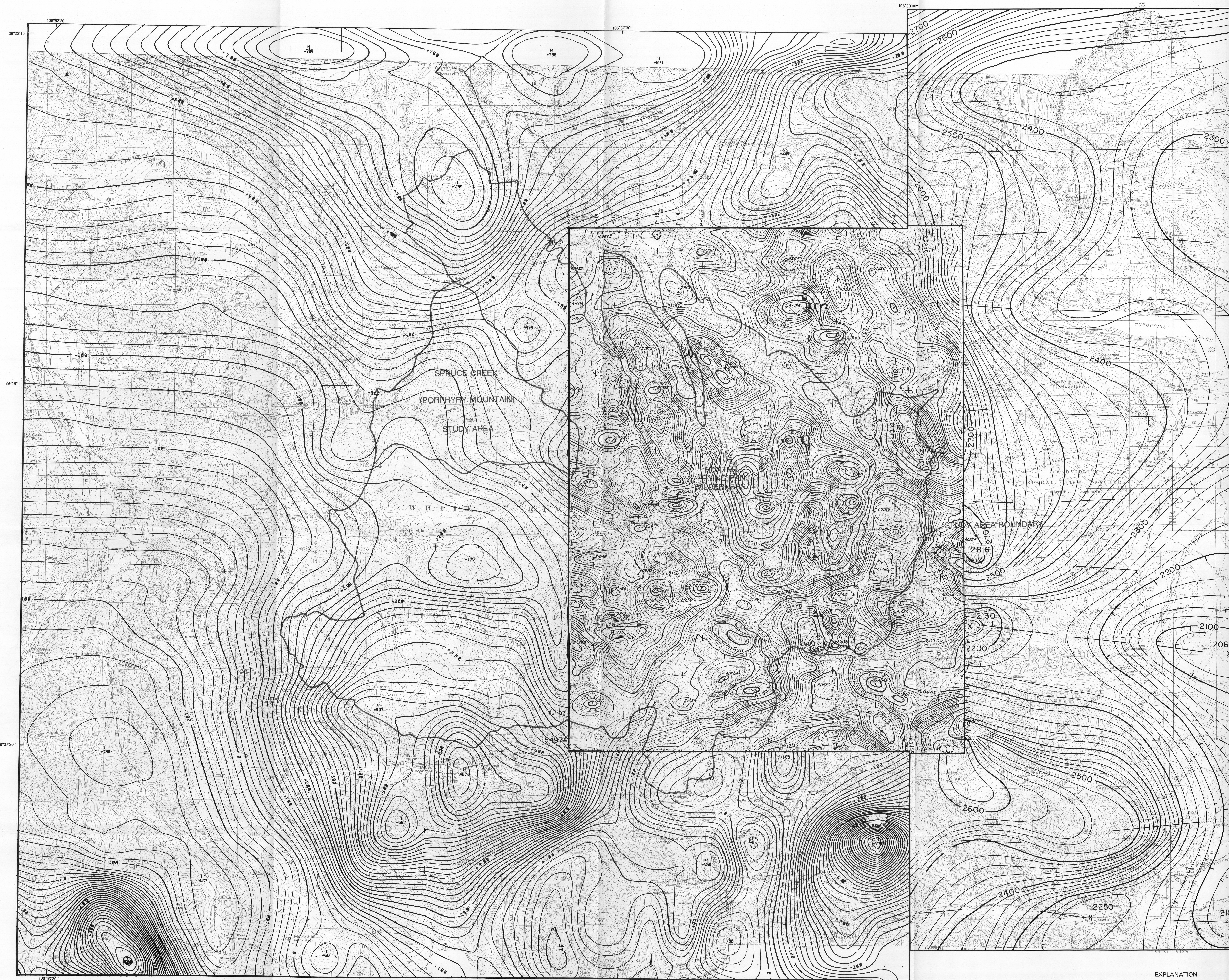

Base from U.S. Geological Survey 1:50,000, Colorado, Pitkin County E., 1976; Lake County, 1975

SCALE 1:50 000

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 KILOMETERS

EXPLANATION

FLIGHT LINE

100-NANOTESLA CONTOUR

20-NANOTESLA CONTOUR

MAP B-AEROMAGNETIC MAP

AEROMAGNETIC AND COMPLETE BOUGUER GRAVITY ANOMALY MAPS OF THE HUNTER-FRYINGPAN WILDERNESS AREA, PITKIN COUNTY, COLORADO

By
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1981

Public Law 95-237 requires the U.S. Geological Survey to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This map and report present the results of a geophysical survey of the Hunter-Fryingpan Wilderness and the Porphyry Mountain Wilderness Study Area, Pitkin County, Colorado.

Aeromagnetics flown in 1974 (U.S. Geological Survey, 1979a) showed relatively flat and uninteresting fields over the western portions of the study area, but several possibly significant features to the east and southeast. Consequently, the southeastern portion of the study area was reflown to changed specifications (fig. 3).

The map of the reflown portion shows much more detail than did the earlier map, but in many places the magnetic intensity appears to mimic the topography, so that strong magnetic highs occur over mountain peaks and deep lows are seen over the stream valleys.

Figure 4, along profile A-A', shows that this magnetic topograpic effect was accentuated by having the newer survey flown draped rather than at constant elevation. This result was surprising; previously it had been generally accepted that draping would minimize aeromagnetic topographic effects (Wynn and Bhattacharyya, 1977). Clearly, most of the features on figure 4 are due merely to topography. An exception involves the higher amplitude fields observed along the central third of profile A-A', indicating that the rocks there have either a substantial component of permanent magnetization, or higher susceptibilities than the $2x10^{-3}$ emu value used in the calculation. This susceptibility value appears to be approximately correct for rocks under the western third of profile A-A', and somewhat too high for rocks under the eastern third. Figure 4 tells us that magnetic highs and lows on this map should be discounted when they fall over corresponding topographic highs and lows, that the general magnitudes of the fields in each portion of the map may nevertheless indicate relative magnetic susceptibilities of the underlying rocks, and that relatively minor features may be significant when they fail to correlate with topography or with variations in ground clearance due to performance characteristics of the aircraft.

Feature F-F' shown on figure 5 corresponds to flight line 7N of the draped survey. This figure shows that the draping was not done well, so that the corresponding portion of the aeromagnetic map, portion 3 of map B (fig. 3), must be regarded as intermediate in type between maps which would result from perfect level and perfect draped surveys. The fields shown on this map are those observed on a variable datum surface which can only be reconstructed by examining barometric and radar altimeter channels on the data tapes provided by the contractor.

The fields calculated at the aircraft position along flight line 7N are shown on figure 5 for a simple version of possible geologic structure. The program used to produce figure 5 was written by Cady (1980). Figure 5 shows that along line 7N the general features of the observed magnetic field may be ascribed to three magnetically distinct terranes. Of these the southernmost terrane is relatively nonmagnetic (susceptibility $k = 5x10^{-4}$emu) and the central and northernmost terranes are more magnetic ($k = 3.5x10^{-3}$emu and $1.75x10^{-3}$emu, respectively). The boundary between the southern and central terrains (B on figure 6) appears to dip to the south at about 80° and that between the central and northern terranes dips northerly at about 55° (apparent dips only). The poor match between observed and calculated fields at coordinates 30 through 48 kft is ascribed to the 2 1/2 D geometrical approximation used in the modeling; the actual topography in this zone is complex and not easily approximated by the simple geometric shapes required by the computer.

Figure 6 is a sketch indicating certain features on the aeromagnetic map. Profile B-B' is a boundary between higher magnetic fields to the north, lower to the south. This boundary corresponds in a general way with the geological boundary between 1400 m.y. old Proterozoic granites to the north and 1700 m.y. old Proterozoic biotitic gneisses to the south (Ludington and Yeoman, 1981a, b). Our laboratory measurements (fig. 7) confirmed the impression that the granites usually have higher magnetic susceptibilities than the gneisses.

L1 (fig. 6) is a belt of strong magnetic lows which occurs, at least along the western portion of the belt, over fractures which mark the rim of the Grizzly caldera (Candee, 1971). The Grizzly stock at the center of the caldera is marked by a relative high (H1) of small amplitude. Samples of rocks from belt L1, dikes associated with the caldera (sample Nos. 304, 292, and 528), and Proterozoic rocks which may have been altered by processes related to caldera formation (sample Nos. 713 and 714), were found to have relatively low susceptibilities (fig. 7). Samples of rocks bordering belt L1 (sample Nos. 308, 346, and 709) had intermediate susceptibilities.

Two lobes (L2 and L3) of magnetic lows extend into the study area from belt L1. Lobe L2 is a very deep low, extending up the valley of the North Fork of Lake Creek, across the Continental Divide and along the right bank of the headwaters of the Middle Fork of the Fryingpan River. Sample No. 522, granite collected from the pass, showed unexpectedly high susceptibility for material in such a pronounced low. A number of Cretaceous to Tertiary dikes and sills with low susceptibility are also present near the pass, however. Volumetrically, such rocks make up a minor portion of the exposed bedrock, however; they cannot explain lobe L2 unless there are substantially more of them present at shallow depths. Perhaps there is an altered zone or buried pluton in this location. Unlike belt L1, no particular gravity features were observed corresponding to L2. The structural and genetic relations, if any, between the features reponsible for L2 and L1 remain unknown.

L3 is a relative magnetic low in terrane presumed to be granite but covered in the headwater valley of the Middle Fork by glacial and landslide debris. This low, not as strong as L2, helps delineate a shear zone exposed on the nearby ridges (Ludington and Yeoman, 1981a). Its substantial magnetic expression suggests that this shear zone must be quite wide and deep.

H2 is a strong magnetic high between L1 and L2. This high reflects strongly magnetic granite terrane there. Details of minor highs and lows within this zone also correlate with topography, and probably reflect operational difficulties maintaining proper flight elevations while draping the survey.

L4 is a broad magnetic low near Midway Creek, probably due to a tongue of less magnetic schist which extends into the more magnetic granites at that place (Ludington and Yeoman, 1981a).

H3 is a magnetic high centered where Lincoln Creek joins the Roaring Fork River. Most of H3 lies outside the study area. Its cause is not known. Sample No. 219A, collected from a site on the western flank of H3, had the highest susceptibility measured for samples in the study area.

H4 is a strong magnetic high extending just into the study area from the northwest. Zietz and Kirby, 1972, show H4 to be a lobe of a region of very high magnetic field amplitudes centered on Red Table Mountain (outside the map to the northwest) where iron-rich sediments of the Maroon Formation are oxidized a red color.

Finally, lineament Z-Z' is a zone of minor magnetic gradients and lows which follows the Middle Fork of the Fryingpan River through a granitic terrane. We found it unnecessary to cite geologic causes to account for lineament Z-Z'. Magnetic modeling of the type shown on figures 4 and 5 indicates that in most places this feature can be attributed to combinations of polarization lows due to the northeast-facing side of the valley together with not unreasonable difficulties maintaining proper aircraft elevations as the draped survey was flown. Note, however, the lobe of relative magnetic lows L5 near the town of Nast, correlating with the (possible) gravity low observed there. Granitic rocks outcrop to the south and east and metamorphic rocks to the north of L5, but alluvial deposits cover the bedrock there (Ludington and Yeoman, 1981a). It seems likely that the relatively less magnetic metamorphic rocks extend from the north far under the alluvial deposits at this location. The (possible) gravity low at L5 indicates that these particular metamorphic rocks also may be less dense than the nearby granitic rocks.

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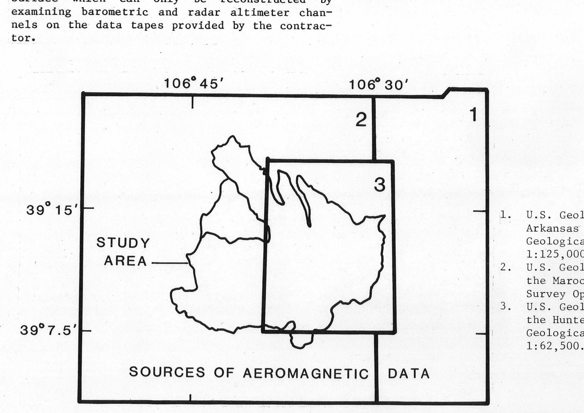

1. U.S. Geological Survey, 1978, Aeromagnetic map of Arkansas Valley and vicinity, Colorado: U.S. Geological Survey Open-File Report 78-112, scale 1:125,000.
2. U.S. Geological Survey, 1979a, Aeromagnetic map of the Maroon Bells area, Colorado: U.S. Geological Survey Open-File Report 79-1449, scale 1:62,000.
3. U.S. Geological Survey, 1979b, Aeromagnetic map of the Hunter-Fryingpan area, Colorado: U.S. Geological Survey Open-File Report 79-1226, scale 1:62,500.

Figure 3.--Sources of aeromagnetic data. 1: U.S. Geological Survey, 1978, Aeromagnetic map of Arkansas Valley and vicinity, Colorado: U.S. Geological Survey Open-File Report 78-112, scale 1:125,000. Data flown in 1963 by U.S. Geological Survey; one-mile (1.6 km) spacing east-west, 14,500 ft (4420 m) barometric elevation. 2: U.S. Geological Survey, 1979a, Aeromagnetic map of the Maroon Bells area, Colorado: U.S. Geological Survey Open-File Report 79-1449, scale 1:62,500. Data flown in 1974 by Aerial Surveys, Salt Lake City, UT; one-mile (1.6 km) spacing east-west, 14,000 ft (4267 m) barometric elevation. 3: U.S. Geological Survey, 1979b, Aeromagnetic map of the Hunter-Fryingpan area, Colorado: U.S. Geological Survey Open-File Report 79-1226, scale 1:62,500. Data flown in 1979 by LKB Resources, Inc., Huntingdon, PA, one-half mile (0.8 km) spacing north-south, draped with 1000 ft ± 200 ft (305 m ± 61 m) terrain clearance. To avoid distorting original data, no attempt was made to smooth or join maps at common borders.

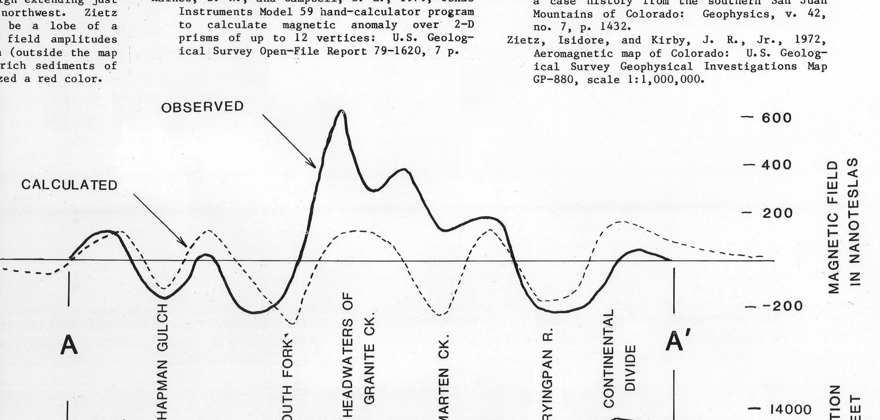

Figure 4.--Observed and theoretically calculated magnetic fields along east-west profile A-A' (Location indicated on fig. 6). The constant elevation curves were at nominal elevation of 14,000 ft (4,267 m), and the draped curves were nominally 1,000 ft (305 m) above ground surface. Theoretical curves were calculated using a program by Haines and Campbell (1979) and supposed a 2-dimensional terrain as shown with constant susceptibility $2x10^{-3}$ emu, magnetizing field 55300nT, magnetic inclination 66.5°, and magnetic declination 15°E (Peddie and others, 1976; Fabiano and others, 1976).

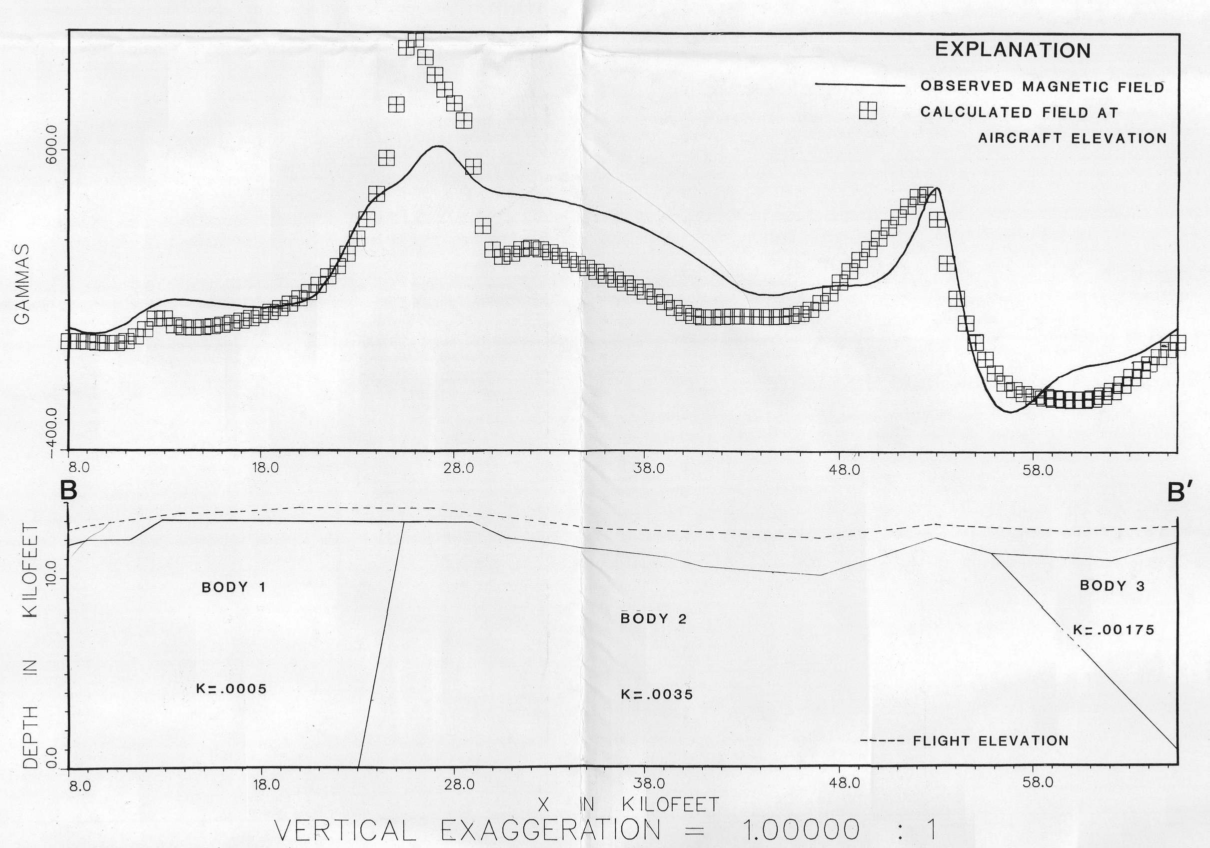

Figure 5.--Observed and calculated magnetic fields along north-south profile B-B', which corresponds to flight line 7N (Location indicated on fig. 6). Theoretical fields at each point were calculated at actual aircraft altitude, reconstructed as shown. The calculation supposed a purely two-dimensional terrain made of blocks having the susceptibilities shown and extending arbitrarily in depth to sea level. The calculation supposed a magnetizing field of 55300 nT, magnetic inclination of 66.5°, and magnetic declination of 15°E (Peddie and others, 1976; Fabiano and others, 1976). A constant value of 55320nT and a regional gradient of 42nT/km (12.8nT/kft) have been subtracted from the observed magnetic field of map B to yield the "observed" field shown here. Several local anomalies also have been removed.

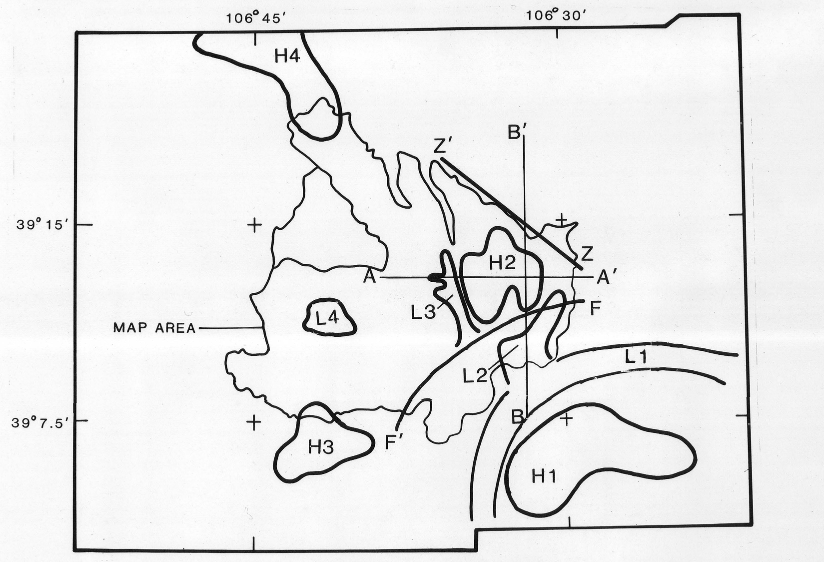

Figure 7.--Magnetic susceptibilities measured for samples from the study area. Absolute values shown may be somewhat in error due to calibration difficulties with the apparatus; relative values are thought to be accurate. On the average, granites from the study area have higher susceptibilities than schists. Tertiary dikes, thought to be volumetrically minor in the study area, have very low susceptibilities. Sample numbers (713) indicate collection site (see Ludington and Yeoman, 1981b).

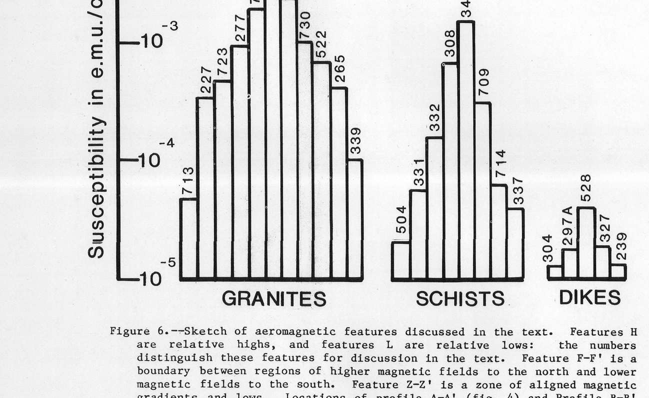

Figure 6.--Sketch of aeromagnetic features discussed in the text. Features H are relative highs, and features L are relative lows: the numbers distinguish these features for discussion in the text. Feature F-F' is a boundary between regions of higher magnetic fields to the north and lower magnetic fields to the south. Feature Z-Z' is a zone of aligned magnetic gradients and lows. Locations of profile A-A' (fig. 4) and Profile B-B' (fig. 5) are also indicated.

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