March 2018

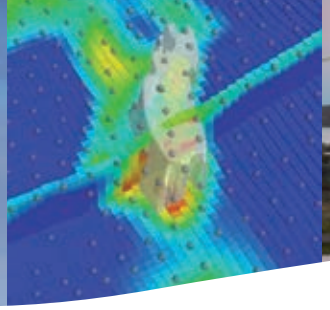
ETD

EXPLORATION TRENDS & DEVELOPMENTS

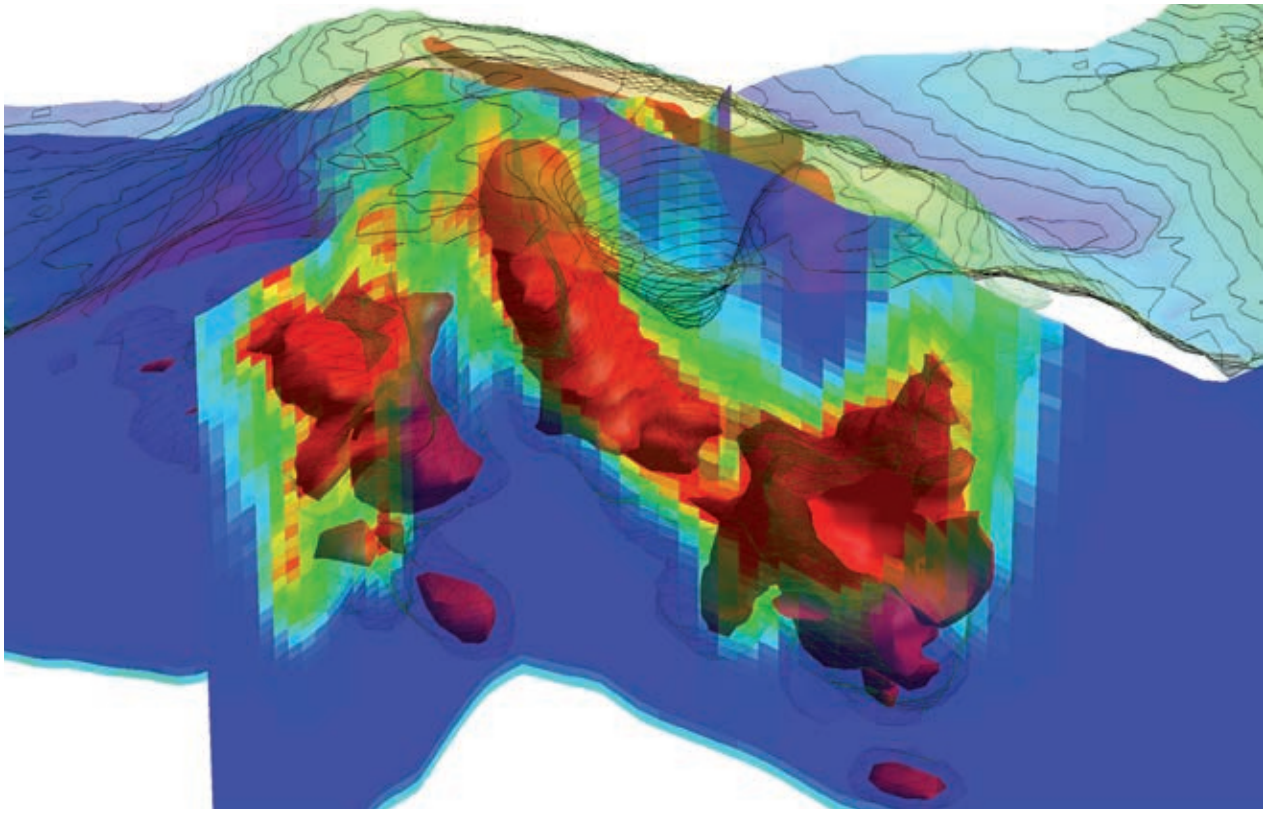
Advances in GEOPHYSICAL TECHNOLOGY

THE NORTHERN MINER
GLOBAL MINING NEWS · SINCE 1915

Complimentary
PM #40069240

See the Whole Picture



CGG Multi-Physics provides the utmost clarity for every decision in your mineral exploration project – from greenfields landholding to drill-hole targeting.

The **Falcon** technologies (**Falcon**®, **Falcon**® **Plus**, and **HeliFalcon**®) are the only airborne gravity gradient instruments designed for the rigors of airborne surveying. Our newest generation of airborne electromagnetics systems (**Helitem**® **C-Series**, **Tempest**® and **Resolve**®) offer conductivity mapping tools to suit your geology. To complete the picture, our Multi-Physics Imaging group will invert and interpret your data.

See more, and spend well with an airborne exploration program from CGG Multi-Physics — your exploration partner.

cgg.com/multi-physics

CGG
Passion for Geoscience

ETD
EXPLORATION TRENDS & DEVELOPMENTS

is an annual publication prepared
by Patrick G. Killeen
9759 Highway 509
Ompah, ON
Canada K0H 2J0
Phone: (613) 479-2478
E-mail: pkilleen@xplornet.ca

Published in co-operation with
The Northern Miner
38 Lesmill Rd., Unit 2
Toronto, ON
M3B 2T5
Phone: (416) 510-6789
E-mail: tnm@northernminer.com

Editor:
David Perri

Writer:
Patrick G. Killeen

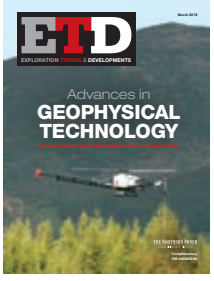
Art Director:
Melissa Crook

Production Manager:
Jessica Jubb

Advertising Sales:
Joe Crofts
Michael Winter

Publisher:
Anthony Vaccaro

THE NORTHERN MINER
GLOBAL MINING NEWS · SINCE 1915



Cover photo: Flying-Cam's SARAH e 4.0 unmanned helicopter, equipped with a Scintrex CS-VL cesium-vapour magnetic sensor and RMS Instruments' AARC51 adaptive aeromagnetic real-time compensator, in flight near Chifeng, Inner Mongolia, China. Credit: Flying-Cam

MINERAL EXPLORATION TRENDS AND DEVELOPMENTS IN 2017

By Patrick G. Killeen Ph.D., Geophysical Consultant and retired Research Scientist, Geological Survey of Canada, Ottawa

This is the second year that Decennial Mineral Exploration Conferences (DMEC) has served as the patron for *Exploration Trends & Developments*. Last year was the lead-up to the very successful Exploration 17 conference, held in Toronto in October. This year DMEC support came from the companies listed in the sponsor's box below.

The ETD review originated with the Geological Survey of Canada (GSC), where for more than 50 years GSC scientists prepared an unbiased annual publication on trends and new developments in geophysical exploration for minerals. This marks the 26th year that Patrick Killeen has written the review, originally as a GSC research scientist.

The Canadian Exploration Geophysical Society (KEGS) was the patron of *ETD* between 2007 and 2016. DMEC and KEGS are committed to the promotion of geophysics, especially as it is applied to exploration for minerals other than oil; to fostering the scientific interests of geophysicists; and to promoting high professional standards, fellowship and co-operation among persons interested in this industry.

CONTENTS

OUR SPONSORS

A double-crew from Abitibi Geophysics setting up a gravity and GPS base station in sub-Arctic taiga, 100 km north of Schefferville, Quebec.

Credit: Abitibi Geophysics

EXPLORATION TECHNOLOGY IN 2017
THINGS ARE PICKING UP

The pace of work in global mineral exploration picked up in 2017 with more exploration dollars invested than in 2016. Companies reported increased sales of geophysical instrumentation and the number of surveys carried out. One airborne survey contractor outfitted an additional aircraft to meet demand. However the increase in activity was not evenly distributed as some companies reported steady business related to mining, but increased activity in other applications like environmental, groundwater, agriculture and geotechnical. This was to be expected as companies sought out non-mineral applications for their technology in previous lean years. The trend to form partnerships, agreements and joint projects continued. At least one company moved to expanded office space to handle numerous new projects and personnel.

As in previous years there was an increase in the amount of data recorded and processed, as new geophysical equipment had more channels, more components, faster sample rates and even more parameters measured. "Integrating the geosciences" was the theme of October's Exploration 17 conference in Toronto, which begged the question: "Can we generate useful conclusions and interpretations from all of these data?"

The year saw several firsts in airborne surveys and data processing. New systems saw their first commercial surveys, some completely new system prototypes began flying, and combined airborne/ground EM systems are evolving with transmitters on the ground, including one with the ground Tx wire deployed and retrieved from a helicopter in flight. New AEM systems are lighter, fly faster and at lower costs.

Comparison studies of inversions for four TDEM surveys over a nickel deposit were done as well as the compilation of geophysical signatures of 25 deposits. Inversion capabilities were expanded to include more methods and joint inversions with numerous datasets from both airborne and ground surveys. New UAV magnetic survey systems evolved including one with "sense & avoid" technology for low-level (e.g. 5 m) surveys that fly over obstacles (e.g. tall trees). Two companies developed gamma-ray spectrometer equipment for UAV platforms.

Ground geophysics saw R & IP testers for use on samples or outcrops extended for use in drillholes, and a new magnetic susceptibility meter with a 10-fold sensitivity increase. Data inversion software was improved with an expanded number of parameters, better 3-D visualization, new 3-D inversion of larger datasets in a shorter time and new methods to manage drillhole and sample data. Borehole geophysical technology saw expanded geophysical logging services, development of several new probes, including a neutron probe with an electronic neutron source that can be switched off, a BHEM system with automatic noise recognition and removal and borehole gravity logging with increased speed. Ground EM saw new systems with greater volume of investigation both vertically and horizontally, a new sensor that measures B field and dB/dt simultaneously on all three axes, new radio imaging tomography and new availability of low-temperature SQUIDs. There are new R & IP techniques and methodology, expanded capacity from 350 to 650 receivers/channels in distributed arrays, new IP receivers, new EM noise cancellation software for field use, new emphasis on EM/MT calibration in specially-built chambers, networking of GPR units for seismic-style multi-fold data collection and a new portable gamma-ray spectrometer for ground, borehole and carborne surveys. ETD

CORPORATE HIGHLIGHTS

Geotech's new Integrated Helicopter Gravity-ZTEM-Magnetic system in flight.

Credit: Geotech

Abitibi Geophysics of Val d'Or, Que., reported 2017 was a good year with several innovative projects going into production with results that exceeded expectations. InfiniTEM XL surface TDEM mapped a mineralized lens that a previous fixed-loop TDEM survey missed in the shadow of a larger parallel zone. The increase in both vertical depth and lateral investigation of InfiniTEM XL allows wider reconnaissance line spacing without missing a target, reducing exploration costs. The borehole version of InfiniTEM XL has a correspondingly large radius of exploration. The company introduced ARMIT 3 TDEM sensor in 2017 and it is now possible to define a depth-of-exploration threshold and rely on ARMIT InfiniTEM XL to effectively investigate to that depth. These new configurations generate more data, so to maintain on-time delivery, **Geosoft**'s VOXI processing solution was formally adopted. Abitibi has also entered into several agreements and partnerships to promote useful exploration technology.

Paris-headquartered **CGG Multi-Physics** acquires, processes, and interprets airborne, marine and land geophysical data for resource exploration and geological mapping, from offices in Toronto and around the world. In 2017 the company launched the CGG Multi-Physics Imaging group, consolidating data processing and interpretation, technical consulting services and commercial software development into a single global team. It is claimed to be the largest and most diverse non-seismic imaging group in the resource industry.

Crone Geophysics & Exploration of Mississauga, Ont., reported increased interest in its Pulse EM TDEM system both for system sales and contract surveys compared to 2016, as well as expanded use of its 3D E-SCAN IP/R technology. Crone's increased emphasis on R&D has resulted in new and improved instrumentation in 2017.

Geophysics GPR of Longueuil, Que., reported that the company now offers geophysical survey services for mineral exploration worldwide through its offices in Botswana, and in partnership with **KTTM Geophysics** in Colombia, **IIC Technologies** in India and **SubMap Geophysics** in Malaysia.

Terraquest's helicopter magnetic gradiometer system on survey in Ontario's Ring of Fire district.

Credit: Terraquest

Geotech, based in Aurora, Ont., and its international subsidiaries offer airborne geophysical surveys and consultingservices using its VTEM helicopter time-domain EM system and ZTEM natural field EM helicopter and fixed-wing systems. It also flies fixed-wing and helicopter magnetic, radiometric and gravity systems in North America and abroad. In 2017 the first commercial surveys were flown with two new systems: VTEM ET (Early Time) helicopter system and the new Integrated Helicopter Gravity-ZTEM-Magnetic system over several projects totalling 11,000 line-km. The Integrated System combined the standard ZTEM helicopter sensor and towed-bird cesium magnetometer with the **Canadian Micro Gravity** GT-2A airborne gravimeter, on-board an Astar B3 helicopter.

Medusa Sensing of Groningen, Netherlands, reported strong interest from the agricultural and environmental markets in the company's geophysical survey systems and increased demand for gamma-ray surveys for soil mapping. The company intensified collaboration with South African, Canadian and Chinese partners to apply its sensors for agricultural purposes. Collaborative research programs of three PhD students began with the nuclear accelerator lab of the **University of Groningen**, the **University of Wageningen** and the **University of Waterloo**, focused on Radiation Physics, Agricultural Studies and Geophysics, respectively.

Toronto-based **Paterson Grant & Watson (PGW)** recently moved to a larger office in the same building to accommodate multi-year international projects initiated in Laos, Democratic Republic of the Congo and India, as well as an increase in personnel. In India, PGW partnered with **International Geoscience Services** and **Datacode** to form **IDPeX Private Ltd**. IDPeX was awarded the technical supervision and quality control contract for the first of three years of a more than 3 million line-km aeromagnetic and radiometric survey for the **Geological Survey of India**. PGW also completed interpretation projects in Canada, Ireland and Africa, and is now managing data acquisition and interpretation projects in Mexico and South America. The company, which is focused on geology-driven geophysical consulting and structural interpretation services, celebrated its 45th anniversary in 2017.

Concord, Ont.-based **Pico Envirotec Inc (PEI)** supplies airborne and ground geophysical survey systems worldwide including off-the-shelf instruments and customized, turn-key systems. In 2017, PEI delivered multiple units of the PGIS-2 portable gamma-ray spectrometer system in China and the U.S. including four PGIS-2-1 (1-litre detector) units employed in environmental surveys of old uranium mines by the **U.S. Department of Energy**. A PGIS portable spectrometer suitable for use on a UAV is in development and is expected to be ready early in 2018. The battery-powered system with no electrical connections to the UAV, includes integrated GPS and laser altimeter and capability to transmit data for real-time viewing. PEI has been working on delivery, installation and testing of an airborne gravity meter in Vietnam and new magnetic survey systems for clients in Mexico. A new Mag/Spec system is in production

for delivery to China early in 2018. The company continued its upgrade program, whereby older DOS-based systems can be traded in towards the purchase of the newest hardware. Pico Envirotec Inc. will be renamed **NUVIA Dynamics Inc.** starting January 1, 2018; the address is unchanged. NUVIA Dynamics will continue providing the same products, services and support to customers around the world.

Toronto-based **Quantec Geoscience** reported a greater use of its IP and MT technologies at mine sites in the last year, as well as growing demand across the globe. Surveys were carried out in Africa as well as eastern Europe and across the Americas. Quantec, after 30 years, refreshed its branding with a new red logo.

Radiation Solutions Inc. (RSI) of Mississauga, Ont. reported that it was status quo in geophysical sales for 2017 which included airborne gamma-ray spectrometer systems to Africa, Asia, Australia and North America. The company saw steady business with mining geophysics customers and increased activity with clients in other applications.

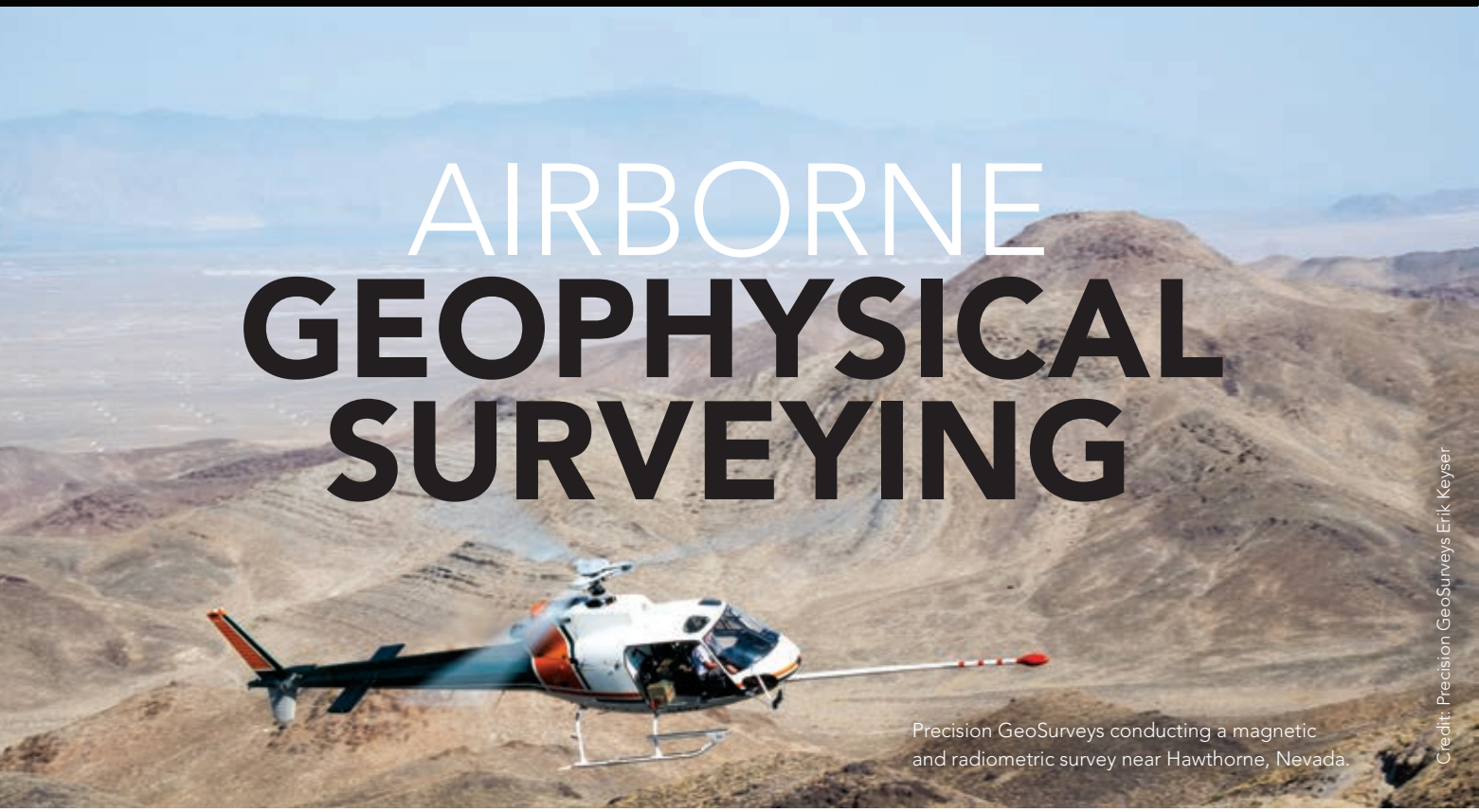
> “In 2017 Terraquest flew both fixed-wing and helicopter surveys in the U.S., Mexico, South America and Canada, including helicopter magnetic gradiometer operations in Ontario’s Ring of Fire.

Ottawa-based **Sander Geophysics Ltd. (SGL)** specializes in high-resolution airborne surveys for petroleum and mineral exploration and environmental mapping. SGL offers fixed-wing and helicopter, gravity, magnetic, EM, radiometric, methane and scanning LiDAR surveys, using state-of-the-art technology. To date, the company has flown more than 13 million line-km of airborne geophysical surveys worldwide and 2017 was another good year. SGL has developed new markets for its unique AIRGrav system, as the company initiated a large gravity survey in the Middle East for geoid modelling. SGL flew the final phase of a three-year EM, magnetic and radiometric survey in Ireland and the company was recently awarded a follow-on three-year contract with the same system.

Vancouver based, **SJ Geophysics** saw increased demand for their universally-distributed Volterra acquisition system, with a mix of IP and EM projects in the Dominican Republic, Greenland, Panama and Turkey. In addition to acquiring geophysical data, the company provided inversion modelling, interpretation and on-site data quality supervision services related to a number of international projects. Internally, the R&D team worked on fine-tuning the Volterra acquisition system hardware. The highly-sensitive induction magnetometers were further calibrated, closely monitoring results and characterizing the frequency response to determine the influence of potential long-term drift in the response of the sensors. The Volterra unit’s timing was greatly improved, and uncertainties in the data due to noise and other factors were significantly reduced. Developments in the signal processing package capabilities included improvements in the MT/CSAMT processing codes.

Terraquest of Markham, Ont. provides high-resolution airborne geophysical surveys including gravimetric, magnetic, horizontal gradient, radiometric, and VLF-EM as well as HyRez helicopter TDEM methods. In 2017 the company flew both fixed-wing and helicopter surveys in the U.S., Mexico, South America and Canada including helicopter magnetic gradiometer operations in Ontario’s Ring of Fire. 2018 marks the 30th anniversary of the company’s first deployment of a commercial fixed-wing horizontal magnetic gradient system. EOD

AIRBORNE GEOPHYSICAL SURVEYING



Precision GeoSurveys conducting a magnetic and radiometric survey near Hawthorne, Nevada.

Credit: Precision GeoSurveys Erik Keyser

CGG Multi-Physics reported on surveying with its three EM technologies. The company deployed the Helitem system on numerous exploration surveys for resource companies in Africa, Australia, North and South America. After upgrades in 2016, the redesigned Tempest fixed-wing TDEM system was utilized on surveys in Australia and North America in 2017 mainly for groundwater and geological mapping. **Geoscience Australia** is collecting conductivity data for geological mapping; the AusAEM project will collect data over an area of 1,000,000 sq. km using Tempest. In addition, the **USGS** awarded the company a multi-year Tempest groundwater mapping project. CGG's Resolve technology continued to be used for high-precision conductivity mapping applications. Numerous Falcon and HeliFalcon surveys were flown for exploration and government clients worldwide. Released in 2016, Full Spectrum Falcon saw increased deployment in 2017 especially for clients interested in the long wavelength gravity field data provided by sGrav combined with the high-resolution Falcon gravity gradient data.

Discovery International Geophysics of Saskatoon, Sask. continued to use the Brisbane, Australia-based **Gap Geophysics** SAM (Sub-Audio Magnetics) technology for helicopter-borne (HeliSAM) surveys in Canada. Discovery has adapted the HeliSAM survey technique for remote North American field conditions with the development of a device called HeliWinder to deploy and retrieve transmitter wire on the ground using a helicopter. With it, the economic HeliSAM hybrid ground and airborne TEM and MMR system can be deployed in any remote bush or mountainous terrain. "Ground" EM and resistivity surveys can now be carried out in terrain previously too difficult or expensive to survey on the ground. Line cutting or ground traversing is not required with the combined HeliWinder/HeliSAM system. A minimal ground crew is lowered into position by helicopter to set up the transmitter and assist with wire deployment and retrieval.

EON Geosciences of Montreal uses both fixed-wing aircraft and helicopters to provide high-resolution airborne magnetic, gamma-ray spectrometric and gravity surveys. Both the ETHEM time-domain and the Hummingbird frequency-domain EM systems are helicopter-only techniques. The company kept its crews busy flying large surveys in the Northwest Territories in Canada for the **Northwest Territories Geological Survey (NWTGS)** and **Natural Resources Canada** (NRCan). EON also flew in Alaska, for the state's **Division of Geological & Geophysical Surveys** (DGGS). A full magnetic gradiometer and gamma-ray spectrometric system was supplied for the **Geological Survey of India**'s Multisensor Aero-geophysical Survey project. The company was also awarded aeromagnetic surveys to be flown in the U.S. in 2018.

Geophysics GPR continued to offer heliborne and fixed-wing magnetic, VLF-EM, radiometric, gravity and TDEM (GPRTEM). GPR reported the company is currently participating in a large regional airborne magnetic and radiometric survey for the Geological Survey of India.

Geosphair Aviation, based in Montreal, which specializes in Airborne Survey Aircraft Rental and Operation, has flown a total of 500 hours of magnetometer and LiDAR surveys for

clients in Canada. The company provides the survey platform and equipment only, as a subcontractor, and does not bid directly on survey projects. In 2018 the latest release of the **GEM** magnetic compensation system and VLF are scheduled to be tested and Geosphair's Piper Navajo and Super-Cub have projects booked. The Super-Cub will be equipped with amphibious floats for the summer in support of the Seaplane Bathymetric Platform R&D project.

Geotech was awarded numerous airborne geophysical surveys for government agencies around the world totalling over 160,000 line-km in 2017. The surveys flown included various combinations of magnetics, radiometrics, ZTEM, VTEM and VTEM ET for Morocco, Australia, India, South Africa and the U.S., as well as for Ontario (**MNDM**), North Dakota (**NDSWC**) and the University of Utah (**Energy Geoscience Institute**).

Moscow-based **Geotechnologies** continued its activities in airborne time-domain and frequency-domain EM, magnetics and radiometrics. In 2017 the company manufactured GT-MAG-2 gradiometry equipment for airborne magnetic surveys and several magnetic base stations for the Norilsk branch (**NF**) of **VSEGEI**. In addition, technical support for the fixed-wing frequency domain airborne EM system was provided to the ALROSA Group that has used Geotechnologies' EM4H systems for regional surveys in Siberia since 2004.

In 2017, **MagSpec Airborne Surveys**, based in Perth, was awarded five large airborne magnetic/radiometric and elevation surveys by the South Australia government as part of their Gawler Craton Airborne Magnetic Survey (PACE Copper program) — comprising a total of 560,000 line-km. To meet the requirements, the company set up a new system (using a Cessna 210), and had up to three aircraft flying simultaneously.

In 2017 **New-Sense Geophysics**, based in Markham, Ont., carried out a variety of magnetic and radiometric surveys using both fixed-wing and helicopter platforms. The projects were flown across South America (Peru, Chile, Paraguay, and Argentina) and in North America. These included regional surveys and smaller-target programs related to mineral exploration for gold, silver, copper and zinc as well as for structural geology information.

Precision GeoSurveys, based in Vancouver, specializes in low-level airborne geophysical surveys in remote and mountainous terrain. The company has flown helicopter and fixed-wing high-resolution magnetic, radiometric, and EM surveys in Africa, Asia, Europe and North America. In 2017, Precision flew 1TEM time-domain EM, frequency-domain EM, magnetic, and radiometric surveys across western Canada and the western U.S.

SGL reported that airborne surveys were completed in North America, South America, Europe and Australia. The company flew several large airborne gravity and magnetic surveys for petroleum exploration in South America and helicopter gravity and magnetic surveys for mineral exploration in North and South America, large magnetic and radiometric projects in South America and Australia as well as several regional magnetic gradient and radiometric surveys. Involvement in **NASA**'s **IceBridge** climate-change monitoring surveys with AIRGrav continued over Antarctica. Other surveys included magnetic-only surveys and methane-mapping surveys. Airborne methane sensing surveys are conducted with ultra-sensitive, high-resolution sensors mounted in the survey aircraft to record methane gas concentrations in the air which can be matched to known methane sources and potential hydrocarbon seeps for petroleum exploration, or man-made sources for environmental monitoring. In 2017 the company carried out two methane sensing surveys for research purposes, mapping and quantifying ground-source methane.

In 2017 the Heli-GT helicopter 3-axis magnetic gradiometer system, developed by Toronto-based **Scott Hogg & Associates**, was used for surveys in Newfoundland and Ontario for base metal, diamond and gold exploration. The entire Heli-GT sensor package; magnetometers, radar altimeter and GPS system is housed in a bird that is towed 25 metres below the helicopter providing reduced magnetic interference and significantly lower noise level for the measurements than for non-bird systems.

SkyTEM Surveys, headquartered in Aarhus, Denmark flew its SkyTEM312 for mineral exploration surveys in Quebec, Ontario, Newfoundland, British Columbia, Yukon and Alaska. A 4,000 line-km high-resolution SkyTEM312 survey flown in the summer of 2017 in the Buchans area of Newfoundland found several conductivity anomalies as potential drill targets. The SkyTEM method was employed for mineral exploration in Ecuador and Chile. It was also used to confirm the availability of water for a mine in Sudan. About 9,000 line-km were flown in a TEM survey for diamond exploration in Angola, mapping both near surface and deep geology to identify the primary kimberlite sources of alluvial diamonds. In Australia, an AEM survey was flown over a 150 sq.-km base metal project in the Batten Fault zone, Northern Territory as well as a survey over a VMS prospect to help identify extensions to Zn-Au-Ag-Pb deposits. Mineral exploration surveys were flown for **Geoscience Australia** and water-resource mapping surveys were flown for the **CSIRO**. In Europe, the first SkyTEM312HP (High Power) survey was flown in Sweden for deep-seated nickel sulphide mineralization. SkyTEM312 was employed in Finland to map magmatic Ni-Cu-PGE mineralization associated with mafic and ultramafic intrusions. The **Geological Survey of Sweden (SGU)** conducted a groundwater survey with SkyTEM and in the U.S. the company worked with Stanford University to survey drought-stricken areas of California including two surveys for salt water encroachment studies along the coastline of Monterey and Marina California. The **U. S. Army Corps of Engineers** and the **Wyoming Department of Environmental Quality (WDEQ)** used the SkyTEM for environmental mapping investigations at a former air force base missile site in Wyoming. The **University of Illinois** and the **Illinois State Geological Survey** also used it to investigate sand erosion and lake-floor topography along the shore of Lake Michigan, from Chicago to the Wisconsin border.

In addition to flying fixed-wing and heli-borne airborne geophysical surveys for private companies in Australia, Southeast Asia and Africa, **Thomson Aviation**, based in Griffith, New South Wales, was awarded more than 530,000 line-km of airborne mag/spec surveys for **Geoscience Australia** over the Gawler Craton in South Australia. The company also successfully completed a 50,000 line-km airborne gravity survey in Western Australia for the **Geological Survey of WA** (through Geoscience Australia). In 2017 the development of rotary-wing and fixed-wing UAVs for collecting high-resolution magnetic data continued.

Cockpit view of Scott Hogg & Associates' DAQNAV system with new dual-screen configuration.

Airborne Data Acquisition and Processing

Aarhus Geophysics based in Denmark, conducted numerous AEM consulting projects with modelling of Induced Polarization (AIP), from all major helicopter TEM systems. Applications ranged from mineral exploration (porphyries or kimberlites) to geological mapping. 3-D models of AEM-derived chargeability are now routine. Besides chargeability, the "IP corrected" conductivity models often provided valuable new insight into geological models. The company continued groundwater mapping and impartial assessment of different AEM systems, from feasibility studies to data comparisons. For example, comparison of inversion results from VTEM, SkyTEM, Xcite and Spectrem data was done at the Sunnyside Nickel mine in Botswana.

CGG Multi-Physics consolidated its 3-D depth inversion modelling capability to include airborne, ground and marine EM data with potential field survey data. The algorithms, developed entirely in-house, work with both frequency and time-domain EM data, include VTI and diagonal anisotropy, for nodal and streamer (airborne, marine) data types. The multi-grid and vertically unstructured mesh implementations facilitate modelling of large 3-D models (1 G cells) required for accurate representation of extreme terrain, prospect detail and large survey data sets. Joint inversion via cross-gradient terms allows diverse data sets to integrate via inversion (e.g. AEM with AGG, or with ground MT, gravity or magnetics).

These codes provide the unique ability to include constraints for the quantitative inclusion of surface or subsurface geological data during 3-D inversion modelling which generates a result consistent with all available data, increasing geological plausibility. This is done by steering the inversion using cross-gradient regularization, where the reference gradient model is derived directly from geology. Because the methodology is generic, it can be expanded to derive a controlling gradient field from the wide range of sub-surface attribute


Credit: Scott Hogg & Associates

data available in exploration and development projects. CGG's Multi-Physics Imaging group completed multiple cross-gradient inversion projects during 2017, mainly for energy and mineral exploration.

In 2017, Lakewood, Colo.-based, **Condor Consulting** continued working on a wide range of exploration problems including projects with a focus on gold, base metals, (mainly copper) and uranium. The company's GeoInterp lithostratigraphic assessment was applied primarily to banded-iron formation and orogenic gold projects in North America. In the past year a major compilation study of the aeromagnetic signatures of porphyry copper deposits was completed. This was a two-year project done under the sponsorship of **CAMIRO** Project 205, supported by six major mining companies. The last such study was undertaken in 1970. Twenty-five deposits were examined with detailed geology provided along with images of the basic aeromagnetic data. Ancillary geophysical data such as radiometrics, EM and IP were also available. Condor conducts special studies on porphyry copper systems and in 2017 continued work on the Kemess deposit system in northern B.C. Results of a detailed assessment of the aeromagnetic responses of the Kemess South deposit are available on Condor's website. The company also initiated an extensive assessment of airborne and ground geophysical data over the Casino porphyry Cu-Mo-Au deposit in the Yukon. Casino is unique for northern Cordilleran deposits as it was not glaciated like most porphyry deposits in B.C. Consequently, Casino has some very unusual geophysical characteristics that make it similar to deposits in Chile's Atacama desert. The results of this work will be the subject of a series of technical presentations at major conferences in 2018.

In 2017, **Geotech** introduced its new Quick 2-D forward modelling and inversion tool for airborne natural field and time-domain EM, gravity and magnetics. It can quickly evaluate the geophysical response of simple or complex-shaped geologic models, which can be easily assigned appropriate physical properties and tested with a variety of airborne methods. The objective is to provide a common model and visual solution space for easier evaluation of multiple technology platforms.

In an industry first, **SGL** provided the processed x and y horizontal gravity components for an AIRGrav survey, in addition to the traditional z component. All of these data are publicly available from **Geoscience Australia**. The company

Credit: Devbrio Géophysique

A UAV magnetometer system equipped with "sense and avoid" technology, developed by Devbrio Géophysique and operated by Abitibi Geophysics.

continued to be involved in several projects designed to enhance the resolution and accuracy of gravity data from AIRGrav surveys, and to improve geoid measurements using AIRGrav. In addition to forward modelling to assist clients with survey design, several large integrated interpretation projects were completed in 2017. The primary datasets were from gravity and magnetic surveys flown by SGL. Data used to constrain the interpretations included seismic data, borehole data and available geological and geophysical information. Interpretation was performed using in-house SGL software, as well as commercial 2-D, 2.5-D and 3-D modelling software.

The DAQNAV airborne navigation, magnetic compensation and data recording system, developed by **Scott Hogg & Associates**, has been in operation since 2013. The DAQNAV's acquisition module logs data from all devices outputting data. The navigation module enables users to load and view in real-time their own flight plan, background map image, DTM grid and drape surface grid. The latest version operates entirely on Panasonic's FZ-G1 (10") and FZ-M1 (7") tablets, both capable of running up to 18 hours on the tablet's internal battery. In 2017 new features were added to the DAQNAV system and it now directly supports **Radiation Solutions**' RS501 spectrometer as well as **Kroum VS Instruments**' KMAG4 magnetometer counter and KANA8 analog/digital converter. It can now also be run in dual-screen configuration to provide both pilot and operator their own display. In 2017 **McPhar International** installed DAQNAV systems in two Pacific Aerospace 750XL aircraft conducting a geophysical survey in India.

The GT-Grid mapping system developed by the company has been used to process more than one million line-km of gradient data collected by airborne survey companies around the world. In 2017, GT-Grid projects were carried out for companies in Canada and Kazakhstan. GT-Grid is compatible with airborne survey systems that measure horizontal gradient but the full benefit of GT-Grid is realized when using the company's 3-axis Heli-GT system to accurately resolve magnetic gradients in the north, east and vertical directions. The GT-Grid process ensures that the magnetic grid produced is consistent with measured horizontal gradients as well as the total field, which is not provided by conventional gradient-enhanced gridding methods.

Aeromagnetic Surveying

Abitibi Geophysics, in partnership with Gatineau, Que.-based **Devbrio Géophysique**, has flown, in survey configuration, what might be the first UAV magnetometer system with "sense-and-avoid" technology. The concept, developed by Devbrio, allows the UAV to be programmed to fly at a mean terrain clearance of 5 m above treetop level. The system will detect an obstacle such as a tall tree and fly over it without breaking line. The low-level survey data are useful in mapping subtle changes in the magnetic field not clearly resolved by conventional airborne surveys.

Flying-Cam with R&D offices in Belgium has jointly developed a high-precision unmanned Air Mag Survey Platform with **LAUREL Technologies**, which has offices around the world including Hong Kong and San Jose, California. Successful acceptance testing was performed in September 2017. The Flying-Cam Airborne Robotic Engineering team designs and manufactures unmanned helicopters based on a unique electric platform developed in-house, called SARAH (Special Aerial Response Automatic Helicopter). The company, which was started in 1988 has become a recognized provider of close-range aerial filming services to the movie industry. Today the company manufactures and sells the SARAH e 4.0 helicopter globally as an integrated solution with modular payloads or as a standalone OEM product.

Established in 1991, LAUREL Technologies is a provider of scientific exploration equipment, specialized in oceanography and geophysics and most recently a developer of unmanned vehicle technologies and their application. The Air Mag Survey Platform consists of an electric unmanned airborne Flying-Cam SARAH e 4.0 helicopter, a **Scintrex** CS-VL cesium-


Credit: Gregory Bedenko

SkyTEM on survey for minerals in Kazakhstan.

vapour magnetic sensor and the AARC51 adaptive aeromagnetic real-time compensator from **RMS Instruments** with a dedicated fluxgate sensor to provide attitude data to the real-time compensator. A radar altimeter provides altitude and the onboard RTK-GPS delivers location data to the compensator datalogger together with true heading (dual GPS antenna-based). Calibration routines and survey flight paths designed in Flying-Cam's 3-D graphical user interface can be performed fully automatically. For the acceptance tests, the SARAH e 4.0 unmanned helicopter was operated in automatic mode both on land (Inner Mongolia) and at sea (East China sea) where it successfully located a sunken ship of 18 m by 140 m, lying at 30 m depth.

In 2017, Mississauga, Ont.-based, **RMS Instruments** introduced innovations in aeromagnetic compensation. Conventional (fixed-wing and helicopter) platforms include new applications with arrays of 8 magnetometers compensated in real-time. For UAV platforms, a prototype system for dual-magnetometer gradiometry with real-time compensation has been completed and fully qualified. The AARC52 includes a built-in dual-frequency GPS receiver (Novatel's OEM7-series) and a next-generation Host CPU, achieving a 2-fold increase in data output and recording rates, relative to its predecessor (AARC51).

Other developments include the addition of embedded ancillary (barometric pressure & temperature) sensors for some members of the AARC500 family, a doubling of data-output rates for small form-factor systems, and more efficient multiplexing of auxiliary GPS variables. The company reported that system sales for the various models in the AARC500 family remained steady throughout the year including multiple units of the most advanced model in the series: the DAARC500 data acquisition & real-time compensation system with 8 magnetometer inputs. The majority of contracts, including recent Turkish airborne systems, included engineering and integration services and advanced training programs.

Airborne Electromagnetic Surveying

Toronto-based **Expert Geophysics** is offering a new airborne EM technology: mobile magnetotellurics (MMT), an advanced generation of airborne AFMAG technologies. The MMT technology uses naturally occurring EM fields with frequencies from 25 Hz to 30 kHz. Based on extensive experience in developing equipment and signal/data processing algorithms to measure natural EM fields, MMT combines the latest advances in electronics, airborne system design and sophisticated signal processing techniques. An airborne bird, towed by a helicopter, measures magnetic field variations, while a

ground station measures electric field variations. The ratio of the magnetic and electric field magnitudes in both in-phase and out-of-phase components provides analytic parameters in selected frequency bands. Both electronic and signal-processing use advanced noise processing techniques to ensure high quality data even for weak natural EM fields. A cesium-vapour magnetometer is used for total magnetic field recording. The lightweight, aerodynamic bird is ideal for cost-effective surveys using small helicopters. Two MMT systems are now available for surveying.

Geotech's latest development in the VTEM system family is the new VTEM LBF (Low Base Frequency) time-domain system that was successfully tested in late 2017. The low (for time-domain EM) 15 Hz base frequency allows the extension of late off-time channels for recording the decay of secondary EM fields. The latest off-times provide better discrimination of highly-conductive targets such as nickel-copper, more reliable exploration under conductive overburden cover and greater depth of investigation. VTEM LBF expands the latest time acquisition to 19.5 milliseconds. The company also added system refinements to its new VTEM ET (Early Time) helicopter time-domain EM system that was field tested in late 2016, and first flew commercial surveys in 2017. So far it has been used in a variety of applications, including groundwater, diamonds, gold and strategic metals. The new VTEM ET system features faster turn-off and earlier time-gates (5 µsec) for more precise, near-surface resistivity characterization. The VTEM ET system also uses the proprietary Full Waveform implementation.

In 2017 **Geotechnologies** continued to improve the EQUATOR helicopter-borne EM system. The main features of EQUATOR are simultaneous time-domain and frequency-domain measurements with a wide range of flight speeds during a survey. The company completed a survey of the entire country of Rwanda using EM, magnetics and gamma-ray spectrometry. Surveying the mountainous part of the country with accurate navigation was possible using the NAVDAT system and skilled pilots. Automation of data acquisition and navigation significantly increased flight duration.

SGL provides EM surveys using their fixed-wing frequency domain system (SGFEM) which acquires both EM and magnetic data and can be combined with other sensors (e.g. gravity, radiometric, methane). The SGFEM four-frequency system is suited for high-speed, high-resolution resistivity mapping for mineral exploration, environmental and geotechnical applications. In 2017, a significant upgrade was made to the SGFEM system to further improve stability and reliability.

In fall of 2017 **SkyTEM Surveys** launched a new generation of helicopter transient EM (TEM) systems with reduced survey costs and improved depth of exploration. The technologies are SkyTEM312 HP (High Power) with 12 turns of the coil around a 340 sq.-m transmitter loop and SkyTEM306 HP with 6 turns of the coil. The new systems are much lighter than other TEM systems with the same power and are designed to fly at speeds up to 150 km/h, or almost twice the speed of other TEM systems, lowering survey costs. While surveying for **Geoscience BC** the SkyTEM312FAST system collected over 1,000 line-km per day, an unprecedented data acquisition rate for any TEM system. This new generation of TEM technology can deliver preliminary data and inversions within 48 hours after collection. This allows near real-time review of survey progress and results and the ability to quickly adjust system parameters to optimize results. Both systems are equipped with a high-power 250A transmitter and a fully digital 3-channel receiver for continuous sampled and streamed data with real-time signal gating and integrated B-field. Enhanced features include extremely high accuracy due to a 5 MHz sample rate with 36-bit resolution in three channels and superior rejection of high-frequency noise. The systems can be re-configured in the field to compensate for varying altitude requirements and to optimize depth of penetration.

Terraquest continued to commercialize its new HyRez helicopter TDEM system, with examples of data acquired over the Sudbury Igneous Complex. The system which is exclusively operated by Terraquest, uses under-utilized frequency bandwidth with time gates from 0.4 to 40 µsec. It has the ability to differentiate resistive and shallow lithologies, map near-surface geology to a depth of about 70 m and, being light-weight, is deployable at high altitudes. Applications include resistivity mapping of geology related to targets such as diamonds, gold and lithium, as well as for near-surface engineering and environmental studies.

During 2017, **Thomson Aviation** along with **Monex GeoScope** and **RMIT** continued to build, evaluate and test an entirely new airborne TDEM system ("BIPTEM"). Both B and dB field data were acquired concurrently from a fixed ground loop survey at Lewis Ponds, New South Wales at a base frequency of 12.5 Hz. An IP target coincident with one from a ground survey was identified, demonstrating the potential to directly delineate economic mineralization. The BIPTEM system will be offered in Australia as a commercial service in early 2018, with a global release to follow.

Airborne Gamma-ray Spectrometric Surveying

In 2017 **Medusa** presented the first data from drone-borne gamma-ray surveying compared to ground-survey data and soil samples. An algorithm was developed to handle the non-linear absorption behaviour of gamma radiation measured by a low-flying (less than 30 m) sensor. The company also commercially released their MS-1000, a fully-self-contained CsI gamma-ray detector for use underneath a drone.

Airborne Gravity Surveying

CGG Multi-Physics reported on experience with the sGrav airborne gravimeter: a small, strap-down instrument designed for drape surveys to complement Falcon Airborne Gravity

Four of Sander Geophysics' Caravans in Bolivia for a large gravity and magnetic survey.

Credit: Sander Geophysics

Gradient (AGG) data at longer wavelengths. The sGrav, which does not require a stabilized platform, can be easily deployed with the Falcon AGG system in a small aircraft. It was found to be very robust to air turbulence during draped airborne surveys. The Falcon Plus system launched in the spring of 2015 and the company's newest development in the Falcon family of AGG systems, was proven over **Geoscience Australia**'s Kauring gravity test site west of Perth. During the summer of 2017 Falcon Plus flew a large mineral exploration project over Somerset Island in northern Canada. The HeliFalcon was used for an ultra-high-resolution gravity survey to map small sinkhole features inside a working oilsands open-pit mine in Alberta. The survey was flown with a 10 m line spacing and 10 m flying height. Customized data processing and 3-D inversion of the data resulted in an ultra-high-resolution density model to identify the sinkholes.

Gedex Systems of Mississauga, Ont. announced the first commercial surveying with its High-Definition Airborne Gravity Gradiometer (HD-AGG) in 2017. The HD-AGG was designed to achieve a resolution of 1 Eotvos Hz $^{-1/2}$ or 1 Eotvos RMS noise at a spatial resolution of 60 m when flown from a fixed-wing survey aircraft. The company reported the system is providing performance comparable to other AGG systems in this competitive technology. Currently flown in a Cessna Caravan, Gedex anticipates improving the system performance by a factor of two or more in 2018 when it commences surveys using a Dash-8 platform.

SGL reported their 12 AIRGrav systems were busy flying airborne gravity surveys worldwide for petroleum and mineral exploration and for geological mapping, environmental monitoring and geoid modelling. In 2017, AIRGrav surveys were flown in North America, South America and Antarctica, and a large survey was started in the Middle East. For the majority of surveys, airborne magnetic data were recorded simultaneously. The company was again involved in **NASA**'s **IceBridge project** in 2017, the eighth year that SGL has supplied its AIRGrav airborne gravimeter to assist with its polar research. The campaign was flown from mid-October to the end of November by NASA's P3 aircraft based in Argentina. The mission of Operation IceBridge is to collect data on the changing polar land and sea ice and maintain continuity of measurements between ICESat missions. The original ICESat mission ended in 2009, with ICESat-2 scheduled for launch in 2018.

The latest TAGS-7 airborne gravity system by **Micro-g LaCoste (MGL)** of Lafayette, Colorado, continues to achieve repeatability in the 0.5 milliGal range. A TAGS-7 system leased by the **U.S. National Geodetic Survey** is now being flown as part of the GRAV-D (Gravity for the Redefinition of the American Vertical Datum) project using a Centaur Optionally Piloted Aircraft (by **Aurora Flight Sciences** of Manassas, Virginia). The Centaur's line-following ability is a significant improvement over normal autopilot performance for airborne gravity surveying. The TAGS-7/Centaur system was also used with excellent results for a large airborne geophysical survey completed in December 2016 for the **California High-Speed Rail Authority (CAHSR)**. Flown in extremely challenging environmental and cultural conditions across the Los Angeles Basin and southern and central California mountain ranges, the system yielded excellent results to be released in early 2018. ETD

Quantec Geoscience's field crew carrying coils for the SPARTAN MT system.

Credit: Quantec Geoscience

GROUND SURVEY TECHNIQUES

Physical Rock Properties & Elemental Analysis

Instrumentation GDD based in Quebec City, Que., reported that the new borehole option of the GDD SCIP Tester now allows measurement of resistivity and chargeability directly under field conditions, in exploration drill holes and in production holes in mining.

Terraplus of Richmond Hill, Ont., introduced the KT-10H Magnetic Susceptibility Meter with a sensitivity of 10^{-7} SI, an order of magnitude higher than the KT-10. It has a circular sensor, and includes a pin mode for measuring samples with rough and uneven surfaces, such as outcrops. The KT-10H can be upgraded to a KT-10H Plus for measuring magnetite.

Ground Data Acquisition & Processing

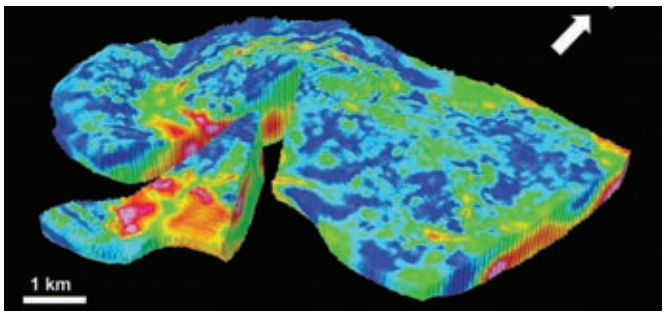
In 2017, Toronto-based **Geosoft** expanded its VOXI Earth modelling service by adding IP and Resistivity to the existing magnetic, gravity, gravity gradiometry and FDEM data inversion suite. Enhancements to VOXI IP and Resistivity and the IP extension include improved QC tools, improved support for local coordinates and the ability to view interim results for each completed iteration. The company enhanced 3-D visualization and navigation in Oasis montaj, Target and Target for ArcGIS platforms and improved 3-D rendering of voxels. A new voxel smoothing option uses real-time interpolation of data to display a smooth image. New voxel caching and pyramiding algorithms with OpenGL shader technology provides better performance when displaying large voxel models. A new 3-D animation tool was also added that combines multiple 3-D snapshots to create a video, which can be saved and shared to visually tell a story about the project.

Working in partnership with Sudbury-based **Minalytix**, Geosoft introduced a new Software-as-a-Service (SaaS) solution for managing drill hole and sample data. MX Deposit simplifies how drilling data are collected, managed and shared. The data can be logged and accessed from anywhere in the world. A mobile data entry application is now available for more efficient data collection in the field. MX Deposit is also integrated with Geosoft Target, Target for ArcGIS and Oasis montaj platforms.

IRIS Instruments, based in Orleans, France, added an innovative software building block to the flowchart of its full 3-D Electrical Resistivity and IP Tomography (3D ERT). This block, called FullWaveDesigner helps prepare a survey using a FullWavers system. The geographical locations of potential electrodes and the current injection positions, which form the "geometry of the survey," are important to obtain good resolution and depth penetration using 3D ERT performed with distributed modules. The FullWaveDesigner software, which is directly linked to Google Earth, is an important part of the framework of a full 3D ERT survey from the survey design to the interpretation.

New waveform options were added to the MultiLoopGL modelling web app by Kingston, Ont.-based, **Lamontagne Geophysics**. It is now possible to calculate a response once and then look at the results with various waveforms, sampling schemes and frequencies. The response profile plots can be viewed in the 3-D scene or the output time step file can be plotted in 2-D using the 3CPlotter web app. Using 3CPlotter the calculated response can be compared to or subtracted from field data.

Quantec Geoscience expanded their data processing, inversion, integration and interpretation capabilities. This includes application of Telluric Cancellation (TC) and Periodic Noise



Survey results from a large-scale 3-D chargeability survey by Quantec.

Credit: Quantec Geoscience

(PN) removal technologies to the processing stream for DCIP data, further enhancing resolution and the ability to image at depth. The use of a code for the Joint Inversion of DC resistivity with MT resistivity resulted in inversions with additional interpretation products for the two survey methodologies. In several data integration projects the geophysical data, drillhole geological and rock-physical property data and structural/geological models were combined. This provides an integrated interpretation with typing of anomalous responses resulting in improved targeting in complex geology. Inversion capabilities were also expanded for 3-D inversion of larger data sets in a shorter time.

Drillhole Methods

Through a partnership with **SEMM Logging**, a world leader in borehole logging headquartered in Vesdun, France, **Abitibi Geophysics** now offers a full suite of borehole logging services for mining and exploration applications. In addition to optical and acoustic imaging for core orientation, the company is encouraging the use of physical property logging to better understand the geology and select the most responsive geophysical method for a given environment and to improve 3-D inversions.

Advanced Logic Technology (ALT), based in Luxembourg, reported that new slim-hole NMR logging tools are now employed in the mining industry. The NMR technique, used in the petroleum industry for decades, measures hydrogen and hence water content of pore spaces in the rock. The processed data can yield information about porosity, pore size distribution and differentiate between free water, capillary-bound and clay-bound porosity. Mining applications include mapping moisture content, specific yield and dry weight density in iron-ore deposits or mapping coal seam gas content and permeability in coal mining. ALT has developed a new NMR module for the WellCAD software to provide processing, visualization and interpretation of NMR data.

Crone Geophysics collected large numbers of full-waveform TDEM time-series data sets on surveys during 2017, as it has become routine to collect it while smart-stacking the data. The time-series data are sampled at 100 kHz, and the data analysis during 2017 was invaluable for testing new smart-stacking algorithms and learning about noise in borehole TDEM data near active mines. The company improved its smart stacking, which removes linear drift and some higher orders of background field variation, and also has optional automatic noise recognition and removal. In some cases, probe movement is the dominant source of noise, so probe-motion monitoring was introduced in their CDR3 receiver which prompts the operator when it is safe to take a reading. Crone's manufacturing facility mainly supports its survey contracting business, but in 2017 it did sell complete borehole TDEM systems with both B and dB/dt probes.

Whitehorse-based **Icefield Tools Corporation** completed a wireline interface modem, to communicate and deliver power to its solid-state Gyro Path North Seeking Gyroscope (NSG). The system, successfully tested to depths of 9000 m, allows operation in real-time or memory mode. During a survey the instrument can seamlessly switch between onboard batteries or external power. The drop-capable system is accurate to +/-1 degree with a gyro compass time of less than one minute.

Lamontagne Geophysics continued development of the UTEM 5 down-hole EM system (U5BH project). After bench-testing two prototypes, a final design is being implemented with sensitivity on all respective components at least 10 times better than the UTEM 4 down-hole sensor. There has been a delay of more than five months in the development of the magnetically-shielded chamber needed for the U5BH project because it was halted in July 2017 by order from **Esafe** (Electrical Safety Authority) which objects to many aspects of the chamber prototype. It would want electrical house-wiring methods used everywhere in the apparatus (use of conduits, junction boxes and grounding of all shield panels) making it useless as a shielded enclosure. At the time of writing, there was no solution in sight and legal action was being considered.

Denver, Colorado-based **Mount Sopris Instrument Co.** has developed a new 19 mm diameter natural gamma logging tool for surveying inside geo push rods, and other small-diameter

Icefield Tools' solid-state Gyro Path North Seeking Gyroscope with tablet.

Credit: Icefield Tools

applications. In addition, the company has developed SIP (Spectral Induced Polarization), and non-source neutron generator geophysical logging tools. SIP response (also known as Complex Resistivity) is measured by applying sine wave currents into the formation at frequencies from 1 mHz to 10 kHz. Impedance and phase angle are determined by correlating induced voltage and stimulus current. These frequency vs. phase and impedance spectral signatures provide reliable information about lithology, permeability, effective porosity, grain/pore size distribution and surface area.

Mount Sopris together with **Starfire Industries**, based in Champaign, Illinois, have developed a new neutron geophysical logging probe that eliminates the use of radioactive materials for neutron production. This will solve problems for users who have been restricted from using Am241-Be or Deuterium-Tritium (D-T) sources. The 4 Curie-equivalent, high-output, long-life electric Deuterium-Deuterium (D-D) fusion neutron generator in the tool provides radiation on/off capability, increasing safety for operators, while reducing the regulatory burden associated with radioactive sources.

Borehole Gravity (BHG) services are provided by **Micro-g LaCoste**. Numerous improvements in the past two years to both the GRAVILOG and Bluecap borehole gravity tools have delivered, high-accuracy results with less than 5 microGal repeatability and density estimates of less than 0.005 g/cm^3 accuracy for approximately 5 m station intervals. A key tool improvement is the replacement of bubble levels with MEMS tilt sensors on both tools. This vastly shortened the time to level downhole, reducing station reading time to about two minutes. Other tool upgrades include the addition of natural gamma ray and CCL, which has improved depth positioning to within 1 or 2 cm downhole.

SJ Geophysics reported an increased demand for their Volterra-BHEM system including a leasing agreement to a third-party geophysical contractor. Key features of the system are its adaptability to measure with multiple sensors simultaneously, its portability and the internal data logging functionality that allows surveying below the drill bit, while rods are being pulled. This is critical when holes are at high risk of collapse and makes surveying horizontal or up-hole feasible.

The Volterra-EM system is powered by fully-programmable transmitters that provide an overall current of 18 A peak-to-peak, for 100% duty cycle, or 10 A for 50% duty cycle. The units can be connected in parallel to increase current output. The transmitter can be programmed to a frequency best suited to the geological environment and avoid local noise interference. Advanced signal processing algorithms can separate the data from two isolated loops transmitting different distinct frequencies. Surveying two loops simultaneously reduces traverses, resources and time spent surveying.

Ground Electromagnetic Methods

Abitibi Geophysics reported that InfiniTEM XL is proving to have excellent depth of exploration as well as lateral exploration equal to the depth, plus resolution of off-set targets previously undetected in the shadow of larger anomalous zones. The company reported a BH InfiniTEM discovery of a new mineralized zone, which was greater than 600 m off-hole at a depth of 1,000 m. A surface InfiniTEM XL survey resulted in the discovery of a previously blind zone of mineralization at a depth of greater than 800 m near an operating VMS mine. The continuation of ARMIT development with Dr. James Macnae at **RMIT University** in Melbourne, led to the introduction of the ARMIT 3 sensor. ARMIT 3 measures B-field and dB/dt simultaneously on all 3 axes on base frequencies from sub-1 Hz through to 30 Hz. ARMIT 3 sensors are manufactured in Val d'Or, Que.

In a new development, the company can now do radio imaging tomography. During 2017 Abitibi entered into an agreement with **GEOFARA** of Saint Petersburg, Russia, to provide FARA's radio imaging services in North America. FARA is a radio imaging technology that investigates and maps resistivity contrasts between boreholes. The cross-hole tomography is presented as a visual showing conductive mineralization between the boreholes.

ClearView Geophysics, based in Brampton, Ont., has designed ruggedized survey platforms for its snowmobile-mode TDEM and cesium magnetometer surveys. Lighter components such as "race-car" lithium batteries, wider and longer sleighs for better stability and stronger components designed for very cold temperatures enables faster data acquisition and better data quality with less vibration at higher speeds. The separation of the transmitter and receiver coils from the main electronic components also allows more accurate measurements simulating an airborne survey on the ground.

Crone Geophysics has developed a new transmitter for its borehole and surface TDEM system which is higher power and yet the Tx with power source remains 2-person portable. The new 15 kW transmitter which delivers up to 500 V and will output 60 A current, retains its portability due to its PFC (power factor correction) design and a PF close to unity. This reduces weight and allows the use of smaller AC generators than would normally be required. Any waveform can be transmitted (standard 50% with high-accuracy linear ramp turn-off or 100% duty cycle, or other) and accurately digitally-controlled with high-frequency switching. Setup time is minimized due to its automatic loop measurements and calculations of resistance, inductance and current adjustment. Peak loop current is held constant during the survey, confirmed with automatic

measurements made and stored by the transmitter throughout the day. GPS synchronization is available or a high-accuracy clock can be used.

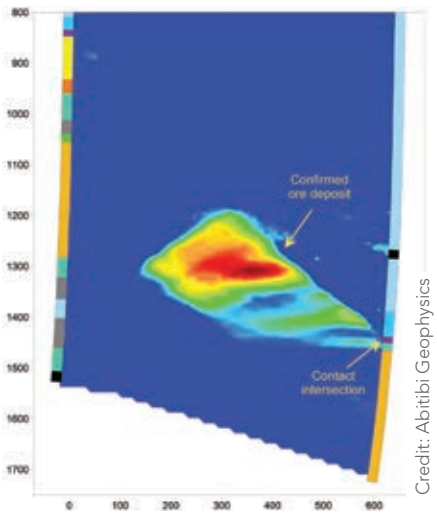
The Jessy Deep, high-temperature SQUID (HTS) sensor for deep TEM exploration continues to be offered by **Discovery International Geophysics** under an agreement with **Supracon AG** from Jena, Germany. In 2017, the company added the liquid helium, low-temperature SQUID (LTS) sensor. The higher signal-to-noise (S/N) ratio of the LTS sensor and the faster measurement time provides significant advantages over the HTS, although maintaining a supply of liquid helium on the job site is more of a challenge than liquid nitrogen. However, where ambient background noise due to minor ground movement or geomagnetic disturbances is low, the greater S/N of the LTS will provide higher quality TEM data from deep conductors with very low signal strength.

In 2017, Mississauga, Ont.-based **Geonics**, further enhanced the capabilities of its TDEM instrumentation for detection and characterization of UXO. The company developed the EM63 Flex Array, a flexible configuration system that provides continuous full-transient data from each of multiple (up to four) receiver coils. An integrated real-time filter rejects responses from magnetic soil. The unit also contains tools for advanced data processing that enables superior target detection and significant reduction of false-positive alarms. The EM63 Flex Array also provides many user-adjustable indicators for real-time data visualization and anomaly recognition.

Quebec City-based **Instrumentation GDD** has improved the penetration depth of its Beep Mat for operation in humid environments. This efficient, inexpensive tool for magnetic and relative conductivity EM measurements was developed and manufactured by GDD in 1976-80, and is still widely used for prospecting.

A prototype of the UTEM 5H transmitter has been field tested by **Lamontagne Geophysics** over the last year. The development project has increased power efficiency to over 90% and doubled the regulation bandwidth. The new transmitter can be powered by a combination of one or two motor generators of 240 V or 120 V AC and can operate at output levels ranging from 2.5 kVA to 10 kVA.

Superior Exploration of Batchawana Bay, Ont., continued with their innovative use of a traditional VLF geophysical instrument, the EM-16. The company has carried out ground VLF surveys, which do not require cut lines, throughout North America since 2011. VLF field data are processed using software co-developed by **EMTOMO** of Portugal with Superior. Data can be presented as a variety of profiles also showing elevation and geological information and can be displayed as plan maps and 3-D shadow maps. 2-D Inversion models can show geological information and drill sections.



Credit: Abitibi Geophysics

A radio imaging map (RIM) of mineralization between holes.

Supracon, located in Jena, Germany, now offers to all explorationists their highest sensitivity SQUIDs, the low-temperature SQUIDs, which previously had limited availability. The system named JESSY DEEP LTS can be applied in active and passive methods for magnetics and electromagnetics (e.g. TEM, CSAMT, MT, MIP) which require the recording of very small signal amplitudes (noise floor below 1.5 fT/vHz) with a frequency-independent transfer function and with large dynamic range signals of high-power TEM. Features include a dynamic range up to 2000 nT (e.g. 200 amps in a 100 m loop) and a slew rate up to 150 mT/s (e.g. switching 15 amps in a 100 m loop in 1 µsec).

Gravity Surveying

Concord, Ont.-based **Scintrex** reported that preliminary 2017 sales of the new and improved CG-6, which was introduced in 2016, have been strong, with positive feedback from customers. Recent improvements to the CG-6 Autograv firmware were added to enhance the user-interface experience and improve efficiency of survey operations. The CG-6 also offers Bluetooth integration and a handheld tablet computer for remote operation.

Induced Polarization

Abitibi Geophysics' OreVision is now believed to be the most-used Resistivity/IP configuration in eastern Canada. Since its introduction in 2014, continued development and dedicated crews have increased productivity in the field by a factor of 2.5. Results are so effective that clients have committed to survey blocks as large as 2,000 line-km. Many discoveries have been made since 2014 and the company has assigned staff to generate new case studies. IP research is now focused on source discrimination and constrained inversion. A new borehole IP approach has been successfully tested in a scale-model tank and confirmed with synthetic modelling.

With many years of IP/resistivity survey work with 2-D and 3-D arrays **ClearView Geophysics** continued with transmitter improvements to increase the signal to noise ratio for higher resolution at greater depths. The company has developed preferred survey array methodologies for sub-vertical gold mineralization, first pass surveys, follow-up surveys and for information from deep layers. UBC inversion software and spectral processing are used to prioritize drill targets.

Crone Geophysics completed and field tested the prototype Mark 7 3D E-SCAN resistivity mapping technology, which includes new real-time QA/QC capabilities in its optional 3-D IP functions. Competent E-SCAN resistivity data sets have


David Goldak, president of EMpulse Geophysics, celebrates in September 2017 after the first-ever collection of PULSAR data in the Sudbury area.

Credit: Abitibi Geophysics

been acquired to depths greater than 4,000 m, supporting objective 3-D inversion modelling conservatively terminated at approximately 2,500 m. This is due to a uniformly distributed, uniformly all-directional and sufficiently high-density 3-D pole-pole field data set to support unambiguous 3-D inversion. The Mark 7 adds new features for this deep mapping, including circuit characterization (spectrum analysis) and normalization of contributions and attenuations due to system hardware and wiring. An increased level of signal sensitivity, noise reduction and certainty of signal origin can therefore be achieved. The Mark 7 can acquire pole and dipole data in line-based, offset current line-based and the all-directional modes typical of distributed IP/resistivity systems. This will enable fair comparison of E-SCAN's usual dense and evenly-distributed, all-directional pole-pole data set to any other array and survey configuration. The Mark 7 advances were evaluated in a recent large 3-D resistivity survey conducted in northern Nevada's National Mine district. Full field deployment of the Mark 7 is planned for mid-2018.

Dias Geophysical, based in Saskatoon, Sask., completed resistivity and IP surveys in the U.S., Chile, Australia, China and Canada. The company continued development of its proprietary DIAS32 resistivity and IP technology, and expanded its survey capacity from 350 receivers/channels to over 650, which represents the largest distributed array capacity in the world. The DIAS32 system now has added the DIASTX technology. Delivering 25 kW at 5,000 V, this new transmitter has the highest power-to-weight ratio in its class. In addition, the transmitter offers high-speed waveform control, internal timing control and current monitoring. Dias reported the 3-D DIAS32 survey was key to targeting the discovery drill holes at the Arrow South unconformity uranium deposit in the southwest Athabasca basin in Saskatchewan.

The Multipole Resistivity Imaging or MRI-32 DCIP resistivity method developed by **Discovery International Geophysics**, using DIAS32 distributed array receivers, is now being used routinely for deep uranium exploration in the Athabasca basin, and for high-resolution mesothermal vein gold exploration in Canada. The DIAS32 distributed array system also allows for greater "n" levels, limited only by the length of the survey lines, and for reconfiguration of the readings into larger dipole "a" spacings, for increased depth of exploration.

Instrumentation GDD reported that in 2018, the new Multi-Rx mode GDD IP Receivers will be able to run distributed IP surveys with monitoring QC/QA of the data directly in the field. It is already possible to merge and process data from a combination of multiple GDD IP Receiver's output files from 2 to 32 channels using the GDD Post-Processing IP Software. Also the new 20,000W-4800V-20A flexible Multi-Tx mode with GDD's model Tx4 IP Transmitters (5000W-2400V-20A), allows a user to link up to four units to obtain maximum power and depth of investigation. The latest GDD Communication boxes (GDD-RTE01) allow collection at the GDD IP Receiver PDA, of real-time information (power and current) broadcasted by the Tx4 IP Transmitter, including recording of the current in an output file. The GDD Post-Processing IP Software can be used to cancel the telluric noise using time-stamped signals from a remote station and to deactivate some channels or even an entire reading.

Quantec Geoscience reported that ORION 3D DCIP and MT surveys now offer cost-effective applications through the new ORION swath methodology. This survey requires fewer receiver units and less line-cutting, yet provides deep effective and rapid 3D DCIP coverage through the use of multiple survey lines simultaneously read and then rolled along, much like application of seismic surveys. In 2017, the company expanded its inventory of broadband RT-160 receivers which have six pairs of HF and LF digitizers, and are deployed as part of SPARTAN MT surveys and ORION 3D surveys when high-frequency MT is to be acquired.

Quantec developed a new processing tool to remove and manage certain types of periodic noise not easily managed with traditional filters. Called PNR (for Periodic Noise Reduction), the tool successfully mitigated noise caused by cathodically-protected pipes in a recent IP survey. This new tool should permit IP acquisition in environments previously considered too noisy.

SJ Geophysics continued to provide customized 3-D IP solutions. Increased inventory of Volterra units now allows multiple large-scale 3-D IP surveys to be conducted concurrently. The company is developing their own current monitors with improved mechanical design and reduced cost compared to commercial versions. This will allow the use of multiple units, improving the tracking of the input waveform and the detection of current leakage. 2017 saw a renewed interest in the system's ability to acquire a fully active 2-D IP survey traverse. Laying out an entire line of dipoles while injecting current at the midpoint of each dipole results in more than double the data density of a traditional rolling 2-D IP array of N = 1 to 10. The benefits include greater data density and maintains near surface resolution with increased depth of investigation.

Georent, a **Terraplus-Iris Instruments** joint venture based at the Terraplus location, added a distributed IP system to their rental pool. The distributed system is geometry-free, allowing the operator to deploy the autonomous receivers anywhere in the grid. The receivers remain stationary while the transmitter is moved through and around the grid, which

enables the operator to collect true 3-D data. The distributed system consists of 20 V Full Waver two-channel receivers (40 simultaneous channels), one I Full Waver single-channel recorder to log the electrical current from the transmitter, Full Waver Designer software to design the survey grid, and Full Waver Viewer processing software.

Magnetotelluric

In 2017, Toronto-based **Advanced Geophysical Operations and Services (AGCOS)** introduced upgraded versions of the company's Super Multifunction Broadband EM receivers GEPARD-4 and GEPARD-8. They are equipped with high-sensitivity interchangeable electrical (E) and magnetic (H) channels which can operate in any configuration providing significant advantages in AMT, MT, LMT and MVP field surveys. The capability of the GEPARD system to simultaneously acquire broadband (43 kHz to 0.00001 Hz) EM data eliminates the need to conduct additional TDEM measurements for static shift correction. Turn-key GEPARD-4 and GEPARD-8 systems are supplied with data-processing software and a full set of induction coil magnetic sensors and fluxgate magnetometers. Compact, low-noise, non-polarizing electrodes with large contact surface areas are supplied in copper, lead and silver.

EMpulse Geophysics of Dalmeny, Sask., continued to advance its new PULSAR (Pulse-Aurora) receiver with the collection of the first-ever PULSAR dataset in the Sudbury area with its two prototype receivers. Due to the high dynamic range of PULSAR, and power-line noise cancellation software, survey operations were successfully conducted within 200 m of a major power-line. In the past, it would not have been possible to survey within 1,000 to 1,500 m of the power-line. A new aspect of the PULSAR receiver is the collection of horizontal magnetic transfer functions (MTFs). A trial survey (with their original SFERIC receiver) over Trevali Mining's Halfmile Deep orebody (Bathurst camp, New Brunswick) showed clear indications of the drill-defined orebody in the estimated horizontal MTFs. As a result, the company's 3-D inversion code was modified to invert horizontal magnetic-transfer-functions, in addition to the impedance phase tensor and tipper. However, even without horizontal MTFs, a joint inversion of the impedance phase tensor and tipper proved to be effective at delineating the Halfmile Deep sulphide body to nearly 1,000 m depth. For the Sudbury PULSAR data, EMpulse expects that the horizontal MTFs will further increase the sensitivity to conductive structures, while also providing better immunity to cultural noise (than the tipper). Importantly, the impedance phase tensor, tipper and horizontal MTFs are all static-free quantities which greatly increases the reliability and interpretability of the final 3-D inverted model.

Quantec now uses a non-magnetic coil calibration chamber. One key to the high-quality results that Quantec produces for MT surveys is using accurately and consistently calibrated magnetic field coils. This permits use of the most appropriate band-specific, highest sensitivity and quality tools from a variety of manufacturers, yet ensures the best results for surveys. Quantec employs a 3-layer passive shielded and active field cancellation calibration room for calibrating magnetic field sensors to determine the calibration constants to extract geophysical parameters from the signals measured at the magnetic field sensors in the field. The calibration process, unique among MT surveyors, consists of transmitting 18 square wave frequencies using the odd harmonics to calculate the coil response, ranging from 750 Hz to 0.0009 Hz (close to 1100 second period).

SJ Geophysics continues to incorporate additional survey techniques into their Volterra Acquisition system. With recent improvements in the MT/CSAMT processing codes, the company is now capable of collecting MT/CSAMT data as a ground technique. Work is also being completed on simultaneous collection of short-interval MT, extracting value from full waveform data during the down-time between IP readings.

Ground Penetrating Radar (GPR)

Sensors & Software, based in Mississauga, Ont., has developed a new concurrent receiver operation for the SPIDAR architecture. SPIDAR enables a number of GPR units to be networked together. This makes possible many new applications for GPR, including rapid seismic-style multi-fold data collection for improved subsurface imaging and physical property calculations. The DVL 500 data acquisition unit is now a standard part of the company's GPR systems. The new unit features a colour touchscreen, Wi-Fi, GPS and improved user interface, making operation simpler, data acquisition faster and providing the ability to analyze data in the field in real-time. The DVL 500 exports data through both wireless and hard-wired connections. Custom systems are also routinely designed for clients with unique GPR needs for many applications, including mining. A new borehole winch allows rapid acquisition of zero-offset and multi-offset gathers using a pulseEKKO borehole system. The automated winch provides positioning and triggering, making borehole data collection more accurate and significantly faster with rapid generation of tomographic images of the subsurface and possibilities for new GPR applications in shallow boreholes.

Ground Radiometric Surveying

In 2017, **GF Instruments** of Brno, Czech Republic, introduced a new 2048-channel gamma-ray spectrometer called Gamma Surveyor Vario. The instrument combines all useful features and accessories for field, borehole and carborne surveys with K, U, Th assays and dose-rate measurements. The versatility of the instrument is enhanced by a wireless probe assembly, and NaI(Tl) or BGO detectors of several volumes (including the carborne version). It also has built-in or external GPS and spectrum stabilization, using natural or man-made gamma-ray sources, especially useful for rapid reliable measurements at very low gamma activities.

COMPANIES AND WEBSITES

Aarhus Geophysics: www.aarhusgeo.com
Abitibi Geophysics: www.ageophysics.com
Advanced Logic Technology: www.alt.lu
AGCOS: www.agcos.ca
Aurora Flight Sciences: www.aurora.aero
CAHSR: www.hsr.ca.gov
CAMIRO: www.camiro.org
Canadian Exploration Geophysical Society: www.kegsonline.org
Canadian Micro Gravity: www.canadianmicrogravity.com
CGG Multi-Physics: www.cgg.com/multi-physics
ClearView Geophysics: www.geophysics.ca
Condor Consulting: www.condorconsult.com
Crone Geophysics & Exploration: www.cronegeophysics.com
CSIRO: www.csiro.au
Datacode: www.datacodeintl.com
Devbrio Géophysique: www.devbrio.com
DGGS (Alaska): dggs.alaska.gov
Dias Geophysical: www.diasgeo.com
Discovery Int'l Geophysics: www.discogeo.com
EMpulse Geophysics: www.empulse.ca
EMTOMO: www.emtomo.com
EON Geosciences Inc: www.eongeosciences.com
Esafe: www.esasafe.com
Expert Geophysics: www.expertgeophysics.com
Flying-Cam: www.flying-cam.com
Gap Geophysics: www.gapgeo.com
Gedex Systems: www.gedex.com
GEM Systems: www.gemsys.ca
GEOFARA: www.farasystem.ru
Geological Survey of Canada: www.nrcan.gc.ca/earth-sciences
Geological Survey of India: www.gsi.gov.in
Geological Survey of Sweden: www.sgu.se/en/groundwater
Geological Survey of Western Australia: www.dmp.wa.gov.au
Geonics: www.geonics.com
Geophysics GPR International: www.geophysicsgpr.com
Geoscience Australia: www.ga.gov.au
Geoscience BC: www.geosciencebc.com
Geosoft: www.geosoft.com
Geosphair Aviation: www.geosphair.com
Geotech: www.geotech.ca
Geotechnologies: www.geotechnologies-rus.com
GF Instruments: www.gfinstruments.cz
Icefield Tools: www.icefieldtools.com
IIC Technologies: www.iictechnologies.com
Illinois State Geological Survey: www.isgs.illinois.edu
Instrumentation GDD Inc: www.gddinstrumentation.com
International Geoscience Services: www.igsint.com
IRIS Instruments: www.iris-instruments.com
KEGS: www.kegsonline.org
Kroum VS Instruments: www.kroumvs.com
KTTM Geophysics: www.geofisicakttm.com
Lamontagne Geophysics: www.lamontagnegeophysics.com
LAUREL Technologies: www.laureltechnologies.com
Lockheed Martin: www.lockheedmartin.com
MagSpec Airborne Surveys: www.magspec.com.au
McPhar International: www.mcpharinternational.com
Medusa Sensing: www.medusa-sensing.com
Micro-g LaCoste: www.microglacoste.com
Minalytix: www.minalytix.net
MNDM (Ontario): www.mndm.gov.on.ca
Monex GeoScope: www.monexgeoscope.com.au
Mount Sopris Instruments: www.mountsopris.com
NASA's Ice Bridge project: espo.nasa.gov/oib
Natural Resources Canada: www.nrcan.gc.ca
NDSWC: www.swc.nd.gov
New-Sense Geophysics: www.new-sense.com
NF VSEGEI: www.nfvsegei.com
NWT Geological Survey: www.nwtgeosciences.ca
Paterson, Grant & Watson: www.pgw.ca
PicoEnvirotec: www.picoenvirotec.com
Precision GeoSurveys: www.precisiongeosurveys.com
Quantec Geoscience: www.quantecgeoscience.com
Radiation Solutions Inc: www.radiationsolutions.ca
RMIT University: www.rmit.edu.au
RMS Instruments: www.rmsinst.com
Sander Geophysics: www.sgl.com
Scintrex: www.scintrexltd.com
Scott Hogg & Associates: www.shageophysics.com
SEMM Logging: www.semmlogging.com
Sensors & Software: www.sensoft.ca
SJ Geophysics: www.sjgeophysics.com
SkyTEM Surveys: www.skytem.com
Starfire Industries: www.starfireindustries.com
SubMap Geophysics: www.submapgeophysics.my
Superior Exploration: www.superiorexploration.ca
Supracon: www.supracon.com
Terraplus: www.terraplus.ca
Terraquest: www.terraquest.ca
Thomson Aviation: www.thomsonaviation.com.au
University of British Columbia: www.ubc.ca
University of Groningen: www.rug.nl
University of Illinois: www.illinois.edu
University of Utah Energy Geoscience Institute: www.egi.utah.edu
University of Wageningen: www.wur.nl
University of Waterloo: uwaterloo.ca
US Army Corps of Engineers: www.usace.army.mil
US Department of Energy: www.energy.gov
US Geological Survey: www.usgs.gov
US National Geodetic Survey: www.ngs.noaa.gov/grav-d/
Wyoming Dept of Environmental Quality: www.deq.wyoming.gov

ABBREVIATIONS
(for acronyms used in the text)

A	Ampere
AC	Alternating Current
AEM	Airborne EM
AFMAG	AMT
AMT	Audiofrequency MT
B	Magnetic Field
BGO	Bismuth Germanate
BH	BoreHole
CCL	Casing Collar Locator
CPU	Central Processing Unit
CSAMT	Controlled Source AMT
CsI	Cesium Iodide
CSIRO	Commonwealth Scientific and Industrial Research Organization
dB/dt	rate of change of B with time
DC	Direct Current
DCIP	Direct Current Induced Polarization
DTM	Digital Terrain Model
EM	Electromagnetic
GPS	Global Positioning System
Hz	Hertz (cycles per second)
IOCG	Iron Oxide Copper Gold
IP	Induced Polarization
kHz	kiloHertz
kW	kiloWatt
LiDAR	Light Detection And Ranging
LMT	Low Frequency MT
MEMS	Micro Electro Mechanical System
MIP	Magnetic IP
MMR	Magnetometric Resistivity
MT	MagnetoTelluric
MVP	Magnetovariational Profiling
NaI	Sodium Iodide
NMR	Nuclear Magnetic Resonance
nT	nano Tesla
OEM	Original Equipment Manufacturer
PDA	Personal Data Assistant
QA	Quality Assurance
QC	Quality Control
R	Resistivity
RMS	Root Mean Square
SIP	Spectral IP
SQUID	Superconducting Quantum Interference Device
TDEM	Time Domain EM
TEM	Transient EM (TDEM)
Tx/Rx	Transmitter/Receiver
UAV	Unmanned Airborne Vehicle (Drone)
UBC	University of British Columbia
UTEM	University of Toronto EM
UXO	Unexploded Ordnance
V	Volt
VLF	Very Low Frequency
VMS	Volcanogenic Massive Sulphide
VTI	Vertical Transverse Isotropy
W	Watt

THE NORTHERN MINER
PODCAST

OVER 6,600 LISTENERS PER MONTH

Expert coverage and analysis of the week's events in junior mining and exploration by The Northern Miner western editor Matthew Keevil, BA (Econ & Poli Sci), and staff writer and geologist Lesley Stokes BSc (Hons.) Geology.

Distributed through The Northern Miner website and weekly newsletter (both free access) and available on iTunes Podcast and SoundCloud.

Listen for yourself at:
www.soundcloud.com/northern-miner

Podcast Sponsorship Opportunities Available

SPOTLIGHT SPONSOR

- Your company logo on podcast page on both NorthernMiner.com and Soundcloud.com
- Also featured on all podcast promo house ads
- Your company mentioned by podcast host at the beginning and the end of the episode

MINING MINUTE

- Four 1-minute interviews over one month
- Interview conducted by TNM reporter
- Full distribution stats for each episode

For More Information Please Contact:

Joe Crofts
Sales Manager
jcrofts@northernminer.com
416-510-6816

Michael Winter
Sales Representative
mwinter@northernminer.com
416-510-6772

CANADIAN COMPANIES OFFERING AIRBORNE GEOPHYSICAL SURVEYS AS A CONTRACT SERVICE 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

COMPANY (President or Senior Officer)	ADDRESS OF MAIN OFFICE	TELEPHONE NO/FAX NO, E-MAIL/WEBSITE	TYPES OF SURVEY OFFERED*
CGG Canada Services (Davin Allen)	2505 Meadowvale Blvd. Mississauga ON L5N 5S2	Tel: 905-812-0212 Fax: 905-812-1504 davin.allen@cgg.com www.cgg.com/en/what-we-do/multiphysics	H: AM, TEM, CAM/TEM, CAM/AR, CAM/TEM/AR, AGG (HeliFALCON), CAM/AGG, FEM, CAM/FEM, CAM/FEM/AR, Gradient AM (MIDAS) FW: AM, CAM/TEM, CAM/TEM/AR, CAM/AR AGG (FALCON, FALCON PLUS, FULL SPECTRUM FALCON), AG, CAM/AGG, CAM/AG
EON Geosciences Inc. (Khaled Moussaoui)	2021 Cote-de-Liesse St-Laurent QC H4N 2M5	Tel: 514-341-3366 Fax: 514-341-5366 info@eongeosciences.com www.eongeosciences.com	FW: AM, AG, CAM/AR, VLFEM Horizontal Gradiometer H: AM, AG, FEM, TEM, CAM/AR, VLFEM CAM/AEM/AR, CAM/AEM
Expert Geophysics Ltd. (Andrei Bagrianski)	19 Lionel Heights Cres., Toronto ON M3A 1L8	Tel: 647-402-8436 info@expertgeophysics.com www.expertgeophysics.com	Natural Field EM: MMT, CAM/AEM
Geodata Solutions Inc. (Mouhamed Moussaoui)	1054 des Pervenches Laval QC H7Y 2C7	Tel: 514-867-9990 Fax: 450-689-1013 mmoussaoui@geodatasolutions.ca www.geodatasolutions.ca	FW: AM, CAM/AR H: AM, CAM/AR
Geophysics GPR International Inc. (Claude Robillard)	2545 Delorimier Street, Suite 100 Longueuil QC J4K 3P7	Tel: 450-679-2400 Fax: 514-521-4128 Claude.Robillard@.GeophysicsGPR com www.GeophysicsGPR.com	H: AM, AR, Transverse, Longitudinal, Vertical Gradiometry VLFEM, Geophex FEM, GPRTEM
Geosphair Aviation Inc. (Olivier Ayotte)	767 Mont-Royal East Montreal QC H2J 1W8	Tel: 514-585-4314 Fax: 514-527-6726 Olivier_Ayotte@yahoo.com www.Geosphair.com	FW: AM, CAM/AR,VLFEM
Geotech Ltd. (Ed Morrison)	245 Industrial Parkway N Aurora ON L4G 4C4	Tel: 905-841-5004 Fax: 905-841-0611 info@geotech.ca www.geotech.ca	H-TEM: VTEM, AeroTEM Natural Field EM (AFMAG): ZTEM, AirMt, H-FEM: Impulse, CAM/AEM, CAM/AEM/AG, CAM/AR FW: CAM/AG, CAM/AR, CAM/ZTEM/AG, ZTEM Transverse, Longitudinal and Tri-Axial Magnetic Gradiometer

***NOTATION: AM - Aeromagnetic; CAM/AEM - Combined Aeromagnetic/Airborne EM; CAM/AR - Combined Aeromagnetic/Airborne Radiometric etc.; VLFEM - Very Low Frequency EM, AG - Airborne Gravity, AGG-Airborne Gravity Gradiometry, FEM - Frequency Domain EM, H-Helicopter, FW-Fixed Wing, TEM - Time Domain EM, UAV - Unmanned Airborne Vehicle**

CANADIAN COMPANIES OFFERING AIRBORNE GEOPHYSICAL SURVEYS AS A CONTRACT SERVICE 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

COMPANY (President or Senior Officer)	ADDRESS OF MAIN OFFICE	TELEPHONE NO/FAX NO, E-MAIL/WEBSITE	TYPES OF SURVEY OFFERED*
GeoVision Geosciences Inc. (Richard Osmond)	23678 108th Loop, Maple Ridge, BC, V2W 1B2	Tel: 604-466-0425, Cell: 604-805-0314 rosmond@shaw.ca www.geovision-geosciences.com	H: CAM/VLFEM
MPX Geophysics Ltd. (Daniel McKinnon)	25 Valleywood Drive Unit 14 Markham ON M2N 7C4	Tel: 905-947-1782 Fax: 905-947-1784 Info@ MPXGeophysics.com www.MPXGeophysics.com	FW: AM, Transverse, Longitudinal, Vertical, AR, CAM/AR H: AM, Transverse, Longitudinal, Vertical Gradiometer, CAM/AR
New-Sense Geophysics Ltd. (Glenn Slover)	195 Clayton Drive Unit 11 Markham ON L3R 7P3	Tel: 905-480-1107 Fax: 905-480-1207 info@new-sense.com www.new-sense.com	FW: Horizontal AM, CAM/AR, VLFEM H: CAM/AR, VLFEM
Novatem Inc. (Pascal Mouge)	1087, Chemin de la Montagne Mont-Saint-Hilaire QC J3G 4S6	Tel: 450-464-1655 Cell: 514-966-8000 Mouge@NOVATEM.com www.NOVATEM.com	H: COLIBRI AM, CAM/AEM, CAM/AR, CAM/AEM/AR; NOVATEM TEM & Resistivity FW: CAM/AR
Precision GeoSurveys Inc. (Harmen Keyser)	Hanger 42, Langley Airport 21330 56th Ave. Langley BC V2Y 0E5	Tel: 604 484 9402 Fax: 604 669 5715 info@precisiongeosurveys.com www.precisiongeosurveys.com	H: AM, CAM/AEM, CAM/AR Biaxial & Tri-axial Gradiometer, TEM, FDEM FW: AM, CAM/AR, VLFEM

***NOTATION: AM - Aeromagnetic; CAM/AEM - Combined Aeromagnetic/Airborne EM; CAM/AR - Combined Aeromagnetic/Airborne Radiometric etc.; VLFEM - Very Low Frequency EM, AG - Airborne Gravity, AGG-Airborne Gravity Gradiometry, FEM - Frequency Domain EM, H-Helicopter, FW-Fixed Wing, TEM - Time Domain EM, UAV - Unmanned Airborne Vehicle**

CANADIAN COMPANIES OFFERING AIRBORNE GEOPHYSICAL SURVEYS AS A CONTRACT SERVICE 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

COMPANY (President or Senior Officer)	ADDRESS OF MAIN OFFICE	TELEPHONE NO.,/FAX NO, E-MAIL/WEBSITE	TYPES OF SURVEY OFFERED*
Prospectair Geosurveys Inc. (Alain Tremblay)	15 chemin de l'Étang Gatineau QC J9J 3S9	Tel: 819-661-2029 Fax: 866-605-3653 contact@prospectair.ca www.prospectair.ca	H-TEM: ProspecTEM H: AM, AR, CAM/TEM, CAM/AR, CAM/TEM/AR
Sander Geophysics Ltd. (Stephan Sander & Luise Sander)	260 Hunt Club Road Ottawa ON K1V 1C1	Tel: 613-521-9626 Fax: 613-521-0215 surveys@sgl.com www.sgl.com	FW: AM, AR, AG, FEM, VLFEM, CAM/AR, CAM/AG, CAM/AG/AR, CAM/FEM, CAM/AG/FEM, CAM/AR/FEM, CAM/AG/AR/FEM, CAM/AR/VLFEM Scanning LiDAR, Methane Sensing Transverse, Longitudinal, Vertical & Triaxial Gradiometer H: AM, AR, AG, VLFEM, CAM/AR, CAM/AG, CAM/VLFEM, Scanning LiDAR, Methane Sensing, Transverse & Vertical Gradiometer
Scott Hogg & Assoc. Ltd. (Scott Hogg)	85 Curlew Drive, #104 Toronto ON M3A 2P8	Tel: 416-444-8245 Fax: 416-444-4409 scott@shageophysics.com www.shageophysics.com	H: CAM-AR-VLFEM, Triaxial Magnetic Gradiometer
SkyTEM Canada Inc. (Bill Brown)	38 Union St East. Waterloo ON N2J 1B7	Tel: 519-502-1436 Fax: bb@skytem.com www.skytem.com	H: SkyTEM 101, 304, 508, AM, CAM/AR, CAM/AEM, Dual Moment TEM
Terraquest Ltd. (Howard A. Barrie)	301-2900 John Street Markham ON L3R 5G3	Tel: 905-477-2800 Fax: 905-477-2820 info@terraquest.ca www.terraquest.ca	FW: AM, Transverse, Longitudinal, Vertical Gradiometer/CAM/AR, VLFEM (Matrix and XDS), AG (CMG GT2A) H: AM, CAM/AR, VLFEM (Matrix and XDS), CAM/AEM-HyRez TEM
Tundra Airborne Surveys Ltd. (John Charlton)	65 Dorchester Blvd. Unit 48, St Catharines ON L2M 7T7	Tel/Fax: 289-362-1609 Mobile: 416-432-9657 Info@ TundraAir.com www.TundraAir.com	FW: AM, CAM/AR/VLFEM, Transverse & Longitudinal Gradiometer

***NOTATION: AM - Aeromagnetic; CAM/AEM - Combined Aeromagnetic/Airborne EM; CAM/AR - Combined Aeromagnetic/Airborne Radiometric etc.; VLFEM - Very Low Frequency EM, AG - Airborne Gravity, AGG-Airborne Gravity Gradiometry, FEM - Frequency Domain EM, H-Helicopter, FW-Fixed Wing, TEM - Time Domain EM, UAV - Unmanned Airborne Vehicle**

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
Aerogeophysica Inc. (Russia) T: 7-495-641-1230 www.aerogeo.ru	Antonov-An-26,An-2 FW Ilyushin-Il14 Kamov-KA25,26 H (Ashtec GPS/Glonass)	Scintrex & Geometrics Cs Vapour (T, VG, LG)	6 Freq. Coax/coplanar FW AGP AEM H Towed Bird 4 Freq. Explorer HEM	Picodas PGAM 1000 R (50 l) Picodas/PEI GRS 410 (33.6 l) AGP G
Aerophysics (Mexico) T: 52-555-590-9928	Cessna 206, FW Piper PA-31 Navajo Leased H (PNAV-GPS + Video)	Cs Vapour Helimag PMAG 3000 (T)	Explorer HEM H Towed Bird 5 Freq. Coaxial/coplanar	Picodas PGAM 1000 R 256 chan (16 l or 33 l down, 4 l up)
Aeroquest Airborne (Canada) (see Geotech Ltd.)				
Bell Geospace, Inc. (USA) T: 281-591-6900 www.bellgeo.com	Basler BT-67 FW Cessna 208B	Geometrics G822A Cs Vapour (T)	NA	Lockheed Martin FTG GG Full Tensor Gravity

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
CGG Canada Services (Canada) T: 905-812-0212 www.cgg.com/en/what-we-do/multi-physics	CASA 212 x 1 FW Cessna 208B x 7 Cessna 406 x 2 Cheyenne II x 1 de Havilland Dash 7 x 1 Basler BT 67 x 1 H Chartered Helicopters (DGPS, RT-DGPS, DVideo)	CGG DAS FW Scintrex & Geometrics Cs Vapour (T, LG, TTG, VG, Triaxial) H (T, LG, TTG, VG, Triaxial)	TD; GEOTEM, FW TEMPEST, GRYPHON TD; HELITEM 30C H 3 axis (x-y-z), concentric, 5.3ms pulse width, 25/30 Hz, 560k NIA) HELITEM 35C 3 axis (x-y-z), concentric, 4-8ms pulse width, 12.5-30 Hz 600k-1.2M NIA) MULTIPULSE FD; RESOLVE (6 Freq. 400 Hz - 140,000 Hz, 1 coaxial & 5 coplanar coil sets) or RESOLVE (5 freq. 900 Hz – 56,000 Hz, 2 coaxial & 3 coplanar coil sets)	Exploranium GR 820 FW R RSI RS-500 (256/512 chan) Exploranium GR 820, H R RSI RS-500 (256/512 chan) FALCON, FALCON FW GG PLUS, FULL SPECTRUM FALCON CMG GT-1A, GT-2A FW G FALCON H GG
EDCON-PRJ Inc. (USA) T: 303-980-6556 www.edcon-prj.com	Dragon Fly Ultralight FW Leased H	Geometrics Cs Vapour (T)	NA	NA
EON Geosciences Inc. (Canada) T: 514-341-3366 www.eongeosciences.com	Piper PA-31 Navajo; FW King Air A90 Cessna 206 Piper Cheyenne II Leased H (DGPS, RT-DGPS, Digital Video)	Scintrex & Geometrics Cs Vapour (T, TTG)	E-THEM TD H Hummingbird FD Herz Totem-2A VLFEM	RSI RSX-5 1024 chan R (32 l down, 8 l up) CMG GT-1A/GT-2A G

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
Expert Geophysics Ltd. (Canada) T: 647-402-8436 www.expertgeophysics.com	Leased H	Geometrics Cs Vapour (T)	Natural Field EM: MMT H	NA
Geo Data Solutions Inc. (Canada) T: 514-867-9990 www.geodatasolutions.ca	Piper PA-31 Navajo; FW ASTAR 350, Bell 206 H Robinson R44 (RT-DGPS)	Geometrics & Scintrex Cs Vapour (T, TTG)	Totem-2A VLFEM	RSI RSX-5 R (16 l down, 4 l up)
Geophysics GPR International Inc. (Canada) T: 450-679-2400 www.geophysicsgpr.com	Hughes 300 H R44 Bell 206B/L ASTAR BA, B2, B3, Lama	Geometrics Cs Vapour (T, LG, TTG, VG)	GEOPHEX HEM H GEM-2A Towed Bird Multi Freq. Coaxial/Coplanar VLFEM GPRTEM	Pico Envirotec R (16 l)
Geosphair Aviation Inc. (Canada) T: 514-585-4314 www.geosphair.com	Piper PA-31 Navaho x 1; FW Super-Cub x 1 (DGPS, RT-DGPS, DVideo)	GEM System K Vapour (T,TTG,VG)	Totem-2A VLFEM	Medusa MS-4000 R
Geotech Ltd. (Canada) T: 905-841-5004 www.geotech.ca	Cessna 206 x 1 FW Cessna 208B x 4 PAC750-XL x 1 Koala AW119 x 2 H AS350-B3 x 13 (DGPS,GLONASS + DVideo)	Geometrics G823A Cs Vapour (T, LG, TTG) FW (T,LG, Triaxial) H	Geotech VTEM TD H (systems configured for shallow to deep penetration) AFMAG ZTEM FW/H AirMt AeroTEM TD H IMPULSE FD H	RSI RSX-5 1024 chan R (32 l down, 8 l up) CMG GT-2A G
GeoVision Geosciences Inc. (Canada) T: 604-466-0425 www.geovision-geosciences.com	Leased H	GEM System GSMP-30A	VLFEM	NA

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
GyroLAG (South Africa & Botswana) T: NA www.gyrolag.com	Maule M5-235C X 1 FW Trojan (1) Sycamore (1), Geoduster (1)-gyrocopter Agnav Guia/Linav (2) Novatel-DGPS (3)	Fluxgate (T, Vectors, TTG)	'SP' experimental device	MS 4000 (4 l CsI) R TAGS-6 G NIR,VIS,TIR, LiDAR RS
MagSpec Airborne Surveys Pty Ltd (Australia) T: 61-8-6260-2041 www.magspec.com.au	Cessna 210 FW Cessna 206 PAC750XL Leased H (Novatel L1/L2 + GLONASS)	Geometrics G822A Cs Vapour (T, G, TTG)	N/A	RSI RS-500 R CMG GT-2A G
Microsurvey Aerogeofísica e Consultoria Científica Ltda (Brazil) T: 55-21-2445-1773 www.microsurvey.net	Cessna 208B FW EMB 820C x 2 Piper PA-31 Navajo	Scintrex Cs Vapour (T, G)	Ms Relief VLFEM SP-4 MT with 3 Coils	Picodas/PEI GRS 410 R (33.6 l) RSI RS-500 256-512 chan (16 l down, 4 l up) Exploranium GR-820 256 chan (16 l, 32 l or 48 l) Lockheed Martin FTG GG Full Tensor Gravity
MPX Geophysics Ltd. (Canada) T: 905-947-1782 www.mpxgeophysics.com	Leased FW Leased H (DGPS RT-DGPS, Video)	Scintrex & Geometrics Cs Vapour (T, TTG)	NA	Pico Envirotec R GRS-10 Spectrometer 256-512 chan (50.4 l down, 12.6 l up) RSI 500
New Resolution Geophysics (South Africa) T: 27-21-789-0509 www.airbornegeophysics.com	Pilatus PC6 x 2 FW AS350 series x 8 H (DGPS)	Scintrex CS-3 (T,LG,TTG,VG)	Xcite TD H	RS-500 x 8 R CMG GT-2A x 2 G

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
New-Sense Geophysics (Canada) T: 905-480-1107 www.new-sense.com	Leased: Piper PA31 Navajo, FW Cessna 206 Leased Bell 206 (stinger) H ASTAR (stinger)	Scintrex CS-3 (T, LG)	NA	RSI RSX-5 x 7 R
Novatem Inc. (Canada) T: 450-464-1655 C: 514-966-8000 www.novatem.com	Cessna 185 x 1 (on floats) FW Piper PA-31 Navajo x 3 Leased ASTAR series H	GEM Systems K Vapour (T, LG, TTG, VG) Geometrics Cs Vapour (T, LG, VG)	NOVATEM TD H	RSI RSX-5 x 6 R (16 l down, 4 l up)
Precision GeoSurveys Inc. (Canada) T: 604-484-9402 www.precisiongeosurveys.com	Cessna 206 FW Piper PA-31 Navajo Bell 206, Airbus AS-350 H (GPS, DGPS)	Scintrex & Geometrics FW Cs Vapour, & GEM K Vapour (T, LG,TTG) H Triaxial (with attitude correction)	VLFEM FW "1TEM" TD H FDEM	Pico Envirotec R GRS-10 Spectrometer 256-512 chan Exploranium GR820
Prospectair Geosurveys Inc. (Canada) T: 819-661-2029 www.prospectair.ca	EC120B, R44 H (RT-DGPS)	Geometrics Cs Vapour (T,G)	ProspecTEM TD H	RSI RSX-500 R (16 l down, 4 l up)
Prospectors A. S. Ltda. (Brazil) T.: 55-21-2502-2526 www.prospectorsbr.com	Piper Chieftain x 2 FW Cessna 208B x 2 Leased H	Geometrics Cs Vapour (T, LG, TTG)	AeroTEM TD H	RSI RS-500 R 3 x (40 l down, 8 l up) CMG GT-2A G
Sander Geophysics Ltd. (Canada) T: 613-521-9626 www.sgl.com	Cessna 208B x 8 FW BN Islander x 2 DHC6 x 1 Airbus AS-350B3 x 2 H (DGPS, RT-DGPS + DVideo)	Geometrics Cs Vapour Sander SGMAG (T, LG, TTG, VG, Triaxial) FW (T,TTG, VG) H	SGFEM FD FW Herz Totem-2A VLFEM	Exploranium GR820 R (256 chan) (60 l) RSI RS-500 256-512 chan 50 l down, 8 l up Sander AIRGrav G

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
Scott Hogg & Assoc. Ltd. (Canada) T: 416-444-8245 www.shageophysics.com	Leased H (GPS)	Scintrex CS-3 Cs Vapour (T, LG, TTG, VG, Triaxial)	Totem 2A VLFEM	Pico Envirotec R 256 chan (32 l down, 4 l up)
SkyTEM Canada Inc. (Canada) T: 519-502-1436 www.skytem.com	Leased H (GPS)	Geometrics Cs Vapour sensors (T)	SkyTEM 101-7K NIA, 304-150K NIA, 508-500K NIA [dual moment available for 304 & 508]	Radiation Solutions R Medusa 256-512 chan; (16 l down, 4 l up)
Spectrem Air (RSA) T: 27-11-659-1518 www.spectrem.co.za	Basler BT-67 FW (DGPS + DVideo)	Scintrex Cs Vapour (T)	Spectrem2000 TD FW	Exploranium GR820 R (32 l)
Terraquest (Canada) T: 905-477-2800 www.terraquest.ca	King Air C90 FW Cessna 206 Navajo 325 Leased H (DGPS + DVideo)	Scintrex & Geometrics Cs Vapour (T, LG, TTG, VG)	XDS VLFEM FW/H Matrix digital VLFEM HyRez TD H	RSI RSX-500 R Pico Envirotec (4 l down, 2 l up) CMG GT-2A G
Thomson Aviation (Australia) T: 61-2-6960-3800 C: 61-4-9999-1963 www.thomsonaviation.com.au	PAC 750XL x 2 FW Cessna 210 x 4 Cessna 208B x 1 Fletcher FU24 x 1 Piper PA-31 Navajo x 2 Owned UAV; Leased H (NovAtel OEMV-1VBS)	Geometrics G822A & G823A Cs Vapour (T,G)	BIPTEM TD H	RSI RS-500 R (up to 67.2 l) CMG GT-1A, GT-2A G
Tundra Airborne Surveys (Canada) T: 289-362-1609 www.tundraair.com	Diamond DA-42 Twin Star FW Piper PA-31 Navajo x 2 Leased H (DGPS + RT-DGPS + DVideo)	Scintrex & Geometrics Cs Vapour Scin= (T, LG, TTG) Geo= (T,LG,TTG,VG,Triaxial)	Totem 2A VLFEM H	Pico Envirotec R 256 chan (32 l down, 4 l up)

CAPABILITIES OF AIRBORNE GEOPHYSICAL SURVEY CONTRACTORS 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

COMPANY (Country) Telephone No. Web site	AIRCRAFT Fixed Wing = FW Helicopter = H (Positioning)	AEROMAGNETIC T=Total Field, G=Gradient L, TT, V=Longitudinal, Transverse & Vertical	AIRBORNE ELECTROMAGNETIC (Time domain = TD) (Frequency domain = FD)	AIRBORNE RADIOMETRIC (R), GRAVITY (G) & GRAVITY GRADIENT (GG) Remote Sensing (RS)
UTS Geophysics (Australia) T: 61-8-9479-4232 www.uts.com.au	Same aircraft as Geotech Ltd. (DGPS,GLONASS + DVideo)	Geometrics G823A Cs Vapour (T, LG, TTG) FW (T,LG, Triaxial) H	Geotech VTEM TD H (systems configured for shallow to deep penetration) AFMAG ZTEM FD FW/H AirMt FD AeroTEM TD H IMPULSE FD H	RSI RS-500 R 1024 chan (32 l down, 4 l up) CMG GT-2A G
Xcalibur Airborne Geophysics (PTY) Ltd. (RSA) T: 27-12-543-2540 www.xagsa.com	Turbo Islander x 3 FW Airtractor x 2	Geometrics Cs Vapour (T, LG, TTG)	NA	Exploranium GR-820 R RSI RS-5OO

COMMERCIALLY-AVAILABLE INDUCED POLARIZATION (IP) EQUIPMENT 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 **(27/June/2018)**

Manufacturer (Country)	(TD=Time Domain FD=Freq. Domain ϕ =Phase S=Spectral)	Transmitter Model No.	Cycling Time or Frequency	Trans-mitted Power	Transmitter Power Source (MG=Motor Generator)	Trans-mitter Weight	Receiver Model No.	Sensitivity or Accuracy	Voltage Range	Microprocessor Controlled/Data Memory	Receiver Weight
Advanced Geophysical Operations and Services Inc. (Canada)	TD, FD, amplitude and φ IP, SIP	AT-100	0.01Hz - 50kHz	100 W	12V battery	4 kg	GEPARD-4A (4ch) GEPARD-8A (8ch)	0.1µV / 1% typ	0.1µV to 10V	Removable Media (SD Card) up to 64Gb	10 kg with internal battery
IRIS Instruments (France)	TD & FD	VIP 3000		3000 W	45 - 450 Hz 1 phase	16 kg					
	TD & FD	VIP 4000	0.0625 - 4 Hz	4000 W	45 - 450 Hz 1 phase	16 kg	ELREC 6	0.01 mV/V0.6% typ. accuracy	10µV to 10V	Yes/2500stations	8 kg
	TD & FD	VIP 5000		5000 W	45 - 800 Hz 1 or 3 phases	23 kg	ELREC 10	0.01 mV/V0.6% typ. accuracy	10µV to 15V	Yes/3200stations	9 kg
	TD & FD	VIP 10000		10000 W	45 - 800 Hz 1 or 3 phases	35 kg					
Instrumentation GDD Inc. (Canada)	TD	Tx III-4800V-10A	DC 1,2,4,8 and 16 seconds	1800 W	120 V, 50-60 Hz	27 kg	GRx2-2 channels	Voltage: Resolution 1 µV, Accuracy ≤ 0.15%	±10µV to ±15V for any channel	Archer 2 PDA-512Mb RAM Allegro 2 PDA-512Mb RAM	1.6 kg
	TD	Tx II-4800V-15A	DC 1,2,4,8 and 16 seconds	3600 W	240 V, 50-60 Hz	32 kg	GRx8mini-4 or 8 channels		±10µV to ±15V for any channel	Archer 2 PDA-512Mb RAM Allegro 2 PDA-512Mb RAM	3.1 kg
	TD	Tx4-4800V-20A	DC 1,2,4,8 and 16 seconds	5000 W	240 V, 50-60 Hz	40 kg	GRx8-32-8,10,16,24 or 32 channels	Chargeability; 1 µV/V, Accuracy ≤ 0.4%	±10µV to ±15V for any channel	Archer 2 PDA-512Mb RAM Allegro 2 PDA-512Mb RAM	7.0 kg
	TD	Tx4-4800V-20A	DC 1,2,4,8 and 16 seconds	10000 W	240 V, 50-60 Hz	2 x 40 kg	Post-processing IP software				
	TD	Tx4-4800V-20A	DC 1,2,4,8 and 16 seconds	20000 W	240 V, 50-60 Hz	4 x 40 kg					
	TD	EM-IP Tx Controller	1 second on and above		2 X Li Ion batteries	4 kg					
	TD	TRM	Higher frequencies								
Phoenix Geophysics (Canada)	TD, FD, ϕ IP	T3	TD: 0.0625 Hz -30 Hz , FD: 0.125 Hz to 10 kHz TD: 50% FD: 100% duty cycle, external drive optional	3000 W	Battery or any single phase generator	12 kg, mounted on backpack					

COMMERCIALLY-AVAILABLE INDUCED POLARIZATION (IP) EQUIPMENT 2018
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0

27//June/2018)

Manufacturer (Country)	(TD=Time Domain FD=Freq. Domain ϕ =Phase S=Spectral)	Transmitter Model No.	Cycling Time or Frequency	Transmitted Power	Transmitter Power Source (MG=Motor Generator)	Transmitter Weight	Receiver Model No.	Sensitivity or Accuracy	Voltage Range	Microprocessor Controlled/Data Memory	Receiver Weight
Phoenix Geophysics (Canada) cont'd	TD, FD, ϕ IP & SIP	TXU-30	TD: 128 s -30 Hz , FD: 256 s to 10 kHz TD: 50%, 33%, 25%, bi-polar, single pole FD: 100 %, 55.55%	20 Kw	Any 200-240 V commercially available 3 phase generator external drive optional	NA					
	TD, FD, ϕ IP & SIP	T4	TD: 0.0625 Hz -30 Hz , FD: 0.125 Hz to 10 kHz TD: 50% FD: 100% duty cycle, external drive optional	2.8 kW, max 130 V input, fast turn-off for EM operations	Low Voltage battery	9.0 kg , mounted on backpack					
Scintrex (Canada)	TD & FD						IPR-12 8 dipole	Better than 1%	50 µV to 14 V	Yes, 400 readings 8 dipoles	5.8 kg
Walcer Geophysics Ltd. (Canada)	TD & FD	IPT-1 & TX KW10	IPT-1: FD: "A" & "B" Models DC - 4 Hz TD: "A" Model- 2 sec. on / 2 sec. off "B" Model - Seconds on / off; in 1,2,4 & 8 seconds TX KW10: 1 sec., 2 sec., 4 sec., 8 sec.	IPT-1 75 - 1200V in 5 steps 3 mA - 10 Amps TX KW10 100 - 3200V in 10 steps 0.05 - 20 Amps Tested to 10.5 kVA	MG-1, MG-2, MG-6 and MG-12 Variable power 400 Hz/3 phase	IPT-1 18 Kg TX KW-10 44 kg					
Zonge (USA)	TD & FD ϕ IP & SIP	GGT-3	DC to 8 kHz	3 KVA	3 Kw MG 400 Hz	30 kg					
	TD & FD ϕ IP & SIP	GGT-10	DC to 8 kHz	10 KVA	5, 7.5 & 10 Kw MG 400 Hz	51 kg					
	TD & FD ϕ IP & SIP	GGT-30	DC to 8 kHz	30 KVA	32 KVA MG 400 Hz	93 kg	GDP-32$_{II}$ 6 channel	0.03 µV	0.1 µV to 32 V AGC	Yes/32 MB/RAM 4 GB/HD	13.2 kg incl. batt.
	TD & FD	NT-20	DC to 512 kHz	480 W	Batteries	5 kg	GDP-32$_{II}$ 16 channel	0.03 µV	0.1µ V to 32 V AGC	Yes/32 MB/RAM 4GB HD	19 kg incl. batt.
	TD & FD	ZT-30	DC to 512 Hz	3.6 Kw	Batteries	8 kg					

Manufacturers and Principal Distributors of Mining Geophysical Equipment & Software in Canada 2018;
Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

COMPANY	TELEPHONE (FAX)	E-MAIL/WEBSITE	SENIOR OFFICER
Advanced Geophysical Operations and Services Inc. (AGCOS) 162 Oakdale Road, North York, ON M3N 2S5	416-747-8800 (416-747-5761)	info@agcos.ca www.agcos.ca	Igor Ingerov
CRONE GEOPHYSICS & EXPLORATION LTD 2135 Meadowpine Blvd. Mississauga ON L5N 6L5	905-814-0100 (905-814-8617)	info@cronegeophysics.com www.cronegeophysics.com	William (Bill) Ravenhurst
DUALEM INC. 540 Churchill Ave Milton ON L9T 3A2	905-876-0201 (905-876-2753)	inbox@dualem.com www.dualem.com	Rick Taylor
EXPLORANIUM 60 Queen St, Suite 1516 Ottawa ON K1P 5Y7	613-563-7242 (613-563-3399)	bryan.d.rockwood@saic.com www.saic.com/products/security	Bryan Rockwood
GEM SYSTEMS INC. 135 Spy Court Markham ON L3R 5H6	905-752-2202 (905-752-2205)	info@gemsys.ca www.gemsys.ca	I. Hrvoic
GEONICS LTD. Unit 8, 1745 Meyerside Dr Mississauga ON L5T 1C6	905-670-9580 (905-670-9204)	geonics@geonics.com www.geonics.com	Miro Bosnar
GEOSENSORS INC. 66 Mann Ave Toronto ON M4S 2Y3	416-483-4691 (416-483-9909)	scott.holladay@geosensors.com	Scott Holladay
GEOSOFT INC. 207 Queens Quay West-Suite 810 Toronto ON M5J 1A7	416-369-0111 (416-369-9599) 1-800-363-6277	info@geosoft.com www.geosoft.com	Tim Dobush
GEOTECH LTD. 245 Industrial Parkway North Aurora ON L4G 4C4	905-841-5004 (905-841-0611)	info@geotech.ca www.geotech.ca	Ed Morrison
ICEFIELD TOOLS CORP. P.O. Box 30085 Whitehorse YK Y1A 5M2	867-633-4264 (867-633-4217) 1-877-423-3435	info@icefieldtools.com www.icefieldtools.com	Erik Blake
IFG CORPORATION 26 Bramsteele Rd, Unit 2 Brampton ON L6W 1B3	905-451-5228 (905-451-2877)	info@ifgcorp.com www.ifgcorp.com	Detlef Blohm
INSTRUMENTATION GDD INC. 860 Boulevard de la Chaudière, St. 200 Québec QC G1X 4B7	418-877-4249 (418-877-4054)	gdd@gdd.ca www.gdd.ca	Pierre Gaucher
KROUM VS INSTRUMENTS LTD. 2206-701 Don Mills R Toronto ON M3C 1R9	416-421-6313	kroum@kroumvs.com www.kroumvs.com	Kroum Stamenkov
LAMONTAGNE GEOPHYSICS LTD. 115 Grant Timmins Dr Kingston ON K7L 4V4	613-531-9950 (613-531-8987)	lamont@kos.net www.lamontagnegeophysics.com	Yves Lamontagne
MARINE MAGNETICS 135 Spy Court Markham ON L3R 5H6	905-709-3135 (905-479-9484)	info@marinemagnetics.com www.marinemagnetics.com	Melissa Marlowe
MIRA GEOSCIENCE LTD #309 – 310 Victoria Avenue Westmount, Quebec, H3Z 2M9	514-489-1890 (514 489-5536)	info@mirageoscience.com www.mirageoscience.com	John McGaughey
NUVIA DYNAMICS INC. 222 Snidercroft Rd Concord ON L4K 2K1	905-760-9512 (905-760-9513)	info@nuvia-dynamics.com www.nuvia-dynamics.com	Sandip Goswami
PATERSON, GRANT & WATSON LTD. 155 University Ave, St. 1710 Toronto ON M5H 3B7	416-368-2888 (416-368-2887)	pgw@pgw.on.ca www.pgw.on.ca	Stephen Reford
PHOENIX GEOPHYSICS LTD. Unit 3, 3781 Victoria Park Ave Scarborough ON M1W 3K5	416-491-7340 (416-491-7378)	yavram@phoenix-geophysics.com www.phoenix-geophysics.com	Yann Avram

COMPANY	TELEPHONE (FAX)	E-MAIL/WEBSITE	SENIOR OFFICER
RADIATION SOLUTIONS INC. 5875 Whittle Road Mississauga ON L4Z 2H4	905-890-1111 (905-890-1964)	sales@radiationsolutions.ca www.radiationsolutions.ca	Jens Hovgaard
RMS INSTRUMENTS LTD. 6877-1 Goreway Dr Mississauga ON L4V 1L9	905-677-5533 (905-677-5030)	rms@rmsinst.com www.rmsinst.com	Onorio Rocca
SCINTREX LTD. 222 Snidercroft Rd Concord ON L4K 2K1	905-669-2280 (905-669-6403)	Scintrex@scintrexltd.com www.scintrexltd.com	Ed Quinton
SCOTT HOGG & ASSOC. 85 Curlew Drive, #104 Toronto ON M3A 2P8	416-444-8245 (416-444-4409)	scott@shageophysics.com www.shageophysics.com	Scott Hogg
SENSORS & SOFTWARE INC. 1040 Stacey Court Mississauga ON L4W 2X8	905-624-8909 (905-624-9365) (1-800-267-6013)	sales@sensoft.ca www.sensoft.ca	Peter Annan
W. SODIN (GRAVITY) LTD. Unit 18, 95 West Beaver Creek Rd Richmond Hill ON L4B 1H2	905-886-8632 (905-886-4477)		Wolf Sodin
TERRAPLUS INC. Unit 12, 52 West Beaver Creek Rd Richmond Hill ON L4B 1L9	905-764-5505 (905-764-8093)	sales@terraplus.ca www.terraplus.ca	Claude B. Meunier
WALCER GEOPHYSICS LTD. 2106 Regional Rd 3 Enniskillen ON L0B 1J0	905-263-8767 (905-263-8766)	awalcer@rogers.com www.walcergeophysics.com	Alex Walcer

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
ADVANCED GEOPHYSICAL OPERATIONS AND SERVICES INC. (AGCOS)						GEPARD-4A & 8A	Receivers: GEPARD-4A, 8A, MARY-24, IMVP, COMx64, ACF-4M, RMT-CS, -M, -F, -5. Transmitters: AT-100, ASTRA-100, GTS-1 Electrical Sensors ACE-84, ALCE-84A, ASCE-84AG. Induction Coils: AMS-15, AMS-37 TDEM Loops: MTEM Precision Tripods: TRI-3/30, -3/50, -1/30, -1/50, -1/30/1, -1/50/1		GEPARD-4A and 8A AT-100, MARY-24, COMx64, IMVP, ASTRA-100	AMS-15, AMS-37	GEPARD-4A and 8A MARY-24, IMVP, COMx64, AT-100, ASTRA-100			1. EM and Seismic software for modeling, data processing, editing, visualization and interpretation 2. Shallow Marine EM Receivers 2AUSS-07A (2Ch) and 5AUSS-07A (5ch) and, SMMT (2ch)
DUALEM							DUALEM-1, 2, 21, 4, 42, 421 and 642							
EXPLORANIUM				GR-660 GR-820				GR-135						

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
GEM SYSTEMS	GEM-DAS (Real time data display & Acquisition Software Compensation (post-processing or real-time)	Manned aircraft: GSMP-35A Complete Towed Birds: GSMP-35A(B) (MagBIRD) GSMP-35GA(B) (GradBIRD) GSMP-35GA3(B) (Tri-AxialBIRD) UAV: GFMP-35U (DRONEMag) GFMP-35U(B) (AirBIRD) GFMP-35UG(B) (AirGRAD)	Manned aircraft: GSM-90AV			GSMV-series: (VLF only) 19, 19W GSM-P series: (VLF attachment) 35V, 35GV (GSMP=potassium) GSM-series: (VLF attachment) 19V, 19WV, 19GV, 19GWV (19= Overhauser) 19TV, 19TWV,19TVG,19TGWV (19T=proton) (G=gradiometer; W=walking mode)								

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
GEONICS					BH 43 BH 43-3D EM 39 EM 39S MAG 43-3D	EM-16 Tx27	PROTEM 67,47,57-MK2, CM, 67-Plus CMX EM42 EM61-MK2 EM61-MK2-HP EM61-HH-MK2 EM61-MK2A EM61-LX2 EM61 BLU26 ARRAY EM63-3DMK2 EM63 Flex Array GTEM				EM16R EM31- MK-2 EM34-3 EM31-S EM38DD EM38B EM38-MK2			DAT(31,34,39 ,38Mk2,61Mk 2) DAS 70-AR2 Logger EM61LX2
GEOSENSORS	Custom	Multi-channel High Rate Processors	Custom FDEM, TEM Helicopter Towed Bird & Fixed Mount				EM Sensors							
GEOSOFT														S
ICEFIELD					MI-03, MI-03N Borehole Surveying & Magnetics									
IFG					Resistivity									

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
IFG cont.					Conductivity IP Magnetic Temperature Gamma Density Caliper Tilt Orientation Systems									
INSTRUMENTATION GDD INC.					SSW System: Probes 25 mm+ EM Conductivity Mag Suscept For Ni, Fe, etc.		TDEM Rx 3 or 8 channels EM-IP Tx controller TRM+Tx4 5Kw 2400V-20A Beep Mat		Tx: Tx III 1.8Kw Tx II 3.6Kw Tx 4 5,10,20 Kw EM-IP Tx controller TRM (higher frequencies) Rx: GRX 2-32 channels SCIP Tester: Resistivity and chargeability Borehole option				MPP-Probe: Mag suscept. and EM conduct	IP and EM post processing software

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
KROUM VS INSTRUMENTS	KANA8 SDAS1-PPC	KMAG4												
LAMONTAGNE														S
MARINE MAGNETICS					Magnum Magnetometer					Sentinel Base Stn. Mag.				
MIRA GEOSCIENCE LTD.														GOCAD Mining Suite Geoscience ANALYST Geoscience INTEGRATOR VP suite inversion codes UBC-GIF inversion codes Training
NUVIA DYNAMICS INC.	IMPAC	IMPAC-M (integrated) PEICOMP-magnetic compensation	P-THEM	AGRS				PGIS-2 PGIS-2-1 PGIS-2-2 RADScout (drone installation)		PBM (diurnal variation station)				Praga4 (Spectrometer Processing) EMDataView MAPConvert DATAView

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
PATERSON, GRANT & WATSON LTD.														S
PHOENIX							V8 TDEM/AMT CSAMT/MT		T3 TXU-30 T4					
RADIATION SOLUTIONS INC. (RSI)				RS-500 series RSX-4 (16L) RSX-5 (16L + 4L) RS-501 I/F Console RS-700 series RSX-1 (4L) RSX-3 (6L) RS-701 I/F Console RS-705 I/F Console RS-607				Handheld: NaI: RS-111, RS-111T RS-120, RS-120T, RS-121, RS-121T, RS-125, RS-125T, RS-230BGO Portable: RS-330NaI RS-332BGO RS-350NaI Vehicle Mount: RS-700 Series						

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
RSI								RSX-1 (4L) RS-701 I/F Console RS-705 I/F Console						
RMS INSTRUMENTS	DAARC 500 DAS 500 PDU 500 GP 300	DAARC 500 AARC 500 AARC 510, AARC 51/52(UAV) Compensator Geometrics-Cs mags	Herz Totem-2A (VLFEM)			Herz Totem-2A (VLFEM)				Geometrics Cs & Proton Mags				S ExportDARRC Support GP 300 Graphic Printer & Chart Recorder GP300 Support software
SCINTREX		CS-3 CS-VL				ENVI VLF			IPR-12-Rx GGT Series Tx	NAVMAG ENVIMAG CS-3 ENVI-CS	SARIS	CG-6		Training Custom/Design-Consulting S
SCOTT HOGG & ASSOC.	DAQNAV acquisition & navigation													S magnetic comp; AGG mag modeling

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
SENSORS & SOFTWARE							GPR: PulseEKKO/ PulseEKKO-Borehole NOGGIN BackTrak IceMap							S
SODIN												100 100T 200 200T		
TERRAPLUS		Gradient mag UAV/Drone System	GSM-90 AV VLF	RS-500	QL40 Series ABI-2G, OBI-2G FWS, GR, SGR ELOG, IP, DLL3, CAL, DEV, OCEAN, FTC, IND, MGS, SFM Heat Pulse Flow Meter, GyroShot MI5 RCAM-1000	GSMV-19 GSM Series 19V, 19WV, 19GV, 19GWV, 19TV, 19TWV, 19TGV 19TWGV	ProEx-GPR GroundExplorer-GPR GDP-3224 GGT-3, -10, -30 XMT-32 AMT/6 TEM/3 Stratagem Numis Lite, -Poly GEM-2 Promis	RS-111 RS-120 RS-121 RS-125 RS-230 RS-330 RS-700 RT-50 oreXpress PSR+	Elrec Pro Elrec 6 Distributed IP System Tipix VIP-3000 VIP-4000 VIP-5000 VIP-10000 IP/L QL-ELOGIP KT-20 IP	GSM-19 GSM-19W GSM-19G GSM-19GW GSM-19T GSM-19TW GSM-19TG GSM-19TGW GSMP-35 GSMP-35G	Syscal Kid Syscal Junior Syscal R1 Syscal Pro Ohm-Mapper		KT-10 v2 KT-10 Plus v2 KT-10R v2 KT-10R Plus v2 KT-10S/C KT-10 Plus S/C KT-10R Plus S/C KT-10R S/C KT-20 KT-20 Plus	Geode ES-3000 StrataVisor SeisImager WellCAD Reflex Res2DINV Res3DINV Full Wave Designer Full Wave Viewer RadExplorer Object Mapper

MINING GEOPHYSICAL EQUIPMENT AND SOFTWARE COMMERCIALLY AVAILABLE IN CANADA 2018

Compiled by P.G. Killeen, 9759 Hwy 509, Ompah, ON K0H 2J0 (27/June/2018)

AIRBORNE EQUIPMENT					ELECTROMAGNETIC			GROUND EQUIPMENT Sus=susceptibility/G Meter=Gravity Meter						
COMPANY	Data Acquisition	Magnetometers	EM	Scint. Spectro-meters	Drill hole	VLFEM	EM	Scint. Spectro-meters	IP	Magnetometers	Resistivity	G Meter	Suscept Meters	Other & Software
TERRAPLUS cont.													KT-20 S/C KT-20 Plus S/C	IX1D Surfer