HELICOPTER-BORNE GEOPHYSICAL SURVEY SYSTEMS

APPLICATIONS:

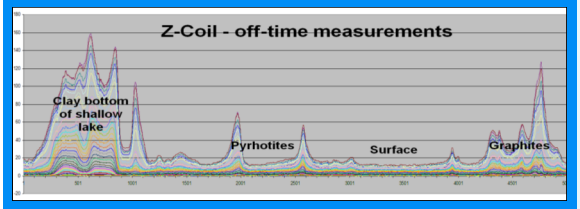
- base & precious metals exploration
- diamondiferous kimberlite exploration
- geological mapping
- mapping of fault zones for engineering and mining applications
- sand and gravel mapping
- geothermal mapping
- mapping of fresh water/salt water interfaces
- permafrost mapping
- sea ice thickness mapping

McPHAR INTERNATIONAL

EQUATOR TDEM SYSTEM
HUMMINGBIRD FEM SYSTEM
HELIMAG/GRAD SYSTEMS
RADIOMETRIC SYSTEMS
QC, DATA PROCESSING AND INTERPRETATION

THEM Time- & Frequency-Domain EM System

Due to the transmitter's unique and very helicopter-friendly design and fast data sampling rates, THEM can be operated at air speeds of from 20 to 120 km/hour. On projects over reasonably flat terrain and with long lines, survey speeds of 120 km/hour can be easily achieved, with no detriment to data quality or resolution. The small weight and good aerodynamics of the system permits surveys to be conducted with record-breaking productivity rates: typically 70-80 line kilometers per flight hour or more.



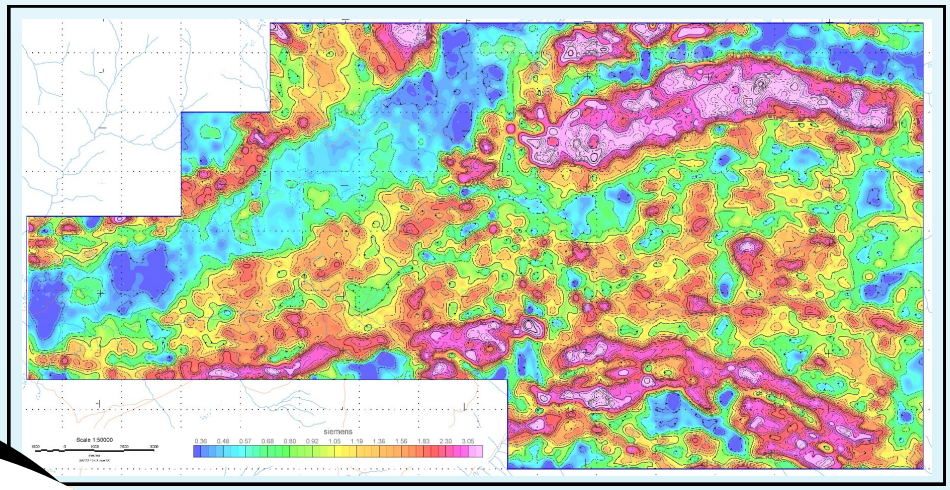
THEM consists of:

- **ON-TIME and OFF-TIME measurements**
- **4-turns transmitter loop, 8.5 metres diameter / 57 m^2 area**
- **Half-sine waveform at 25 Hz or 30 Hz base frequency**
- **Dipole Moment of minimum 250,000 NIA**
- **Unlimited customized time-channels**
- **Towed, asymmetric 3-axis X, Y, Z receiver**
- **Depth of penetration 300 to 400 metres**
- **3 axis (XYZ) dB/dt receiver at half-tether on tow cable**
- **Magnetometer mounted on XYZ receiver mast**
- **Data Acquisition / Control Console and Gamma-ray Spectrometer in helicopter cabin**
- **Survey height of the transmitter is 30 meters above ground.**

The THEM transmitter airfoil, total towed weight less than 300 kg

Applications:

- **base & precious metals exploration**
- **kimberlite exploration**
- **groundwater exploration**
- **regional mapping**
- **geothermal mapping**
- **contamination mapping**
- **permafrost mapping**



Apparent Conductance for selected time window No. 15 of vertical coplanar

Apparent Conductance for Selected Time Window No.15 of Vertical Coplanar Coil Bz

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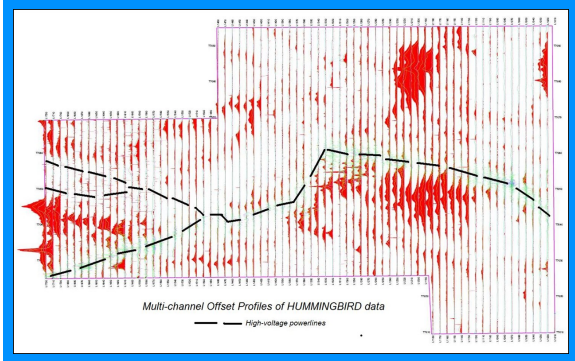
HUMMINGBIRD 5-Frequency Electromagnetic System

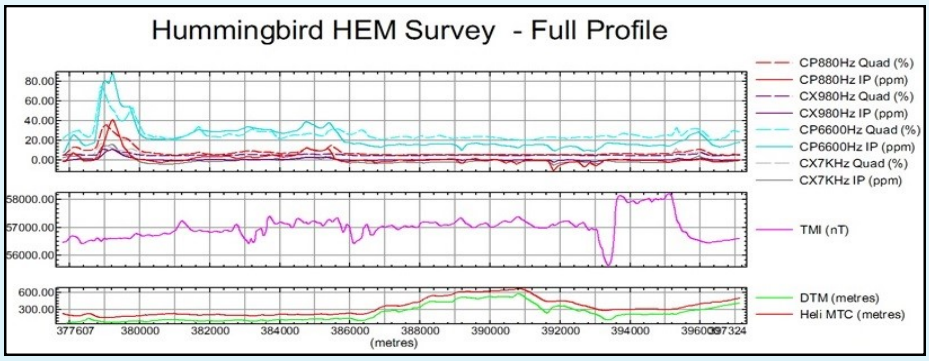
HUMMINGBIRD survey in Greenland



Multi-channel offset profiles of HUMMINGBIRD data

- **Multi-frequency, multi-coil electromagnetic system**
- **Measures the inphase and quadrature responses from five (5) coil-pairs installed in a tubular airfoil (bird), towed beneath a helicopter**
- **5-frequency sensor, 880 Hz, 980 Hz, 6.6 kHz, 7 kHz & 34 kHz frequencies**
- **Real-time GPS receiver updating at 10 Hz to provide positioning information and navigation**
- **Radar altimeter operating at 10 Hz**
- **High-sensitivity cesium vapour magnetometer - sensitivity of 0.6 pT/√Hz, sampling & recording at 10 Hz**

HUMMINGBIRD 5-frequency sensor, 7.5 meters long in 3-sections, 30 metres long tow-cable



HUMMINGBIRD HEM survey data profile from a single flight line; top trace is of the 880 Hz, 980 Hz, 6.6 kHz and 7 kHz frequencies. Middle trace is of the Total Magnetic Intensity, Lower trace is of the radar altimeter data and DTM for the line.

The depth in the earth to which a single frequency can penetrate is a function of the frequency and the conductivity of the earth [Skin Depth » 503 / (frequency x conductivity)$^{1/2}$]. Lower frequencies penetrate deeper into the earth than higher frequencies. The higher frequencies are more sensitive to weakly conductive geology, and to subtle changes in the conductivity of the ground.

HUMMINGBIRD EM system measures the in-phase "I" and quadrature "Q" components of the total EM field. The amplitude of these components are always given as a value that is relative to the transmitted primary. The ratio of in-phase to quadrature (I/Q) depends mostly on the conductivity of the geology and the operating frequency; the amplitude depends mostly on the depth of the conductor below the sensor.

HELIMAG/ HELIGRAD SYSTEMS

McPhar can provide a HELIMAG system with a single cesium vapour magnetometer measuring the total magnetic intensity or a HELIGRAD system, with two cesum vapour magnetometers measuring the horizontal gradient of the magnetic field as well as the total magnetic intensity. These magnetic systems can be installed on a variety of helicopter models, usually obtained from a local operator for cost effectiveness.

Scintrex CS-3 cesium vapour magnetometer, sensitivity of 0.001 nT sampling at 10 or 20 Hz.

Ancillary instruments also provided include a radar altimeter, dual-frequency real-time differentially corrected GPS navigation systems and a PC-based data acquisition system.

Magnetic compensation is accomplished either in real-time, or it may be effected post-flight using proprietary software installed on the field workstation.

HELIMAG system, featuring one cesum vapour magnetometer measuring the total magnetic intensity, installed on a Bell 206L3 Long Ranger Helicopter

HELIMAG system, featuring one cesum vapour magnetometer measuring the

HELIGRAD system, featuring two cesum vapour magnetometers measuring the horizontal gradient of the magnetic field as well as the total magnetic intensity, installed on a Eurocopter AS350B2 Helicopter

RADIOMETRIC SYSTEMS

Any of the airborne systems featured on earlier pages can be optionally equipped with a multichannel gammaray spectrometer system, as shown to the right.

McPhar uses two models of spectrometer, Pico Envirotec's AGRS system, and the RS-500 system from Radiation Solutions.

Although a standard helicopter-borne system uses a system with 16.8 litres of NaI(TI) detector downward-looking and 4.2 litres of detector upward-looking, larger volume systems are available.

WHY USE GAMMARAY SPECTROMETRY?

Airborne gamma-ray spectrometry provides a physical measurement which contributes to geochemical mapping of the top 30 cm of the earth's surface. The technique provides bedrock and overburden mapping assistance by fingerprinting the radioactive element signatures inherent in all rocks and soils. Where the normal signatures are disrupted by mineralizing processes, anomalies provide direct exploration vectors.

Pico Envirotec's AGRS airborne gammaray spectrometer system. This system includes 16.8 litres of NaI(TI) detector downward-looking and 4.2 litres of detector upward-looking. Also shown s the equipment rack, which contains an IMPAC data acquisition system and GPS receiver.

Radiation Solutions RS-500 Gammaray Spectrometer Sensor with 16.8 litres of NaI(TI) detector downward-looking

Quality Control, Data Processing & Interpretation

Quality Control

It is McPhar's practice to ensure that good quality data is collected and processed at each stage of the project. An on-site qualified technician will ensure the following:

- Set-up of the equipment and helicopter
- Pre-survey tests and calibrations
- Collection of the data in-flight
- Evaluation of data quality as they are collected each day (QA/QC)

In addition, all data is monitored from our office in South Africa via FTP file transfer.

McPhar's hangar and offices in Mossel Bay, South Africa

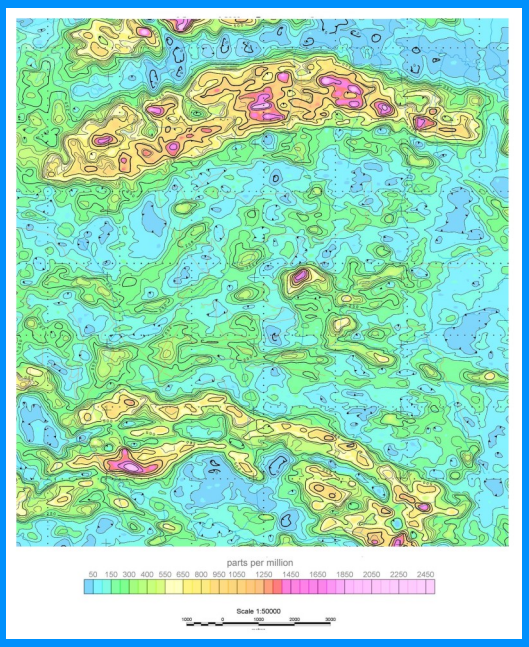
Data Processing & Interpretation

Final Data Processing and Data Interpretation is undertaken at our data processing center in South Africa using Geosoft's Oasis Montaj and INTREPID software packages with additional Geosoft partner and custom modules.

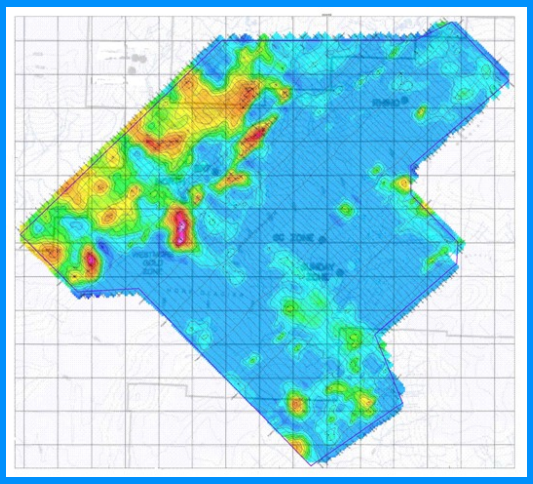
The processing and interpretation of airborne geophysical results into meaningful geological parameters is the prime function of any of our geo-scientists. The manipulation of geophysical data is only a means to an end, and the final products of the processing and interpretation are a series of maps showing interpreted geological parameters.

We bring many techniques to bear on an interpretation project in order to determine depths to causative sources, to delineate discontinuities and boundaries, and to draw conclusions regarding geological structure beneath the survey.

A wide variety of contour and interpretation maps, profiles, cross-sections and models, and a written report are the result of the interpretation.



EM anomaly image of time domain EM data dB/dt Z-channel—window 15.



HUMMINGBIRD Apparent Resistivity contours image of 6.6 kHz Coplanar Frequency data

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