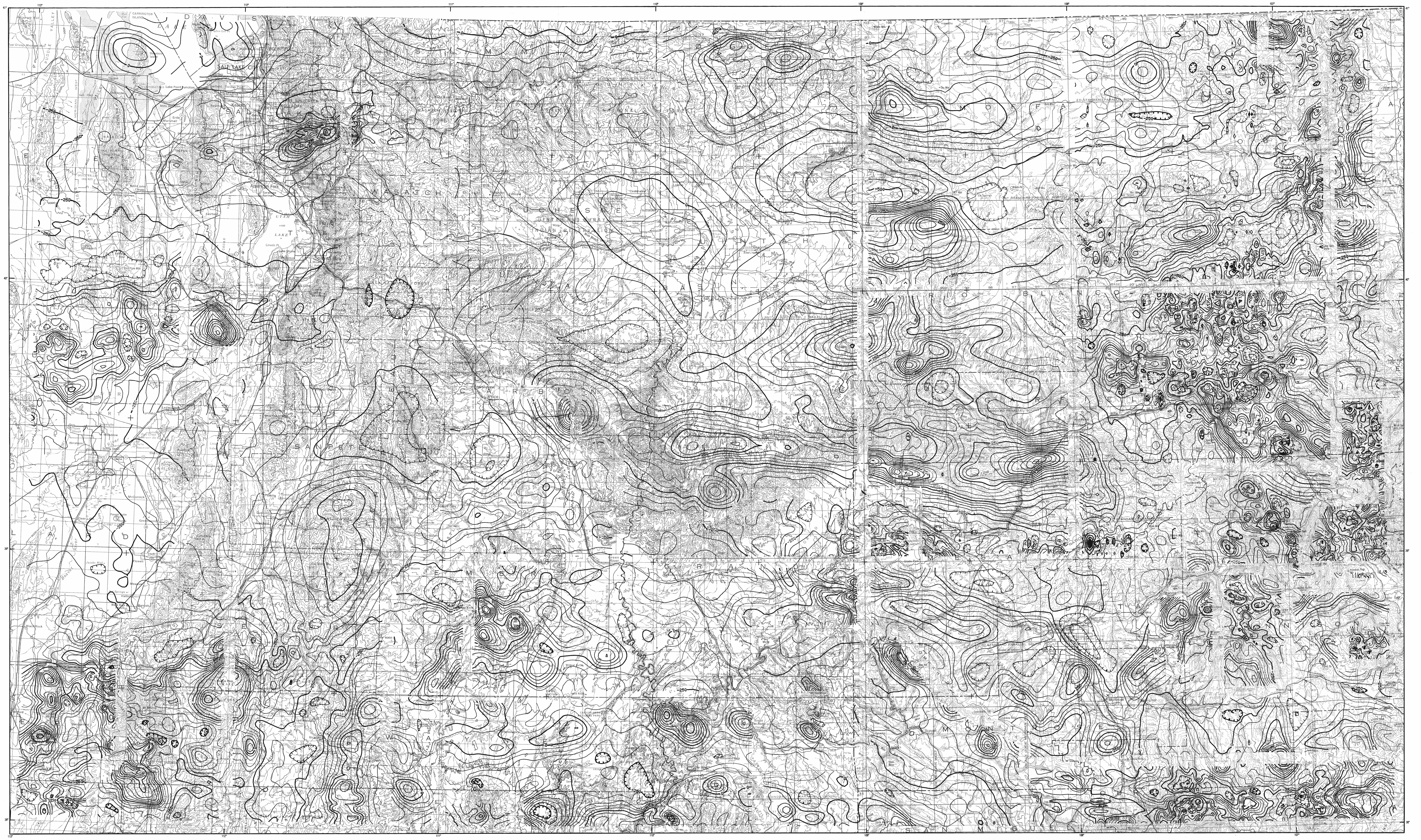
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-2008-C
SHEET 1 OF 2



Base from U.S. Geological Survey
state topographic maps of Colorado and Utah.

Data compiled by V.J.S. Grauch, 1986, and composited by J.L. Plesha, 1987.

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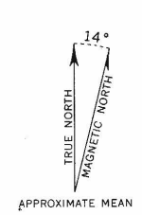

SCALE 1:500 000

10 0 10 20 30 40 50 MILES

10 0 10 20 30 40 50 KILOMETERS

CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

PLATE 1.--COMPOSITE AEROMAGNETIC MAP

INTRODUCTION

In order to understand the evolution of sedimentary basins, it is important to understand their tectonic setting. In a U.S. Geological Survey (USGS) study of the Uinta and Piceance basins in Utah and Colorado, this understanding is approached through characterization of subsurface structure and lithology of a large region encompassing the basins. An important tool for interpreting these subsurface features is aeromagnetic data.

Aeromagnetic anomalies represent variations in the strength and direction of the Earth's magnetic field that are produced by rocks containing a significant number of magnetic minerals (commonly magnetite). The shape and magnitude of an anomaly produced by one body of rock are complexly related to the amount of magnetic minerals present, the magnetic properties of those minerals (determined by a number of factors, including the history of the rock), and the shape of the rock body. In the study area, only crystalline basement rocks and volcanic rocks are likely to contain enough magnetic minerals to produce anomalies; sedimentary rocks and metasediments are generally so poor in magnetic minerals that their magnetic effects cannot be detected by the types of surveys presented in this report. Patterns of anomalies on aeromagnetic maps can reveal not only lithologic differences related to magnetite content, but structural features as well, such as faults that have juxtaposed crystalline rocks against sedimentary rocks, and upwarps of crystalline basement underlying sedimentary sequences.

Tectonic features of regional extent may not become apparent until a number of aeromagnetic surveys have been compiled and plotted at the same scale. Commonly the compilation involves piecing together data from surveys that were flown at different times and have widely disparate flight specifications and data reduction procedures. The data may be compiled into a composite map, where all the pieces are plotted onto one map without regard to the differences in flight elevation and datum, or they may be compiled into a merged map, where all survey data are analytically reduced to a common flight elevation and datum, and then digitally merged at the survey boundaries. The composite map retains the original resolution of all survey data, but computer methods to enhance or model regional features crossing the survey boundaries cannot be applied. On the other hand, these computer methods can be applied to the merged data, but the resolution of the data may be somewhat diminished. This report presents both composite and merged aeromagnetic maps for a large region that includes the Uinta Basin in Utah and the Piceance basin in Colorado (fig. 1). Interested persons can acquire the gridded digital data by supplying a magnetic tape to the authors.

DATA COMPILATION

Total-intensity aeromagnetic data for both composite and merged maps were obtained from 33 different surveys (fig. 2). Digital data were acquired, if available; otherwise, published contour maps were digitized by hand (table 1). For each survey, the data were projected using the Lambert conformable system (base latitude 38°N; central meridian 109°30'W), then gridded using a minimum curvature algorithm (Webring, 1981) at a 1-km grid interval. Next, the modelled effects of the Earth's magnetic field, defined differently for the separate times each survey was flown, were removed from the grids. Where possible, definitive and International Geomagnetic Reference Fields (DGRF and IGRF) were removed following the revised IAGA guidelines (IAGA Division I Working Group 1, 1985). Removal of geomagnetic models outside of these guidelines was necessary where data processing spanned revisions in the IGRF, or where geomagnetic field models were removed before the data were obtained by the USGS (table 1). In the exceptional case of the southwest Utah survey (S on fig. 2), a crude geomagnetic field model, which was removed by the original contractors prior to contouring, could be restored to the data before the more correct DGRF model was removed.

COMPOSITE AEROMAGNETIC MAP

The composite map (pl. 1) displays the survey grids plotted next to each other after geomagnetic field removal. Constant values were added to each grid before plotting to minimize the range of values of all grids. Data were removed from the grid edges before plotting, producing the blank areas along survey boundaries. This form of display avoids joining contour values across grid boundaries, which is extremely difficult because of the widely varying flight specifications of the original surveys.

MERGED AEROMAGNETIC MAP

After removal of the geomagnetic field, the survey grids were further processed in order to create one, large, uniform data set observed on a draped surface 1000 ft (304.8 m) above ground. In draped surveys, magnetic anomalies, caused by sources on mountaintops, will tend to look similar to anomalies in valleys (if the sources are similar), which facilitates qualitative interpretation. Continuing data downward to 1000 ft above ground enhances small variations in the original data. Unfortunately, noise in the data is also enhanced. To diminish noise amplification, lowpass filters are applied during downward continuation, which may result in a decrease in resolution.

To produce the merged map (pl. 2), each survey grid was analytically continued to the draped surface 1000 ft above the ground, using the method of Cordell (1985), except for the Mt. Massive and Fossil Ridge surveys (W and Z on fig. 2), which required no continuation. The Cordell continuation method, an approximate technique, primarily addresses continuation of data from a level to an irregular surface, but can be extended (with less accuracy) to continuation between arbitrary surfaces as well. In the level-to-surface case, the original data are first continued by standard fast Fourier transform methods (Hildenbrand, 1983) onto a stack of horizontal levels that encompass the irregular surface. Then the magnetic field is evaluated at each point on the irregular surface by interpolation in the vertical direction within the stack of levels. The procedure is similar for continuing data between two different irregular surfaces, except that the stack of levels becomes a stack of parallel surfaces. Most of the survey grids required level-to-surface continuation. Seven draped-survey grids (table 1) required continuation between parallel draped surfaces where the 1000-ft draped surface was higher than the original surface. All the draped surfaces were constructed by adding the specified altitude above ground to digital topographic data that were originally gridded at 30 seconds (about 0.8 km) of latitude and longitude.

After continuation, constant values were added to each grid to make the values of neighboring grids compatible. Then the grids were merged together by splining across their edges (M. Webring, USGS, unpub. computer program). Some difficulty in joining the grids is expected owing to differences in resolution, geomagnetic field removal, and data reduction of the original surveys. Gradients aligned exactly east-west or north-south may reflect survey boundary mismatches or may represent unresolvable problems with the original flight lines of a survey.

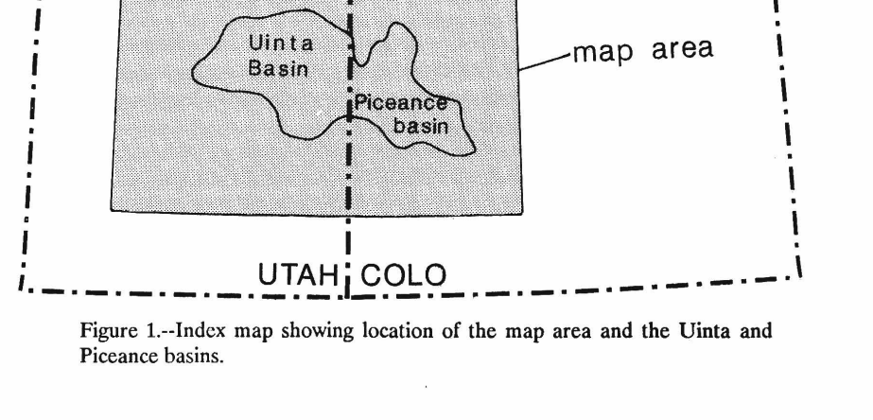

Figure 1.--Index map showing location of the map area and the Uinta and Piceance basins.

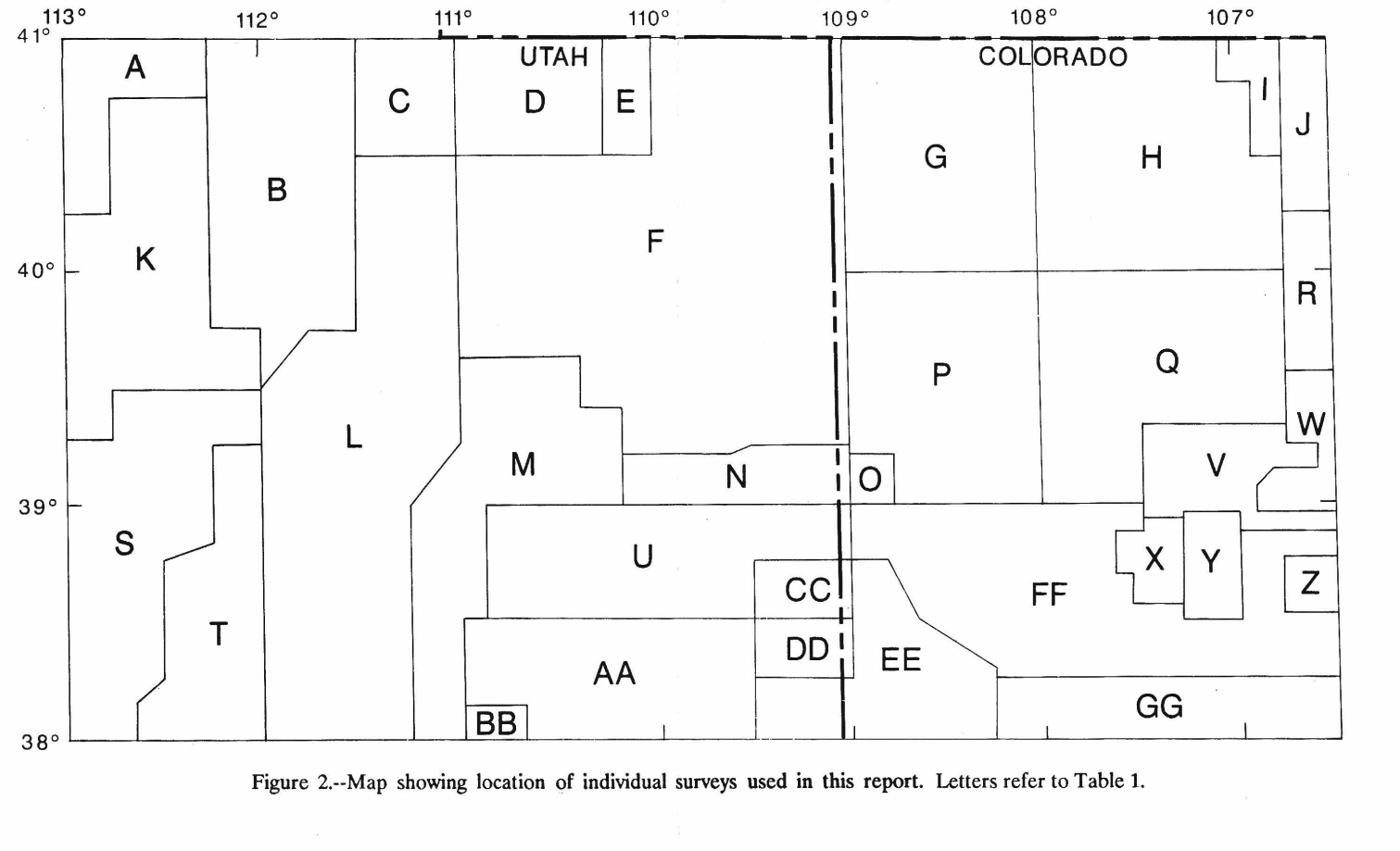

Figure 2.--Map showing location of individual surveys used in this report. Letters refer to Table 1.

Table 1.--Aeromagnetic Survey Specifications

SURVEY[1]	FLIGHT LINES	ALTITUDE[2]	YEAR FLOWN	DATA TYPE	GEOMAGNETIC FIELD REMOVED[3]	SURVEY NAME
A	5-mi N-S	12,000′ BE	1969	Digitized	IGRF 1965 [9][4]	Bonneville [30][4]
B	1-mi N-S	9,000′ BE	1968	Digitized	DGRF 1965-70 [13]	Salt Lake Valley High Lines [16]
C	2-mi N-S	11,000′ BE	1965	Digitized	DGRF 1965 [13]	Uinta Mountains (west) [17]
D	2-mi N-S	13,000′ BE	1965	Digitized	DGRF 1965 [13]	Uinta Mountains (east) [17]
E	3-mi E-W	400′ AG	1979	Digital	DGRF 1975-80 [13]	Salt Lake NURE [4]
F	2&4-mi N-S	12,000′ BE	1971	Digital	POGO 6/71 [14]	Univ. of Utah Area #3 [30]
G	3-mi E-W	400′ AG	1978	Digital	DGRF 1975-80 [13]	Vernal NURE [6]
H	3-mi E-W	400′ AG	1978	Digital	DGRF 1975-80 [13]	Craig NURE [15]
I	1-mi N-S	12,000′ BE	1972	Digitized	DGRF 1970-75 [13]	North Park (west) [23]
J	1-mi E-W	13,000′ BE	1965	Digitized	DGRF 1965 [13]	North Park (east) [23]
K	1-mi N-S	9,000′ BE	1968	Digitized	DGRF 1965-70 [13]	Salt Lake Desert [19]
L	2&4-mi N-S	12,000′ BE	1971	Digital	POGO 6/71 [14]	Univ. of Utah Area #2 [30]
M	2&4-mi N-S	8,500′ BE	1971	Digital	POGO 6/71 [14]	Univ. of Utah Area #4 [30]
N	4-mi E-W	8,500′ BE	1971	Digital	POGO 6/71 [14]	Univ. of Utah Area #5 [30]
O	1/2-mi E-W	500′ AG	1985	Digital	IGRF 1980 [12]	Black Ridge Canyon [27]
P	3-mi E-W	360′ AG	1980	Digital	IGRF 1975 [11]	Grand Junction NURE [5]
Q	3-mi E-W	400′ AG	1978	Digital	IGRF 1975 [11]	Leadville NURE [7]
R	1-mi E-W	14,000′ BE	1967	Digitized	DGRF 1965-70 [13]	Wolcott-Boulder [18]
S	1&2-mi N-S	9,000′ BE	1972	Digitized	DGRF 1970-75 [13]	Southwest Utah [20,21]
T	2&4-mi N-S	12,000′ BE	1971	Digital	POGO 6/71 [14]	Univ. of Utah, Area #1 [30]
U	1-mi E-W	8,500′ BE	1955	Digitized	IGRF 1955 [13]	North Colorado Plateau [2]
V	1-mi E-W	14,000′ BE	1974	Digitized	POGO 6/71 [14]	Maroon bells [25]
W	1/2-mi E-W	1,000′ AG	1984	Digital	PGRF 1980-85 [13]	Mt. Massive [8]
X	1-mi N-S	13,500′ BE	1973	Digitized	DGRF 1970-75 [13]	West Elk Extension [24]
Y	1-mi N-S	13,500′ BE	1970	Digitized	DGRF 1970 [13]	West Elk [24]
Z	1/2-mi E-W	1,000′ AG	1981	Digital	IGRF 1975 [11]	Fossil Ridge [26]
AA	1-mi E-W	8,500′ BE	1954	Digitized	GSFC 12/66 [1]	West Colorado Plateau [2]
BB	1-mi E-W	12,500′ BE	1954	Digitized	GSFC 12/66 [1]	Henry Mountains [2]
CC	1-mi E-W	12,500′ BE	1956	Digitized	IGRF 1955-60 [13]	La Sal Mountains (north [2]
DD	1-mi E-W	12,500′ BE	1955	Digitized	IGRF 1955 [13]	La Sal Mountains (south) [2]
EE	2-mi E-W	500′ AG	1952	Digitized	GSFC 12/66 [1]	Uravan [2]
FF	5-mi E-W	14,500′ BE	1969-70	Digitized	IGRF 1965 [10]	USGS [29]
GG	1-mi E-W	14,500′ BE	1967	Digital	DGRF 1965-70 [13]	Durango [22]

[1] Letters refer to fig. 2.

[2] BE = Barometric elevation; AG = above ground, in ft.

[3] Years next to IGRF and DGRF indicate the year of the model used, updated to the time of the survey. Two years shown next to DGRF and PGRF (provisional geomagnetic reference field) indicate a linear interpolation between the coefficients of those two models. POGO (Polar Orbiting Geophysical Observatory) and GSFC (Goddard Space Flight Center) models are followed by month and year of the model. The POGO model listed was provided to the survey processors by J. C. Cain (Florida State University) but never published. Langel (1987) discusses POGO models in general.

[4] Numbers in brackets are keyed to the References Cited. NURE = National Uranium Resource Evaluation program.

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EXPLANATION

MAGNETIC CONTOURS--Contours show total residual magnetic intensity of the Earth's field in nanoteslas (nT). Hachures indicate direction of decreasing intensity within closed magnetic lows. Contour interval is 50 nT.

Blank areas represent survey boundaries across which data could not be contoured because of the differences in flight specifications.

AEROMAGNETIC MAPS OF THE UINTA AND PICEANCE BASINS AND VICINITY, UTAH AND COLORADO

By

V.J.S. Grauch and Joseph L. Plesha

1989

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