Airborne Surveying for

Mining Exploration

MAGNETICS

GRADIOMETRY

GRAVITY

RADIOMETRICS

ELECTROMAGNETICS

LIDAR

HYPERSPECTRAL

- **base & precious metals exploration**
- **uranium exploration**
- **kimberlite exploration**
- **coal exploration**
- **groundwater exploration**
- **regional mapping**

McPHAR INTERNATIONAL

SOUTHERN EXPLORATION SURVEYS

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INTRODUCTION

The search for and mapping of subsurface natural resources can be a tedious, costly and time-consuming project when conducted on the ground. Traverses must be made across mountains, rivers and swamps and through towns and cultivated areas. In some cases, danger to personnel is involved from disease, animals, insects and extremes in climate and terrain. As equivalent measurements may now be made from the air, however, undertaking exploration using airborne techniques will result in great benefits of time and money and safety of personnel.

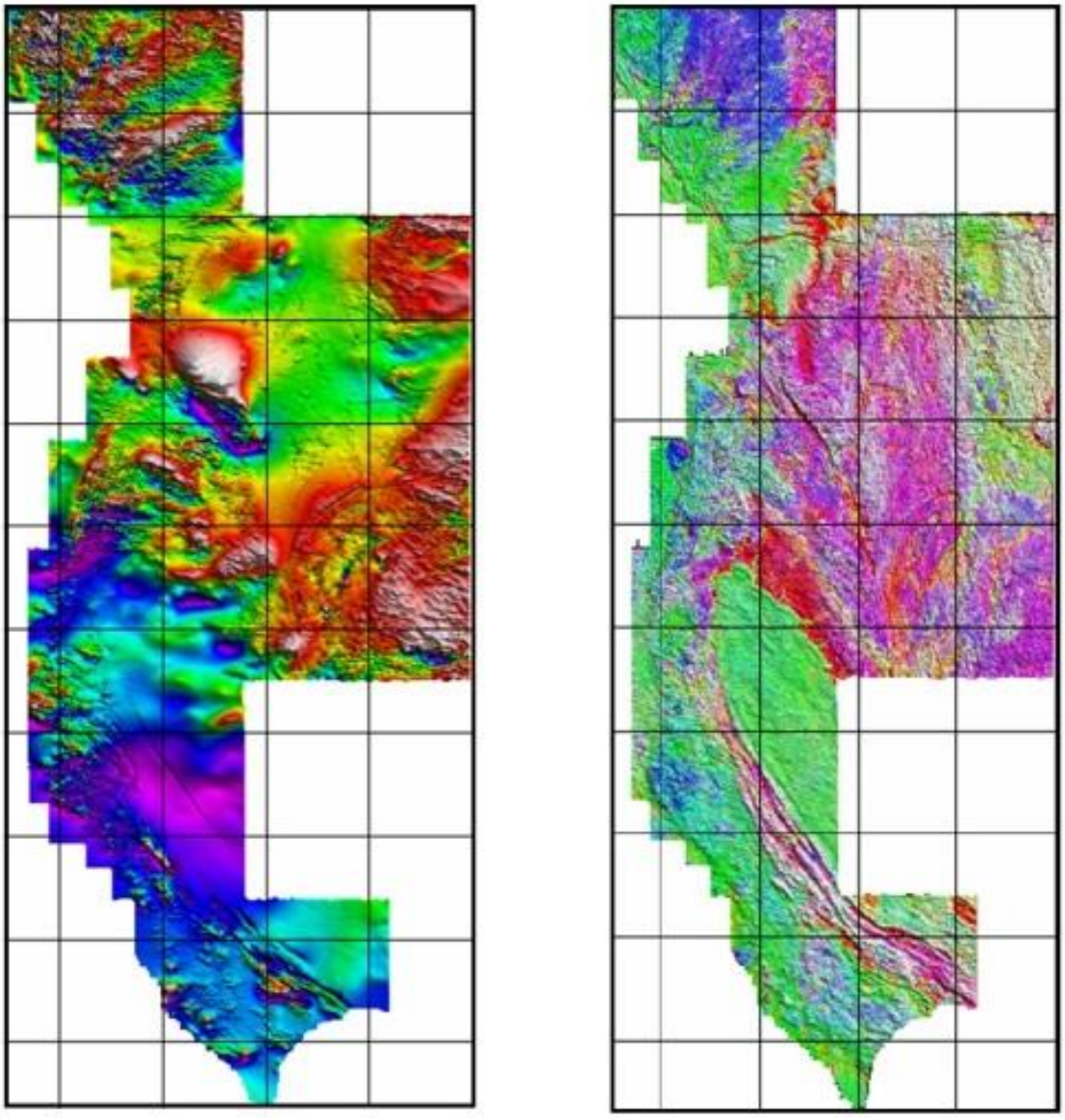
Airborne geophysical surveys, whether installed on helicopters or fixed-wing aircraft, are the most effective and rapid means of evaluating the potential for mineral resources in both unexplored areas and mature mining regions.

The use of GPS satellite navigation and powerful computers onboard the aircraft, to control the systems and to record data; and on the ground to process, plot, interpret and model the data; has made airborne geophysical surveying a powerful and necessary tool in man's search for materials beneath the ground. Fixed-wing and helicopter-borne airborne geophysical systems are designed for use **in** different terrains, although helicopter-borne systems are undertaking high-resolution surveys in areas traditionally the domain of fixed-wing systems.

A fixed-wing aircraft has a number of advantages in addition to its lower operating costs. First, it has a payload and cabin space larger than a helicopter and thus can carry more instrumentation. Second its operating range is generally three or four times greater than that of a helicopter.

Surveys can be flown farther from population centres, thereby reducing some of the logistical problems of a helicopter-borne survey

Without a doubt, helicopter-borne electromagnetics (EM), combined with total field magnetics and gammaray spectrometry, have been the most productive and useful of these airborne system developments to date, and have accounted for the discovery of billions of dollars-worth of mineral resources, tapped into numerous ground water reservoirs and provided immense volumes of data for environmental site evaluations. These systems are ideally suited for working in rugged, mountainous terrain, or over small claim block-sized properties, and are the techniques of choice for most mining companies to locate base metal and precious metal deposits and/or kimberlites



Total magnetic intensity map (left) and radiometric ternary map (right) from an airborne magnetic and gamma-ray survey conducted recently in West Africa. A total of 185,000 line-kilometers of data were acquired, processed and mapped on this project.

HELICOPTER-BORNE GEOPHYSICAL SURVEYS

Our helicopter-borne geophysical systems include:

HELIMAG magnetometer & GPS navigation only – towed bird or rigid-boom

HELIGRAD magnetic gradiometer with 2 or 3 magnetometer sensors & GPS navigation – horizontal or vertical gradients, towed-bird or rigid-boom.

HELIMAG&SPEC with magnetic & gammaray spectrometer sensors & GPS navigation.

HELIGRAV with dynamic gravity sensor and magnetometer & GPS navigation.

HUMMINGBIRD a multi-sensor system with 5-frequency EM, magnetometer & gamma-ray spectrometer sensors & GPS navigation

THEM a multi-sensor system with time domain EM, magnetic & gammaray spectrometer sensors & GPS navigation

HELIMAG&SPEC *"stinger" system installed on an AS350B2 helicopter. The gammaray spectrometer system is installed in the helicopter cabin*

HELIGRAV *with GT-2A airborne gravity sensor and magnetometer & GPS navigation.*

HELIMAG *towed-bird magnetometer system installed on a Robinson R44 Raven helicopter.*

HUMMINGBIRD *multi-sensor system with 5-frequency EM, magnetometer & gamma-ray spectrometer sensors instald on a AS315B LAMA helicopter.*

HELIGRAD *magnetic gradiometer with 2 magnetometer sensors and gammaray spectrometer installed on an AS350B2 helicopter.*

THEM *multi-sensor system with time domain EM, magnetic & gammaray spectrometer sensors typically installed on an AS350B2 or B3 helicopter*

FIXED-WING GEOPHYSICAL SURVEYS

Several fixed-wing geophysical aircraft are available to fly your surveys. These aircraft include the Piper PA-31 Navajo, Cessna C208 Caravan, Beech C90 King Air and Cessna C206 and C210 aircraft.

The geophysical systems fitted to these aircraft include:

AIRMAG magnetometer & GPS navigation only – towed bird or rigid-boom

AIRGRAD magnetic gradiometer with 2 or 3 magnetometer sensors & GPS navigation – horizontal or vertical gradients, towed-bird or rigid-boom.

AIRMAG&SPEC with magnetic & gammaray spectro-meter sensors & GPS navigation.

AIRGRAV with dynamic gravity sensor and magnetometer & GPS navigation.

Piper PA-31 Navajo *- a twin-engine aircraft, modified with an extended tail-stinger and wing-tip pods for magnetometer sensors. The Navajo has extended fuel tanks providing up to 7 hours duration. Used to acquire AIRMAG, AIRGRAD, AIRMAG&SPEC and AIRGRAV data.*

Beech C90 King Air *- a twin-engine turboprop aircraft with 5 plus hours duration,modified with an extended tail-stinger for a magnetometer sensor. The King Air is used to acquire AIRMAG, AIRMAG&SPEC and AIRGRAV data.*

Cessna C208 Caravan *- a single engine turboprop aircraft, features wing-tip pods, an extended tail-stinger and 6 hours duration. The Caravan is used to acquire AIRMAG, AIRGRAD, AIRMAG&SPEC and AIRGRAV data.*

Cessna C210 *(Top) and* ***Cessna C206*** *(Bottom) – single piston-engine aircraft featuring wing-tip pods for the magnetometer sensors. These aircraft are used to acquire AIRMAG, AIRGRAD, AIRMAG&SPEC and AIRGRAV data.*

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AIRMAG&SPEC *system installed in the cabin of a Piper PA-31 Navajo Aircraft, The AGRS system shown here has 33.6 litres of NAI(TI) sensor downward-looking and 8.4 litres of sensor upward-looking.*

Q.C., DATA PROCESSING & INTERPRETATION

Quality Control

McPhar undertakes Q.C. and preliminary data processing in the field at the survey base. For this purpose all our airborne systems are mobilized with a geophysicist and a PC-based data processing system to support them. The Field Data Verification Workstation (FWS), as this system is known, can process airborne EM, magnetic and radiometric data, and produce plots and maps in full-colour of the survey data, often within hours of the survey flight ending.

FWS work station in use in a field camp

The FWS software, which is the core of this system, permits the Q.C. geophysicist to differentially correct the GPS navigation data; carry out flight path recovery; perform magnetic compensation and leveling; undertake radiometric corrections and preliminary processing; EM leveling and processing; and generally to perform filtering, gridding and contouring of data, imaging of selected data and plotting to any map scale and layout.

Data Processing and Interpretation

Final data processing and interpretation is undertaken at our processing centre in Mossel Bay, South Africa, which is staffed by very experienced geoscientists and equipped with a state-of-the-art network of computers, scanners, plotters and other hardware. Software we use includes Geosoft montaj and INTREPID data processing software, as well as many in-house developed programs and routines.

McPhar's data processing centre

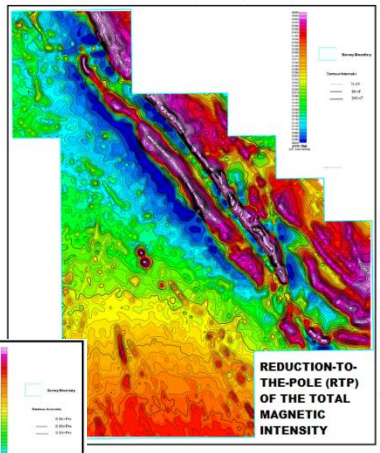
The interpretation of geophysical results into meaningful geological parameters is the prime function of any of our interpreters. The many highly qualified geophysicists and technicians on our staff share a strong geological background. The manipulation of geophysical data is only a means to an end, and the final product of the interpretation is the compilation of a series of maps showing interpreted geological parameters.

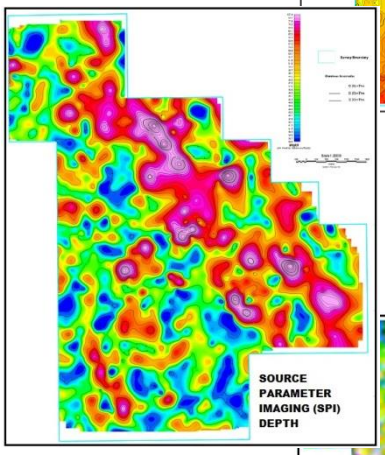
The data processing routines and mathematical operators applied to the data are not the end product of the interpretation; they help delineate geologic and economic targets to be discussed in the final report.

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 typically the result of the interpretation. Some examples of an interpretation from a small multi-sensor survey are shown below.

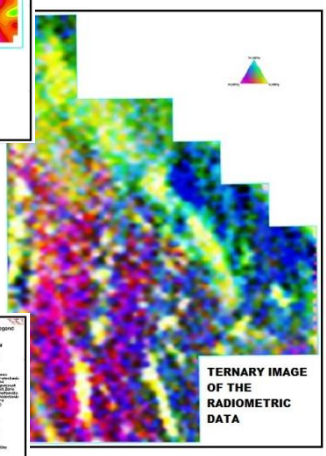
Colour image of the Reduction-to-the-Pole (RTP) of the Total Magnetic Intensity





Colour image of the Source Parameter Imaging (SPI) Depth

Colour Ternary Image of the Radiometric data



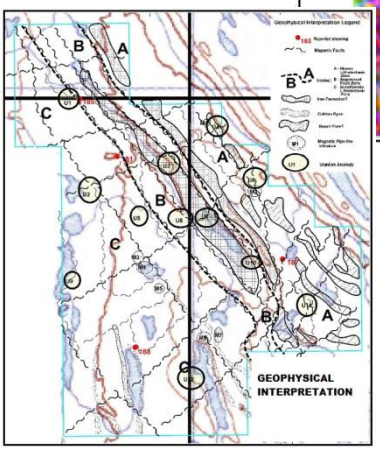


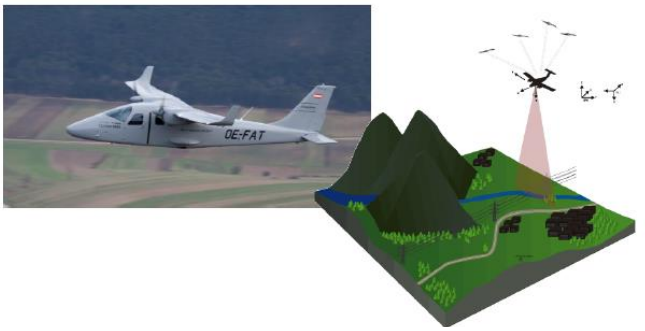
Image of the geophysical interpretation overlay

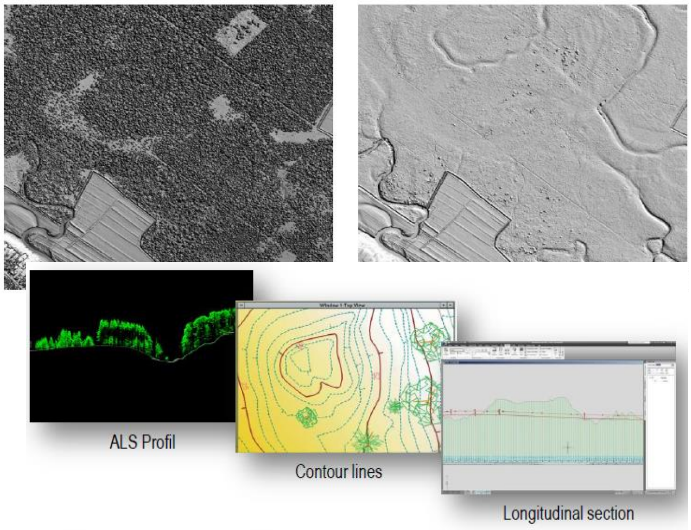
AIRBORNE REMOTE SENSING

McPhar can offer a wide range of remote sensing from aerial platforms using a wide range of equipment, including Laser Scanners, Hyperspectral Imagers, Synthetic Aperture Radar (SAR) and Thermal-Cameras, covering a wide range of applications. Through our multidisciplinary team of highly qualified engineers and their network of scientific partners, we are able to develop tailored solutions for each customer's needs. A specialty is a multi-sensor application with up to 6 sensors operating simultaneously in one flight.

SES / McPhar can provide large quantities of geodata to the market due to our manpower, technical equipment and a very modern production center. The knowledge of our personnel, the availability of different sensors, and our combined expertise in data processing allows us to offer solutions for a variety of application including:

- Planning Work & Construction Processes
- Precision Farming & Agriculture Management
- Environmental & Infrastructure Monitoring
- Mineral Exploration
- Oil & Gas Exploration
- Forest Management
- Archaeology
- Hydrography





ABOUT McPHAR

McPhar has been involved with airborne geophysical surveys for many years, providing high-technology airborne surveys around the world for both the Oil & Gas and the Mining & Engineering Industries. McPhar has evolved into its present position of providing the most modern, cutting-edge, space-age technology for the exploration of petroleum and minerals, based on techniques that permits the detection of geological anomalies by the use of modern airborne geophysical techniques, including gravimetry, magnetometry, gammaray spectrometry, and electro-magnetics. The data acquired from such surveys flown by fixed-wing and/or rotary-wing platforms are processed, mapped, imaged and interpreted at our data processing centre in South Africa.

In recent years, McPhar has undertaken more than 4 million line-km of airborne geophysical surveys worldwide. The airborne surveys were undertaken using both fixed-wing and rotary-wing aircraft, and were for a variety of clients, including mining companies, oil/gas companies and government agencies. A complete and detailed interpretation of the acquired data was often included in these projects.

Countries where we have worked in recent years include; Angola, Argentina, Belize, Bolivia, Botswana, Canada, Chile, Colombia, Czech Republic, D.R.C., Ecuador, Eritrea, Gabon, Ghana, Guyana, Greenland, India, Kazakhstan, Kenya, Kyrgyzstan, Lao PDR, Libya, Madagascar, Mexico, Namibia, Nicaragua, Norway, Oman, Peru, Romania, Solomon Islands, South Africa, Sudan, USA, Venezuela, Zambia, Zimbabwe.

McPhar has its headquarters in Singapore, and offices in Mumbai and Hyderabad in India, Toronto in Canada and Mossel Bay in the Western Cape, South Africa.

SES / McPhar's hangar and offices at Mossel Bay, South Africa

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