wing TDEM system that acquires X, Y and Z-components of the secondary field
- Schreiber – High-Sense – a helicopter FDEM system that acquires inphase and quadrature using three coplanar coils (865, 4175 and 33000 Hz) and two coaxial coils (935 and 4600 Hz)
- Garden-Obonga/Vickers – Dighem – a helicopter FDEM system that acquires inphase and quadrature using three coplanar coils (900, 7200 and 56000 Hz) and two coaxial coils (900 and 5500 Hz).

All of these systems were flown under contract by Fugro Airborne Surveys, with the Spectrem$_{2000}$ provided by Spectrem Air Ltd. under a subcontract. Each system acquires both the electromagnetic and magnetic data using towed birds, providing superior resolution due to their closer proximity to the ground. The surveys were flown at 200 m line spacing, with 1500 m control line spacing. The line direction was selected to be most appropriate to the local geological strike directions, which resulted in the Kirkland Lake and Cochrane areas being divided into smaller survey blocks.

7. Products

At the time of writing, 90% of the data acquisition has been completed. QA/QC of the data in the field, by both the survey contractors and the OTH Geophysicist, has been stringent. This will lead to high quality final products. The survey contractors are responsible for preparing the digital and map products in publication-ready form. Considerable effort has gone into the specification of products and formats, so that the end user will be able to review the published data immediately and quickly proceed through the exploration decision-making process. The digital products include:

- profile database of the raw, intermediate and final data channels
- archives of the "streamed" fullwave/halfwave TDEM data
- grids of the total magnetic intensity, its second vertical derivative, FDEM apparent resistivity, TDEM decay constant (tau), TDEM apparent conductivity and digital elevation model
- EM anomaly database including model parameters
- 1:20,000 and 1:50,000 scale maps of certain grid products
- survey reports.

Hard copy maps of the total magnetic intensity with flight path and EM anomalies will also be prepared.

With the permission of Falconbridge Limited, OGS established a test range for airborne electromagnetic systems. Each system was required to fly the 5 km x 4 km site, located in Reid and Mahaffy Townships north of Timmins, Ontario, along a pre-determined flight path at survey altitude. One line was flown in both directions, and at a range of survey altitudes, to test the effects of system asymmetry and height attenuation respectively. The test range provides a series of electromagnetic conductors that test the lateral resolution, depth penetration and overburden response of the various systems. Falconbridge provided ground truth (geology, drill logs and ground geophysical data) to help evaluate the airborne results. The test surveys will allow end users to determine the strengths and weaknesses of each system, within the geological limitations of the site itself.

In parallel to the data acquisition, OGS and the OTH Geophysicist searched out proprietary airborne survey data offered by industry, which complement the existing and new government coverage. These data will be purchased from their owners and released to the public. An atlas of all significant airborne surveys flown in Ontario that are available in the public domain will also be prepared.

All products generated in the first year of Operation Treasure Hunt will be released commencing in April 2000. In the summer of 2000, it is anticipated that additional airborne survey data acquisition will be underway.

8. Conclusions

Analysis of the airborne geophysical data collected to date under Operation Treasure Hunt demonstrates that they will be an extremely valuable addition to the geoscience knowledge base of Ontario. The Ontario Geological Survey has put mechanisms in place to quantify the impact on mineral exploration that the release of these data will have.

9. References

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