USGS
science for a changing world

FS–237–95 OCTOBER 1997

Compiling Magnetic Databases

Introduction

Aeromagnetic anomaly maps show variations in the Earth's magnetic field that are caused mainly by magnetic minerals in crustal rocks. These anomalies vary with amount and type of magnetic material and the geometry and depth of the magnetic body. Igneous and metamorphic rocks frequently are magnetic enough to cause anomalies, whereas sedimentary rocks commonly are nonmagnetic. Aeromagnetic anomaly maps are important tools for mapping surficial and buried rocks, for determining geologic structure, and for discovering some types of mineral deposits. Regional geologic features may become evident after individual aeromagnetic surveys are compiled and plotted at the same scale in a consistent way.

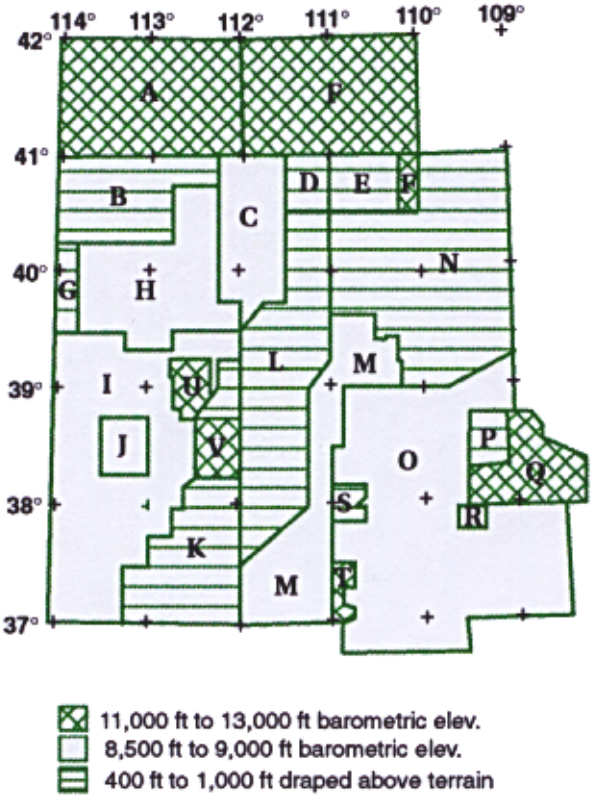

Figure showing 22 aeromagnetic surveys covering Utah; each has different flight specifications.

History of aeromagnetic surveying

Magnetic surveying from an aircraft became possible with the development of stable airborne magnetometers used to detect submarines during World War II. The first airborne magnetic survey for geologic purposes over land was completed in 1944. Shipborne magnetic surveys of the ocean floor emerged in the 1950's, and satellite magnetic surveys over much of the Earth's surface became available in the 1960's.

In the ensuing years, numerous aeromagnetic surveys were conducted for geologic mapping and mineral exploration by both Government agencies and private companies. Most of these surveys were small, and no attempt was made to tie them to neighboring surveys by using the same flight elevation or spacing.

In the 1970's, the U.S. Government completed a national airborne survey for uranium resources (the National Uranium Resource Evaluation, or NURE Program). Although the main purpose of this survey was radioelement measurement, a second purpose was to acquire aeromagnetic data, which were compiled for almost all 2-degree quadrangles in the United States. These data were collected 400 ft above the land surface and usually had flight-line spacings 3 or 6 miles apart. These data are useful for giving the geoscientist some indication of the regional magnetic field for an area of interest anywhere in the United States.

Combining magnetic data

The optimum aeromagnetic map of the United States would be one created from a new survey flown with closely spaced lines at a uniform elevation. In the absence of such an ideal survey, geoscientists have been creating large magnetic data sets by "stitching" together existing surveys with their many differences and inconsistencies. Differences in magnetic data include

- whether the survey was flown at a constant barometric elevation (e.g., 9,000 ft above

sea level) or was flown a constant distance above terrain (e.g., 400 ft above the ground, also called "draped")
- original flight elevation
- whether original data were obtained from digital tapes or had to be digitized from maps
- original flight-line spacing

The first two differences can be minimized using mathematical techniques to predict magnetic fields at different elevations.

Composite and merged magnetic maps and databases

Surveys may be plotted as a **composite** map, where each piece is juxtaposed against the others without regard to differences in flight elevation or spacing. A composite map retains the original data resolution, but computer methods to further enhance or model regional features crossing survey boundaries cannot be applied. All USGS magnetic maps published before 1980 are composite magnetic maps. The first-generation composite magnetic map of the United States was created by the Committee for the Magnetic Anomaly Map of North America as part of the Geological Society of America's Decade of North American Geology (DNAG) project.

Computer methods have been developed to transform magnetic data into a **merged** map, wherein all survey data are analytically reduced to a common flight elevation and then digitally merged at the survey boundaries. In theory, a merged data set is homogeneous—the data represent the magnetic field at a uniform flight elevation, whether at a constant barometric elevation or draped over topography. In practice, homogeneity is only partially achieved due to differences in the resolution and quality of the original data sets. Poor measurements caused by wide flight-line spacing, surveying too far above the magnetic source, and insufficiently sensitive magnetometers cannot be improved.

Databases and maps of merged magnetic data covering large areas are listed in a bibliography (USGS Open-File Report 95–77), also found at the web site listed under Additional Information.

How are aeromagnetic data merged?

If original flight-line data are available, these are gridded at an interval 1/3 to 1/4 of the flight-line spacing and are then regridded to the final merged grid interval. This two-step gridding process preserves more detail than does gridding at the coarser interval first.

Original flight-line data from surveys flown before the 1970's are no longer available, and only the published maps remain. To recapture the data, most of these maps have been digitized, primarily along flight lines where actual data were recorded, but sometimes between flight lines wherever necessary. Digitizing reproduces the map, but reproducing the measured magnetic field depends on the carefulness of the mapmaker. The randomly digitized points are gridded, converting them to a representation of the magnetic field at equally spaced locations, which further modifies the original data.

The International Geomagnetic Reference Field (IGRF), a model of the Earth's main magnetic field, is calculated for the time and flight elevation of the survey and then removed from the gridded data; sometimes this step has already been accomplished. If a regional field other than the IGRF has been previously removed, it is restored, and the IGRF is removed subsequently. The gridded data are mathematically transformed to a new flight-elevation surface. The adjacent surveys are merged by blending overlapping data or by butting surveys together and smoothing the seams.

Additional information

USGS Open-File Report 95–77 lists many USGS computer programs and databases used to create magnetic maps and lists some published magnetic maps.

Information on the availability of magnetic maps and data in specific areas and other general information on USGS airborne coverage can be obtained from:

Pat Hill
U.S. Geological Survey
Box 25046, MS 964
Denver Federal Center
Denver, CO 80225
(303) 236-1343
pathill@musette.cr.usgs.gov
(136.177.80.14)

Viki Bankey (same address)
(303) 236-1348
viki@musette.cr.usgs.gov

web site:
http://minerals.er.usgs.gov