Operation Treasure Hunt –
Does the Ontario model work for you?

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SUMMARY

The Ontario Geological Survey is midway through a three-year, C$29 million initiative known as Operation Treasure Hunt. Its main objectives are to collect and disseminate geophysical, geochemical and geological data to industry, to identify exploration targets to attract investment in mineral exploration of the province. The geophysical component in the first two years has included the acquisition of nearly 140,000 line-km of magnetic-electromagnetic data over eight survey areas, and the purchase of an additional 105,000 line-km of proprietary data from industry. The Reid-Mahaffy airborne electromagnetic test range was established to facilitate comparison of systems for a variety of geological targets, and has been rapidly adopted by industry. Early impact analysis has shown that the imminent release of geophysical and geochemical data in strategically chosen areas results in a significant increase in claim staking activity and subsequent exploration expenditures in an area. A twinning agreement with the Geological Survey of New South Wales and discussions with other Australian state agencies has allowed the Ontario Geological Survey to optimise its program based on the Australian experience, while adapting it to the local geological and jurisdictional conditions.

Key words: state initiative, airborne geophysics, magnetic, radiometric, electromagnetic

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 strong partnerships with the exploration industry and focused efforts on geological domains of particular interest, with airborne surveys designed accordingly. 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, more governments documented the economic impacts of their geological survey activities (e.g. Robson and Lewis, 1997). The preliminary analyses show that each $1 of government investment in geoscience levers between $2 and $5 of exploration activity. Discovery of ore deposits contributes up to several $100 return per $1 of government investment in geoscience.

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, C$19 million program that commenced April 1, 1999. The initial success of the program has led to its extension to a third year, and an additional C$10 million commitment. OTH incorporates:

- airborne geophysics (high-resolution magnetic-electromagnetic and some radiometric surveys)
- surficial geochemistry (lake sediments and indicator minerals)
- bedrock map compilation
- studies of industrial mineral sites and aggregate potential
- replacement of digital claim maps system
- delivery of digital data products.

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 industry, universities and other governmental organizations. 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.

AIRBORNE GEOPHYSICAL SURVEYS

The OGS contracted the function of "OTH Geophysicist" from the private sector. Paterson, Grant & Watson Limited (PGW) was contracted in this role through a Request for Proposal and Contractor Selection process. PGW's main functions as 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.

MNDM funded 105,000 line-km of high-resolution magnetic-electromagnetic surveys over seven areas. An additional 33,500 line-km was flown in the second year and more are contemplated for the third year.

The Kirkland Lake, Cochrane, Temagami, Matheson and Stormy Lake/Dryden blocks are located in fairly mature exploration regions, 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 frontier areas where there has been minimal exploration. 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
- Stormy Lake/Dryden – gold, volcanogenic massive sulphides, intrusion-related copper-nickel-platinum group elements, porphyry-related copper-molybdenum-gold, rare metal pegmatite

The airborne survey contracts were awarded through a Request for Proposal and Contractor Selection process. The electromagnetic systems were chosen as follows:

- Kirkland Lake/Cochrane/Temagami/Stormy Lake/Dryden – Geotem (Megatem for half of Stormy Lake/Dryden) – 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, Cochrane and Stormy Lake/Dryden areas being divided into smaller survey blocks.

Figure 1 shows a ternary image of the apparent resistivity data for the Garden-Obonga survey area. The shaded relief provided by the digital elevation model demonstrates the coherence between topography, surficial cover (glacial sand and gravel) and electromagnetic responses. The highest frequency tends to reflect the near-surface electromagnetic response (e.g. glacial cover and outcropping bedrock). The lowest frequency tends to reflect the bedrock electromagnetic response at depths on the order of 100 m. The granitic country rock shows as the darker greens. Most of the bedrock anomalies are hosted by the WSW-striking greenstones (lighter blue). The diabase sills along the eastern margin of the area are particularly conductive, as are the lake-bottom sediments. The area hosts a world-class palladium mine and is currently enjoying intense exploration activity.

At the time of writing, the second year's data acquisition (Stormy Lake/Dryden survey) has nearly been completed. 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

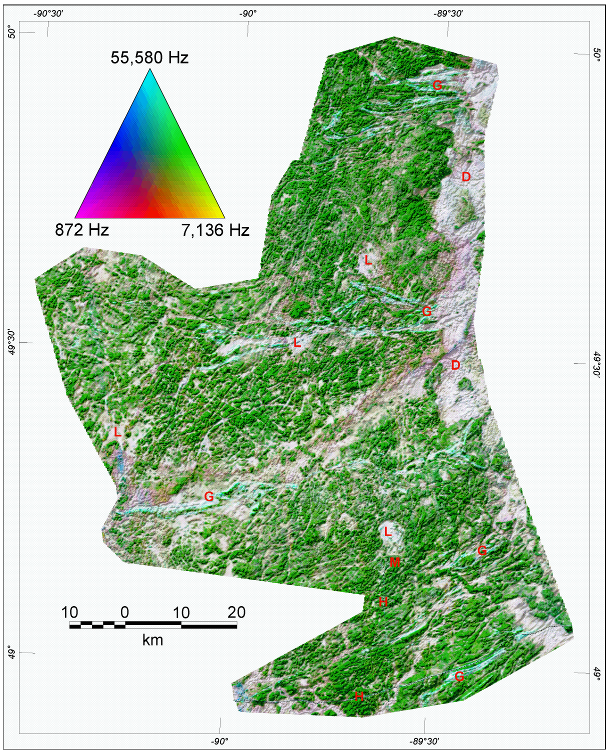

Figure 1. Ternary image of apparent resistivity computed from the three coplanar coil pairs, incorporating the digital elevation model shaded from the northwest, Garden-Obonga survey area. Lighter areas are more conductive. L=lake, H=hydroelectric line (black dots), G=greenstone, D=diabase sill, M=Lac des Iles palladium mine (North American Palladium Ltd.).

the end user will be able to review the published data immediately and quickly proceed through the exploration decision-making process. The OGS Data Manager provides extensive product review to ensure the integrity of the published material and common standards between several processing centres. 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/or 1:50,000 scale maps of most grid products
- survey reports.

REID-MAHAFFY AIRBORNE GEOPHYSICAL TEST RANGE

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 allow end users to determine the strengths and weaknesses of each system, within the geological limitations of the site itself. The test range has been adopted by industry and has been used on several occasions outside the auspices of OTH to test a variety of new or upgraded electromagnetic systems.

PROPRIETARY DATA

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. Some 105,000 line-km of data (three magnetic surveys and nine magnetic-electromagnetic surveys) were selected for purchase from their owners and will be 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.

COMPARISON WITH THE AUSTRALIAN EXPERIENCE

The Twinning Agreement (1999) between the OGS and the Geological Survey of New South Wales (GSNSW) provides for the exchange of expertise and experience in order to enhance scientific knowledge and application, and the programme delivery and impact in each organization. A recent visit to the GSNSW by OGS staff has identified the many similarities in purpose and product delivery process, but has highlighted many fundamental differences as well.

The similarities, among other things, include aggressive programmes of acquisition and dissemination of primary geoscience data, the move to internet-enabled product distribution, full integration of all of the geoscience disciplines, land access and land claims issues, and the establishment of standards to ensure consistency across all projects.

The types of differences are diverse, ranging from geology, climate and field logistics to client expectations regarding the publication of data. The needs and priorities of the respective mineral industry clients differ particularly with respect to demand for digital versus paper products.. Product releases in Ontario must provide for both the digital client and the analogue, or map-based, client. In addition, publication releases must be carefully orchestrated to ensure that all clients have simultaneous access. Because the New South Wales clientele is more homogeneously digital, data releases are primarily digital with map products available on demand. The ability to publish digital-only allows the GSNSW to provide data virtually real-time throughout the life of a project.

The OGS geologic programmes are administered by the Sedimentary Geoscience Section and the Precambrian Geoscience Section. This separation is needed because of the unique scientific and operational challenges that each discipline presents for efficient and effective program delivery. Exchange of information between administrative units is critical. For example, the interpretation of geophysical information requires an understanding of the characteristics and distribution of overburden in order to more effectively interpret the bedrock. (It is to this specific challenge, among others, that the OMET program speaks.) Ontario may enjoy the benefits that glacial scouring provides, but areas where the scoured material has been deposited are challenging. In that much of the surficial material in NSW is not transported and the regolith on surface reflects the underlying bedrock, the surficial and bedrock geology are not studied and mapped by separate teams.

The climate, topology, and infrastructure in Ontario present a logistical challenge that effectively limits the geologic field season to six months of the year. Furthermore, the costs of mobilization to and from the more remote projects limits the field work to a single excursion each year. In the GSNSW, mapping can be carried out virtually year-round and access and infrastructure support are less onerous.

The OGS's ongoing consultation with its advisory board provides a strategic framework for programme planning which can respond quickly to the ever-changing needs of the exploration community. The OGS is currently operating under a balanced programme which targets both high-risk, unexplored areas and low-risk, established mining camps .

The geophysical programme at the OGS fulfills two distinct roles: geophysical expertise to the teams carrying out the ongoing bedrock mapping programme, and management of geophysical data acquisition and distribution through extraordinary funding such as OTH. Because OTH originated as a 2-year programme, the OGS elected to contract out the required geophysical expertise. In contrast, the longer terms of the GSNSW's 6-year Discovery 2000 programme and 7-year Exploration NSW: Mining Beyond 2000 programme allow for the hiring of geophysical expertise.

IMPACT ANALYSIS

The OGS has reviewed more than fifteen studies of the impact of geoscience initiatives in various jurisdictions of Canada, Australia and the United States. The leverage of private sector to 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.

Presently the OGS tracks claim staking activity, exploration expenditures, product sales, and economic mineral deposit discoveries (Churchill et al., 2000). Initial impacts are realized through product sales and claim staking activity. This will be followed by a targeted questionnaire and follow-up with those clients investing in exploration within the OTH areas.

Claim-staking activity during the first year of OTH systematically increased during the eight to ten-month period between announcement of the airborne survey areas and release of the data, more than doubling in the case of the Garden-Obonga survey (Figure 2). In some areas, release of new geochemical data contributed, as did the prospectivity for platinum group elements at a time of record prices. This tangible demonstration of exploration activity was an important factor in the Ontario Government's decision to extend OTH to a third year.

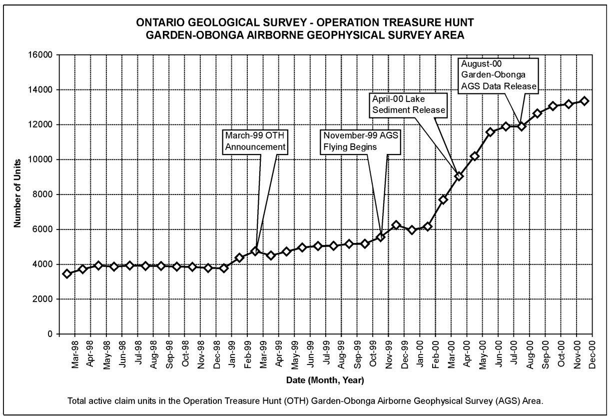

Figure 2. Claim staking activity as a function of Operation Treasure Hunt milestones for the Garden-Obonga survey area.

CONCLUSIONS

After a nine-year hiatus, the Ontario Geological Survey has reinvigorated its airborne geophysical program through the acquisition of nearly 140,000 line-km of high-resolution, magnetic-electromagnetic data in eight survey areas, and the purchase of an additional twelve airborne survey datasets from industry, totalling 105,000 line-km. These form significant components of Operation Treasure Hunt, along with various geochemical and geological projects. The early impact analysis parallels the Australian state initiative experiences, where a tangible increase in exploration activity can be attributed directly to the acquisition and dissemination of primary geoscience data.

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