Integrated airborne geophysics and remote sensing

With the development and refinement of increasing numbers of airborne geophysical and remote sensing techniques, mounting multiple complementary sensors on one aircraft has become possible. This enables the collection of multiple data sets during a single flight. These data sets can be jointly interpreted to give a much better picture of the survey target than any of these techniques alone, at a much reduced cost compared with flying separate surveys using dedicated, single-sensor aircraft.

Aeromagnetic surveying

Some materials become magnetised when in the presence of the Earth's magnetic field and develop an induced magnetic field, while others posses their own intrinsic magnetic fields. The interaction of such fields with the Earth's primary field gives rise to the observed field at the Earth's surface and above. Aeromagnetic surveying is the process mapping that field using magnetometers attached to or suspended from aircraft.

Figure 1: Aeroquest Ltd's helicopter-mounted 'stinger' magnetometer.

Aeromagnetic surveying has several applications, including as a reconnaissance tool before 3D seismic surveys to estimate depths to basement, to inform geological maps and to map mineral deposits. Magnetic fields are measured using magnetometers. In magnetometry, a single sensor is normally used to measure the intensity of the Earth's magnetic field (in units of nano-Tesla; nT). In gradiometry, two sensors mounted either vertically above or horizontally adjacent to each other are used to derive the vertical or horizontal magnetic gradient (in units of nano-Tesla per metre; nT/m). The advantage of gradiometers is that temporal variations in the magnetic field are essentially cancelled out by subtracting the signal from one magnetometer from the signal of the other. Magnetic data may be used not only to map anomalies, but, when processed, can also be used to infer the depth at which the causative bodies lie.

Airborne electromagnetic (AEM) surveying

AEM surveying is used to find electrically conductive bodies in the ground. An electrical current is passed through a wire coil, which is mounted on or suspended from an aircraft. This current generates an electromagnetic field. This field causes secondary electrical currents to be generated within conductive bodies that lie within its influence. These secondary currents in turn generate a secondary electromagnetic field, which is detected using a secondary wire coil. The strength of this secondary field and the time taken for it to develop is diagnostic of the conductive material.

AEM is used primarily for mapping mineral deposits, which tend to be more conductive than their surroundings. There are two types of electromagnetic techniques; time domain/pulse-transient EM (TDEM/TEM) and frequency domain EM (FDEM/FEM). Both types can be operated from aircraft. TEM systems can generally probe more deeply but have poorer vertical resolution than equivalent FEM systems.

Figure 2: Aeroquest Ltd's helicopter-borne TEM System, AeroTEM.

Radiometrics/Gamma-ray spectometry

Some rocks naturally emit gamma radiation, depending on the amount of the elements Potassium, Thorium and Uranium that they contain. Using sensitive radiometers, the energy and amount of gamma ray radiation can be detected from the air. The radiation characteristics are diagnostic of the amount and proportion of the three radioactive elements in rocks within 10 cm of the Earth's surface. Because of this, airborne radiometric data can only be used to interpret the underlying geology if the rock is exposed, or the weathered layer/soil preserves the mineral characteristics of the rock underlying it.

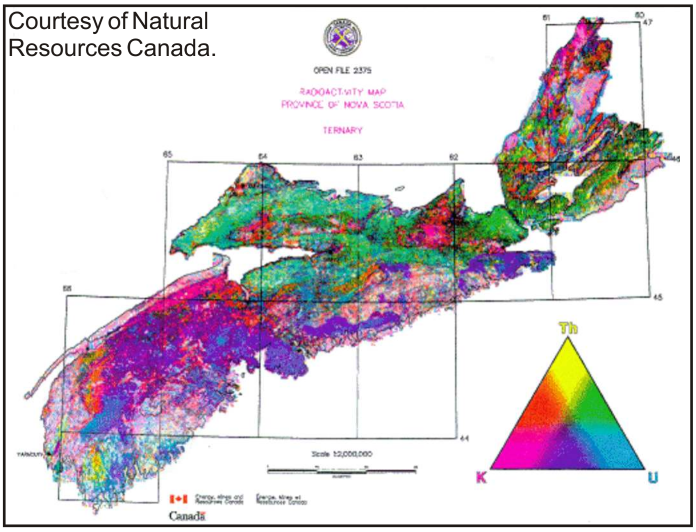

Figure 3: Radiometric ternary plot.

Radiometry data are plotted as ternary maps in which three colours represent the three isotopes, intermediate colours represent areas where more than one element is present, black represents regions where no radiation is detected, and white represents areas where all three are abundant.

Photogrammetry

Photogrammetry is a technique based on aerial photography. A single camera, or multiple cameras at angles to each other, are mounted on an aircraft. Processing of the photographs allows accurate mapping of land uses and definition of building footprints, for example.

Light Detection and Ranging (LIDAR)

LIDAR involves firing a laser from an aircraft and measuring how long the laser pulse takes to be reflected back to the aircraft. That time depends on the distance of the reflecting object from the aircraft. LIDAR is used to map topographic heights, including building heights. Processing algorithms have been developed that allow vegetation cover to be 'stripped' off the true ground surface, making LIDAR a powerful tool for such applications as mapping flood-plains and landslides.

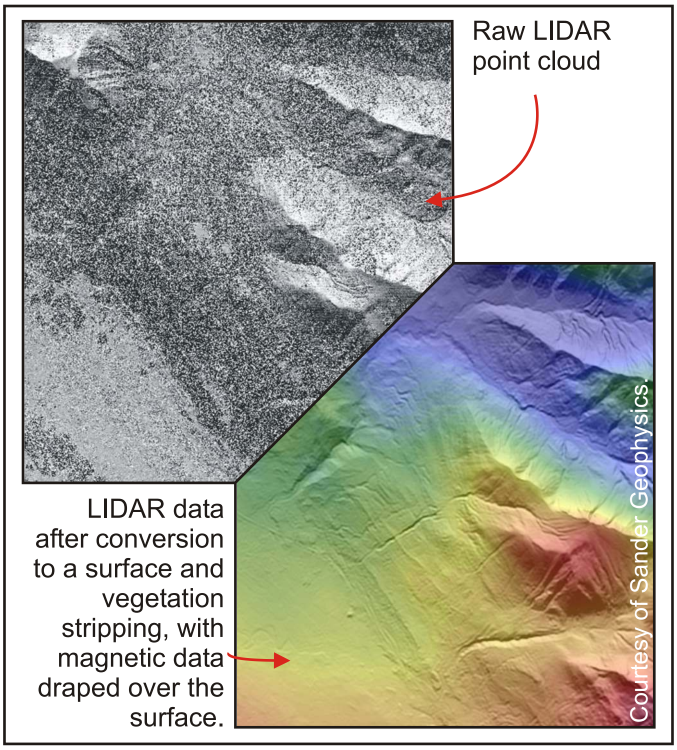

Figure 4: LIDAR and magnetic data.

Integrated interpretation

Different combinations of sensors are suitable depending on the survey target. For mineral exploration, a combination of EM, magnetometry and radiometry instruments is useful. Using three sensors that give different and complementary information about the mineral assemblages means that different mineral zones can be distinguished. Figure 4 shows an example of combined LIDAR and magnetometry data. Geospatially rectified datasets can be integrated into a Geographical Information System (e.g. ArcGIS) and correlated with each other to aid visualisation and achieve more robust 2D and 3D interpretations. Datasets can include geophysical contour maps, satellite images, Digital Elevation/Terrain Models, LIDAR images, geological maps, borehole logs, *etc.*

