GEOPHYSICAL INSTRUMENTATION AND SERVICES

By Dr Patrick Killeen

Perhaps 2000 will be known as the year of co-operation. In all parts of the world, companies shared resources to conduct and process surveys, and agreements to collaborate in software developments were numerous. Staff and facilities were expanded, new aircraft were acquired and exploration equipment was improved. Although survey activity did not seem high except in South America and the African continent, the industry seems poised for a return to boom days.

In corporate news, the primary mineral exploration technologies to be offered globally by the new Fugro Airborne Surveys (FAS) group formed in 2000, are airborne electromagnetics, magnetics and radiometrics as well as ground geophysics. FAS also offers the petroleum exploration sector the airborne laser fluorosensor (ALF) for offshore basin exploration, ALTREX (electromagnetics) for mapping near-surface hydrocarbon alteration effects and airborne gravity (in association with Fugro-LCT). Operational offices are located in Ottawa and Toronto in Canada, Guildford in the UK, Santiago in Chile, Rio de Janeiro in Brazil, Johannesburg in South Africa and Perth in Australia.

Toronto-based Geosoft Inc. announced an agreement with several well known geophysical software developers to provide access to their technologies using a program called 'Geosoft Plus Partners'. With its new Pretoria office, the company now has five offices employing more than 50 people.

A new Czech company, GF Instruments, was established in Brno which will offer geophysical equipment and survey services. Toronto-based Paterson, Grant & Watson Ltd (PGW) reported a significant increase in the provision of survey management, interpretation, database development and training. During 2000, PGW expanded its capacity at its Santiago office, opened a new office in Dublin and joined with EarthScan Inc. to establish SkyMapper Ltd in Toronto which provides acquisition, processing and interpretation services in hyperspectral scanning. Ottawa-based Sander Geophysics Ltd (SGL) reported a busy year, and a fourth turbine-powered Cessna 208B was purchased.

Concord-based Scintrex Ltd has formed two new divisions - Scintrex Survey and Exploration Technology, and Scintrex Earth Science Instrumentation. This restructuring is designed to "sharpen the focus" of its earth science business unit and to facilitate the worldwide delivery of innovative solutions in support of growing oil and gas and mining activities.

Airborne Surveying

FAS flew surveys in Canada's NWT and Ontario, and in Morocco, where surveys now total over 100,00 line-km of DIGHEM EM, magnetics and radiometrics. DIGHEM surveys were also carried out in Ireland, Russia, Romania, several South American countries and in Eastern Europe.

Hyvista Corp. of Australia has been contract flying airborne imaging spectrometer surveys internationally with its HYMAP 128-channel instrument manufactured by Integrated Spectronics Pty Ltd (Baulkham Hills, NSW). Surveys in 2000 covered areas in Brazil, Germany, Spain, the UK, Finland, Greenland, the US and Australia for environmental, land use and mineral exploration purposes. A new HYMAP airborne imaging spectrometer that includes a module in the mid infrared-range is being built by Integrated Spectronics for the mineral exploration programmes of a major international mining company.

Scintrex Surveys conducted airborne surveys from its Toronto headquarters and through its Brazilian affiliate company, Megafisica Survey Aerolevantamentos, in Brazil. In collaboration with Megafisica (one of only two companies with an airborne geophysical surveying licence in Brazil), several fixed-wing aeromagnetic and radiometric surveys were conducted, mainly for government organisations. In addition, several surveys were flown using the helicopter EM IMPULSE system built by Ontario-based Aeroquest Ltd. Scintrex Surveys was also active in Canada, the US, Mexico, Chile, Paraguay and Bolivia.

Airborne Data Acquisition

Controlled Geophysics Inc. (CGI) of Thornhill, Ontario, undertook large surveys in eastern Canada and Africa by processing data from the new helicopter-borne TDEM system of THEM Geophysics (Old Chelsea, Quebec). The EMFLOW processing package developed by CRCAMET, an Australian government research group, and commercialised by Sydney-based Encom Technology Pty was acquired and adapted by CGI for this purpose. The program, which supports multiple transmitter and receiver coils, also allows for anomaly picking and for fitting of simple plate and prism models to the anomalies.

In a novel method of data acquisition, ultralights are being used for combined magnetic, radiometric and infrared geophysical surveys by the Council for Geoscience of South Africa (formerly the Geological Survey) all over southern Africa as well as in neighbouring countries such as Zambia, Namibia, Botswana and Zimbabwe. All data are recorded on Flash disk via PC104 architecture. A time-domain EM system for the ultralights is also planned.

Encom Technology released Profile Analyst in December 2000, with QuickMag scheduled for release in the March quarter of 2001. Profile Analyst enables displays and analysis of geophysical data sets in an OASIS montaj. QuickMag is the result of an Encom research project which has been funded by a A$700,000 Australian federal grant.

GEM Systems' AirNAV airborne data acquisition and navigation system now includes both real time and post processing capability with software configuration to a full 12 channel DGPS and new hi-tech touch screen display hardware.

Geosoft released the first sets of airborne data from the Ontario Government's Operation Treasure Hunt (OTH) program in Geosoft format. The OTH initiative uses state-of-the-art geophysical and geochemical technologies to expand and improve Ontario's geoscience infrastructure by uncovering new mineral exploration targets. OTH data can be viewed with Geosoft's new free Oasis montaj v5.0 interface to the Internet. PGW is participating in the new Geosoft Plus Partner program through the September release of six specialised software tools for incorporation in Geosoft's OASIS montaj. These are designed primarily for airborne geophysical processing and interpretation.

PGW was also appointed to manage the geophysical component of OTH for the Ministry of Northern Development and Mines in Ontario. This includes eight magnetic/electromagnetic surveys with six different time-domain and frequency-domain systems, plus the solicitation and preparation of proprietary airborne survey data from industry. The company also documented the newly established Reid-Mahaffy airborne geophysical test site for airborne geophysical systems, and an atlas of airborne geophysical surveys for Ontario. PGW completed magnetic compilations of China as well as aeromagnetics of Arabia, India and the Middle East in co-operative projects. The results of these studies are now available to the exploration industry.

In co-operation with Scintrex Survey & Exploration Technology, PGW completed a multi-client 65,000 line-km magnetic/

radiometric survey over a porphyry copper property in northern Chile, and the coverage is now being extended over the Escondida deposit and elsewhere (in co-operation with FAS). The company also expanded its compilation of South American aeromagnetic data by reprocessing the entire PetroBras database, which has applications for both petroleum and mineral exploration.

Aeromagnetic Surveying

FAS reports having completed its largest magnetic survey in Namibia, consisting of over 700,000 line-km. In association with LASA Engenharia e Prospecções, major off-shore surveys were carried out in Brazil, in addition to magnetic surveys in eastern Canada.

GEM Systems delivered two GSMP-20GS high resolution potassium gradiometer systems to the US Navy. In addition to sensitivity enhancement, the potassium 'supergrad' sensors have improved absolute accuracy (0.2 nT), and virtually no heading error. They are the highest sensitivity (30 fT/sqrt [Hz]) magnetic-field measuring devices ever developed. GEM would like to adapt this equipment for multi sensor aeromagnetic gradiometer surveying, and is now seeking research partners.

In 2000, Sander Geophysics flew numerous small surveys for industry clients, and a large aeromagnetic survey in the Canadian Arctic for the Geological Survey of Canada.

The Scintrex Cesium magnetometer sensor, CS-2, has high-sensitivity, high-gradient tolerance, narrow dead zone and the smallest heading error of all cesium magnetometer sensors. The company has formally started to develop the CS-3, which will include features from the CS-2 plus automatic hemisphere switching, increased input voltage (to 24-35 V), and electronic circuitry upgrades.

Vanguard Geophysics' boom-mounted helicopter magnetometer system is used for extremely high resolution mapping projects, such as unexploded ordnance. The system was upgraded from a 5 to 8 sensor array by Geosensors Inc., and a prototype time-domain electromagnetic system based on the Geonics EM61 was added to produce a Vanguard Magnetometer Array (VMA). Oak Ridge National Laboratory purchased a VMA in 2000, and the system was successfully deployed in September at the Badlands Bombing Range in South Dakota. Data were collected concurrently at 1200 Hz and 60 Hz from all sensors, with 1.75 m spacing between sensors and an average survey altitude of 2 m.

Airborne Electromagnetic

Aeroquest Ltd has improved the AeroTEM helicopter-borne time-domain system which it launched in 1999. Since its introduction it has flown over 25,000 line-km of production surveys. The concentric, symmetric transmitter-receiver configuration has many benefits, including a symmetric response that is fully independent of flight direction, and the highest possible spatial resolution. In addition, corrections are not required for receiver motion relative to transmitter, and the transmitter and receiver can be operated at lowest possible ground clearance. In 2000, PGW implemented a complete suite of processing algorithms for digital data acquired by the new AeroTEM system. IMPULSE is an Aeroquest digital helicopter-borne frequency domain electromagnetic system producing a total of six frequencies for the coils from a single high-output transmitter. This differs from conventional frequency systems which use independent coils with individual frequencies, each with different drift characteristics. The IMPULSE system is currently being flown in Canada and internationally by Scintrex Surveys.

FAS reports there has been an increase in requests for MEGATEM surveys compared with last year. The Ontario Geological Survey, as part of Operation Treasure Hunt, awarded FAS some 30,000 line-km of AEM, split roughly 60:40 between MEGATEM and GEOTEM. Time-domain AEM surveys

(GEOTEM, MEGATEM and/or TEMPEST) were flown in Argentina, Australia, Brazil (in association with LASA Engenharia e Prospecções), Canada, Chile, Denmark, Finland, India, Namibia, Sweden and Togo. B-field data is now a standard deliverable on most surveys. FAS reports that the new upgraded digital DIGHEM system employs new digital technology inside the bird that does not limit the high frequency range, and includes automatic airborne phase and calibration adjustments, reduced drift and real-time signal processing.

Montreal-based Sial Geosciences has developed the Phoenix HEM system, a new helicopter-borne electromagnetic system which was field tested in November. The towed-boom system, with a Tx-Rx separation of 8.35 m, has dipole moments of 400 NIA for the low frequencies (1 kHz), 300 NIA for the medium frequencies (4.5 kHz) and 50 NIA for the highest frequency (36 to 60 kHz). The company reported overall demand for its helicopter-borne EM surveys was moderate in 2000; highlights included large surveys in northern Spain and the Red Lake mining camp in Ontario. SIAL's fixed-wing survey fleet was increased to six aircraft last year. Through a co-operative venture with Scintrex and Megafisica in 2000, the company also participated in airborne surveys in Brazil.

Airborne Radiometric

SGL completed a large combined radiometric/magnetic/VLF survey in northern Saskatchewan for the Geological Survey of Canada. A detailed environmental survey of Atomic Energy of Canada's Whiteshell Laboratories was conducted by SGL in conjunction with Ottawa's Gamma-Bob, using both airborne and ground-based gamma-ray spectrometers. In addition to natural radiation, man-made elements, including cesium and cobalt, were mapped.

Airborne Gravity Surveys

SGL reported flying several airborne gravity surveys for major oil industry clients in North America, both onshore and offshore. The superior stability of the Airborne Inertially Referenced Gravimeter (AIRGrav) system in turbulence was a major factor in a successful drape surface survey in moderate turbulence in the Rocky Mountains. SGL reports that the resolution and accuracy of AIRGrav were significantly improved through refinements in gravity and GPS data processing in 2000.

Ground-Based Surveying

IP Vision has been released by Encom Technology for analysis of induced polarisation (IP) data. The software supports both time and frequency domain and several array configurations. Map and pseudo-section displays are dynamically linked with spreadsheet displays for decay or multi-frequency QC analysis.

The new PIMA SP field portable infrared spectrometer from Integrated Spectronics can identify alteration minerals, typically clays, amphiboles and carbonates, around mineral deposits. Measurements are made on samples, usually surface soil, rock and drillhole chips and cuttings. The instrument is currently being sold through Terraplus (Richmond Hill, Ontario).

In a July 2000 agreement with Geosoft, Interpex Ltd (Golden, Colorado), a developer of geophysical software for the mineral exploration market, will provide integrated modelling and inversion solutions for Oasis montaj. The interpretation of IP anomalies for drill targeting in mineral exploration will benefit from this software integration in the Geosoft Plus Partner program. Also seeking to integrate software into Oasis montaj is Geophysical Software Solutions (Canberra, Australia) with its new PotentQ inversion application. PotentQ performs rapid semi-automatic modelling of a single magnetic and/or gravity anomaly. The model consists of a single body chosen from one of seven possible geometries, including dyke, ellipsoid and arbitrary polygonal prism.

A prototype version of MultiLoop 3, a software tool for the EM modelling of complex thin sheet models which has been the subject of research at Lamontagne Geophysics (Kingston, Ontario) for several years, will be ready by March 2001 to be demonstrated at the PDAC event in Toronto.

Under the restructuring announced by Scintrex Ltd, ground geophysical surveys in Australasia, will be handled by Scintrex Pty from Perth.

Drillhole Methods

A new spectral gamma ray logging tool, the A-SGR1405, was released by Antares Datensysteme GmbH (Stuhr, Germany). The 1.0 m long, 52 mm diameter, tool which uses a a BGO detector, can operate to pressures of 25 MPa, a maximum temperature of 75°C, and transmits the full 256 channel gamma energy spectrum digitally via a single conductor cable. The acquired data are: total gamma rays in API units, potassium (in percent or kg/Bq), and uranium and thorium (in ppm or kg/Bq). Using the method of gamma-ray spectral analysis from neutron capture, and the GRS-2000 gamma-ray spectrometer with a BGO detector, GF Instruments can now make direct measurements of concentrations of the elements H, S, Fe, Ti, Si, Mn, Cl and Hg in boreholes.

Several new developments were announced by IFG Corp. (Brampton, Ontario) in 2000. These include a new borehole winch designed for portable applications, a new inductive conductivity probe developed for ore grade measurements in base metal mining, the completion of its 'Rate Gyro' orientation probe, and the revision of the editing and processing software PC-LOG to operate in MS-Windows. The new BW-100M winch has a cable capacity of 150 m and includes the digital data interface console (BIN-07) which supplies power to the probe and records data in its non-volatile memory. The very sensitive BIC-01 conductivity probe is primarily tuned for conductivity and de-tuned to any magnetic interference. The BGO-01 gyro probe has a dual axis gyro sensor, combined with a 2 axis tiltmeter. The operating range is from 5-80° from vertical. The company is also developing a version of gyro orientation probe (BGO-02) that will have no directional limitations.

The new Windows-based MSLog data acquisition software from Mount Sopris Instrument Co. (Golden, Colorado) allows customers to use the spectral gamma and borehole gyro tools from IFG Corp. (Canada) and the acoustic and optical borehole televiewer tools from ALT srl (Luxembourg). In 2000, the company also began shipping its new monopole-dipole, multi-frequency full waveform sonic tool.

Quantec Logging Services Inc., a division of Quantec Geoscience Ltd (Porcupine, Ontario), has added full wave form sonic logging capabilities to its multi-parameter logging truck.

Reflexit AB (Vallentuna, Sweden) introduced its 'SmartTools' for borehole surveying. The 32 mm diameter tools measure seven parameters simultaneously; including azimuth, inclination, total magnetic field, magnetic dip and temperature. The sealed tool has a ten-year battery life, can store 1,000 measurements and communicates via a radio data link to download stored measurements.

Contract logging service capabilities within Canada were expanded by Robertson Geologging Ltd (RG) of Deganwy, UK, during 2000, and RG can now undertake short or long-term logging surveys. The company introduced the Micrologger-2 borehole logging unit which can be used directly with CCTV cameras from RG and third-party manufacturers, for borehole video surveys. The latest digital version of the optical televiewer operates on standard four-conductor cable to a depth of 2,000 m while improvements to the standard analogue optical televiewer have increased the

maximum logging speed to 2.5 m/min at the full resolution of 720 samples per revolution. A new high-resolution digital acoustic televiewer now offers 300 sample per revolution acquisition in borehole sizes between 45 and 300 mm.

Electromagnetic Work

Dualem Inc. (Milton, Ontario) announced the new Dualem-2 EM instrument with a z-axis transmitter, and dual z-axis and x-axis receivers. The 2 m long Dualem-2 was used for near-surface EM measurements in base metal exploration in 2000.

Several new developments were announced in 2000 by Geonics Ltd (Mississauga, Ontario), including the EM31-SH, 2 m, coil separation version of the EM31 ground-conductivity meter, the new version EM61-MK2 with multiple time gates for improved target characterisation and increased sensitivity to smaller targets, the new EM38-DD, 1 m coil separation ground conductivity meter which allows simultaneous measurement of ground conductivity in the vertical and the horizontal dipole, and the EM38B for simultaneous measurement of ground conductivity and susceptibility.

IRIS Instruments (Orleans, France) developed the two-frequency PROMIS-4 EM system, which can be operated in the vertical and horizontal coplanar loop modes so as to optimise the inductive EM coupling to the target geometry. Also new is the ten-frequency PROMIS-10, which allows simultaneous acquisition of data with a three-component receiver in the maximum and minimum coupling configurations.

A new three-component surface sensor for the UTEM 4 system has been developed by Lamontagne Geophysics. The digital sensor output is routed to the receiver by a short fibre optic cable to achieve complete electrical isolation. The UTEM 4 surface sensor is specifically designed for low frequency measurements where the main technical difficulty is the resolution and linear measurement of very small signals.

Zonge Engineering (Tucson, Arizona) introduced the GDP-32II multi-channel receiver for collection of controlled and natural source geoelectrical and EM data. Capabilities include remote control operation of the system as well as broadband time-series recording of TEM transients and CSAMT and IP waveforms. The NanoTEM early-time Transient Electromagnetic System has continued to evolve with the addition of the NT-32, which integrates the transmitter into the GDP-32II receiver and reduces the number of cables and external instrument packages.

Gravity Surveying

An efficient and economical procedure for reconnaissance gravity surveys has been developed by Allan Spector and Associates (Toronto) which employs a dual digital barometric altimeter system consisting of base station monitor unit and a ‘rover’ unit. Elevation accuracy better than one metre can be achieved at half the cost of using alternative procedures. The procedure uses a Sodin thermostatic gravimeter for gravity measurements and all data reduction, compilation and analysis operations can be completed entirely on-site. It has been extensively applied in Canada, the US and Mexico.

Scintrex’s SeaGrav meters and up to three boats were deployed in the ocean bottom surveying of 3,000 sea-floor points in the western Gulf of Mexico for Pemex, in 2000. The now completed 7,400 point land and ocean bottom gravity survey started by Scintrex Surveys late in 1999 is one of the largest combined surveys of its kind. Most of the surveying in 2000 was done on the ocean bottom at water depths of up to 200 m.

Induced Polarisation

Zonge Engineering announced the ZETA IP System, which allows connection of both transmitter and receiver subsystems of up to

30 electrodes simultaneously and rapid collection of IP data using short dipoles (10 m or less).

Magnetic

To handle more multi-tasking required from its advanced signal processing and GPS algorithms, GEM Systems has added Motorola Cold Fire RISC processors and up to 32 Mb of optional memory to its high resolution GSMP-30 potassium magnetometer/gradiometer system and the new GSM-19 v6.0 Overhauser data acquisition / display console. The GSMP-30 has true 1pT sensitivity at a sampling rate of up to 10 Hz without data smoothing. Systems can be configured as single sensor magnetometers, or multiple sensor gradiometers and can display real-time navigation, conversion to UTM coordinates, grid rotation and lane guidance with DGPS corrections.

Radar

The new Model CU-II radar control unit from Sweden's MALÅ GeoScience AB can easily expand from single channel to multiple-channel operation. Multiple-channel (MC) antenna modules are added as required for up to 4 antenna sets and up to 16 channels of radar data. Multiple-channel data acquisition is a cost-effective way of acquiring large GPR data sets with more precise antenna positioning for 3D imaging of subsurface conditions. 2D and 3D images can be presented within minutes of acquiring GPR data using the new Easy 3D software for Windows 95/98/NT.

Radiometric

A new 256-channel handheld gamma-ray spectrometer was announced by GF Instruments. The integrated weatherproof GRM-260 unit which has a 2"x2" NaI(Tl) detector can also be operated from a user's PC for measurement of K, U, Th concentrations and dose rate values with enhanced capabilities. The backlit graphic screen displays the measured spectrum and concentration values. The company also announced the GRS-2000 gamma-ray spectrometer can now be equipped with 2"x2" or 3"x3", NaI(Tl) or BGO detectors.

Resistivity

The Campus Tigre, the latest resistivity development from Campus International Products Ltd (Dunstable, UK) is now expandable to 128 electrodes, using a Windows operating platform. A complete system consists of the Campus Tigre, Imager cables (1, 2 and 5m spacing), electrodes and a portable computer.

The ARS-200 from GF Instruments is a new DC geoelectrical system for multi-electrode measurements (2D imaging). The ARS-200 main system unit is equipped with a transmitter (up to 200 W output), a sensitive receiver (with 24-bit A-to-D converter) and is powered from a rechargeable battery pack.

Seismic

Geometrics (San Jose, California) is now shipping the Geode, a distributed, modular seismic system. Each rugged Geode module consists of 3-24 channels, is submersible, weighs only 3 kg and can be controlled by the new StrataVisor NZ seismograph, which holds up to 128 internal channels.

Toronto-based Vibrometric Canada Ltd is the Canadian representative of Finland's Vibrometric Oy. Vibrometric has developed a new family of Swept Impact Seismic sources for surface and borehole applications. The VIBSIST 20, 50 and 500 are built around standard mechanical equipment and can deliver from 20 J per impact to over 500 J/impact. Estimated investigation ranges are from 100 to 1,500 m respectively. The SPH 44, 54 and 74 borehole piezoelectric sources are designed for investigation ranges from tens to hundreds of metres at depths down to 1,000 m (in minimum borehole diameters of from 46 mm to 76 mm). The sources are either clamped or water coupled.