Chapter 8
Airborne Geophysical Methods

8-1. Scope of Airborne Investigations

Airborne geophysical procedures have had an important impact on the mineral recovery industry. Several advancements in geophysical equipment, types of airborne platforms and global positioning systems (GPS) have provided application to particular engineering and environmental problems. In general, airborne platforms will not often be sufficiently detailed and economic for these latter two topic areas. Airborne methods may be quite reasonable for some specific projects of large area with targets of ample anomaly strength.

a. Scale. Scale is an important consideration for airborne procedures to be cost-effective. Sizeable costs are associated with the platform to fly the geophysical equipment. Towing a geophysical "bird," flight path surveying, and more sophisticated equipment are usually necessary for airborne measurements. For small area sites, where surficial geophysics may be applied, the great cost addition and the reduction of available methods would normally eliminate airborne geophysics. The lessened field strength and the broadening of the anomalous shape as distance increases for potential field methods (gravity and magnetics) normally are counter to the greater detail requirements for engineering and environmental studies. When airborne methods are appropriate, lower and slower flying platforms will be more beneficial for engineering and environmental uses. Helicopters will normally provide more coverage, due to their slower flight speeds and potential for tighter flight paths, than fixed wing transport. Helicopter may also be able to fly at lower altitudes, providing better measurement quality.

b. Dimensions. The dimensions of a site may be so great that some airborne geophysical reconnaissance may be prudent prior to other studies. A large site with potential radiometric contamination would be a particular problem type with beneficial airborne geophysical approaches. Moderately sized sites where the surface is hazardous (or extremely expensive) for personnel entry, or is unavailable for personnel access to the site, may be assessed to some extent by airborne geophysical methods.

c. Purpose. A study's purpose will be an aspect to resolve the most appropriate geophysical means. Geologic characterization objectives for a site with significant rock variations may be more likely to employ airborne measures than a site with objectives to delineate large organic plumes. The anomalous contrast of the objective is the key in resolving whether a geophysical procedure is worthy of a given purpose.

8-2. Airborne Geophysical Measures

The three chief airborne procedures are magnetic, electromagnetic, and radioactive methods. Airborne magnetometry (aeromag) is quite common and aeromag maps are available for most of the United States. Aeromag mapping is very useful for mineral exploration and geological studies of magnetic rocks. Airborne electromagnetic methods are used in both the frequency and time domains. Ore body exploration is the chief use of airborne EM methods. Airborne radioactive measurements of gamma rays may be used for uranium and thorium exploration.

a. Magnetics.

(1) Engineering and environmental surveys could have a varying purpose in which aeromag would provide useful information. Two alternative targets might be considered: site characterization of locale with magnetic rocks or ferrous man-made objects. The differing purposes and targets would necessitate differing flight parameters for the aeromag surveys. Aeromag can be flown for regional geologic structure, which may aid site characterization. Few sites would exist with massive, buried ferrous objects in a region of little magnetic mineralization. Searches for buried ferrous objects would require low-altitude flights in search of local anomalies relative to aeromag for structural investigations.

(2) There are several possible uses of aeromag flights.

(a) One hypothetical situation to illustrate the potential of aeromag use might be the search for buried steel transmission casing over a large site. The horizontal steel pipe would produce a small, broad anomaly near the axis of the pipe. In the case of determining the route of a 1-m-diam, horizontal steel pipe in a sparsely populated region, a magnetometer slung from a helicopter might be able to follow the anomaly route (the pipeline's unknown path) by survey initiation at a known origin and heading of the pipeline. The search would cross perpendicular to the last observed azimuth following the anomaly using a GPS location.

(b) A short length of vertical, steel well-casing buried below the soil surface would likely produce a sharp, large magnetic anomaly. An aeromag search for unknown, short (< 20 m length) abandoned wells may not be productive, because the diameter of the anomaly would be so confined that an airborne flight path would be unlikely to pass sufficiently close to the well axis. The separation distance between economically feasible aeromag flight paths would most likely be too large for the well-head search to be successful.

(c) Searches for long lengths (> 50 m) of buried steel casing produce large, broad magnetic anomalies. Properly planned flight paths of aeromag surveys would be likely to encounter the casing's magnetic signature.

(d) The target anomaly, linear but small in the first case, enables the method to be useful for the horizontal transmission lines. The second target of short, abandoned well casing has an anomaly of narrow dimensions and is biased against aeromag discovery. The last case of long, deep casings usually has broad, large anomalies and aeromag surveys should be effective.

b. Airborne EM.

(1) The benefit of airborne EM (AEM) procedures is the search for conductors; conductors need not be ferrous objects. Further, air as a medium does not attenuate an EM field. The secondary field from the target, albeit small, is less affected by distance above the surface than aeromag.

(2) There are several different AEM methods in use since the 1960s. Telford, Geldart, and Sheriff (1990) describe the VLF procedure of AEM as follows: "simple, cheap compared to other air surveys, and provides limited data for shallow depths." No one AEM technique would be preferred for different problems.

(3) AEM might provide a better definition of the transmission pipeline example above than aeromag. However, AEM would be much preferred if the pipeline was not a ferrous metal. The target anomaly due to the engineering or environmental problem would suggest whether AEM was an appropriate technique.

c. Radioactive searches.

(1) Airborne radioactive searches are obviously limited by the type of source target. These measures would be used infrequently compared to aeromag and AEM work.

(2) Radioactive detectors may be flown for a search of buried radioactive waste containers. As a hypothetical consideration, an airborne exploration for a 1-m-diam, 20-m-long, horizontal lead pipe filled with low-level radioactive waste would be a possible solution.

d. Complementary airborne surveys.

(1) Once the platform for one type of survey is selected another method is often added as a comparator for the data taken. Hempen and Hatheway (1992) recommend that complementary methods be utilized to reduce ambiguity and to lessen the number of solution models for the measurements. The increased cost of a second method is small compared to the expense of the airborne platform, its flight path and the labor to conduct the survey.

(2) Aeromag and AEM would be very appropriate complements to locate the steel transmission pipeline in the example above, given that an airborne survey was selected. Airborne radioactive detection and AEM would be supportive of a search for the radioactive waste-filled, lead pipe cited; aeromag would not be acceptable, as a ferrous metal was not involved.

8-3. Contracting

a. Airborne geophysical surveys are specialized procedures. The nature, scope, and cost of these methods dictates that specialized contractors should provide these services. The cost of airborne geophysical contracts will normally be tens of thousands of dollars. The production by length or area of airborne surveys will compete with surficial geophysics because of the large dimensions covered by airborne platforms.

b. Selection of airborne geophysical contractors will be analogous to other geophysical services. The airborne geophysical contractor must have experience, equipment, and documented results from prior airborne services. Preferably the cited work should not only be of the same methodology, but the previous services should resolve a similar problem. Flying AEM for mineral exploration will not be similar in scope to obtaining AEM for engineering purposes. Avoid contracts for services without interpretation. No matter how well another geophysicist can evaluate airborne geophysics, the most prudent contract will pay for useful interpreted results. Flying specialized equipment with complex data streams does not guarantee that the measurements have any application to the purpose for the work. Pay for results, not data.

c. Hempen and Hatheway (1992) suggest that client lists be requested of specialty contractors. The cited clients would then be contacted concerning reliability, timeliness, accuracy, and cost experience with the contractor. Normally, airborne geophysics will be conducted via architect/engineer services with proposal submissions and evaluation of the proposals. It may be wise to have a government geophysicist on the proposal evaluation team.