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OF THE MAGNETIC ANOMALY AT
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In January 1949 the Geological Survey of Canada made an aeromagnetic survey of part of southern Ontario between 77° 30' and 78° 00' (see Figure 1). Near the town of Marmora a very intense magnetic anomaly was recorded, which later proved to be the location of a magnetite deposit. Ground exploration indicated that the orebody contained 20 million tons of material averaging 35 per cent iron[1]. The following year a series of experimental flights was made over this anomaly to determine the effect of various altitudes on the intensity and dimensions of the anomaly. Flights were made at heights of 5,000, 2,000, 1,000, 500, 400, 300, 200 and 100 feet above ground level. Lines were flown in a north-south direction at a spacing of 1/4 mile.

The results of this survey are shown on Figures 2 to 9. The datum level is set at 56,000 gammas less than total field, and flights at the different altitudes have all been tied to the same datum level. Because of the extreme variation in magnetic intensity over the anomaly at low altitudes, the magnetometer recorder had to be set at a very low sensitivity. As a result the data may be unreliable in the areas of low magnetic intensity adjacent to the anomaly.

As would be expected, the major effect of a decrease in flight elevation is a great increase in the magnetic intensity of the anomaly peak. At the lower elevations also several smaller anomalies are resolved which at 5,000 and 2,000 feet are indicated only by a slight distortion of the main anomaly. The width of the anomaly increases slightly with height. In all except the 5,000-foot flight there is a pronounced low to the northeast of the anomaly.

The following table shows some of the basic data for the eight flights.

Table 1

Altitude (Feet above ground)	Anomalous Intensity of Peak (Gammas)	Horizontal distance from Peak to Depression (Feet)
5,000	169	—
2,000	951	6,040
1,000	3,100	3,000
500	4,480	2,650
400	7,000	2,130
300	6,600	1,900
200	8,000	1,900
100	11,100	1,700

The values for the anomaly on the 400-foot flight appear to be somewhat out of line with the others. There are two possible reasons for this:

(1) The magnetic intensity increased so rapidly that the magnetometer could not record all the data received. On some flight lines the resulting gaps in the records made it difficult to determine accurately the magnetic values.

(2) Because of the sharpness of the anomaly, if the flight path of the aircraft missed the peak by as little as 100 feet, the maximum value recorded might be several hundred gammas lower than the true maximum. The peak value recorded for the 400-foot flight may be the true maximum, whereas the 300-foot flight, and possibly others, may have missed the anomaly peak, giving a reading less than the maximum.

Figure 10 illustrates the Marmora anomaly in profile. The set of profiles has been drawn across the peak of the anomaly in a direction N 25° E.

Figure 11 is a vertical section of the magnetic field of the Marmora anomaly, plotted in a north-south direction. The figure was constructed by plotting on the section each flight line crossing the anomaly peak, at its correct elevation and marking on it the various magnetic intensities read. Points of equal magnetic intensity were then joined after the manner of constructing contours. The dimensions and location of the orebody are approximate. The magnetic field is somewhat asymmetrical, the peak being displaced toward the north at lower elevations. This is probably caused both by the southwest dip of the orebody and its limited depth. For these reasons the magnetic field is stronger toward the north side at low elevations producing the effect noted. As the distance from the body increases, this effect diminishes, and the magnetic field becomes fairly symmetrical over the body.

The graph in Figure 12 shows the relation between peak anomalous intensity and flight elevation. The anomaly intensity used is the difference in reading between the peak and the average background level, given in the second column of Table 1. When plotted against flight elevation these values give a fairly smooth curve, as shown by the solid line in the graph. Using the method of orthogonal polynomials, a curve has been fitted to the data, and is shown by the broken line. The equation of this curve was found to be

$$\Delta F = \frac{2.16 \times 10^{13}}{A^3 - 1850\,A^2 + 962 \times 10^4\,A + 62 \times 10^7}$$

where ΔF is the peak anomalous intensity in gammas and A is the flight elevation in feet.

This equation shows that at a height of about 2,000 feet the inverse cube law overtakes the inverse square law, indicating that the magnetic source is dipolar in nature. This conclusion is reasonable, as the body is known to be of limited depth.

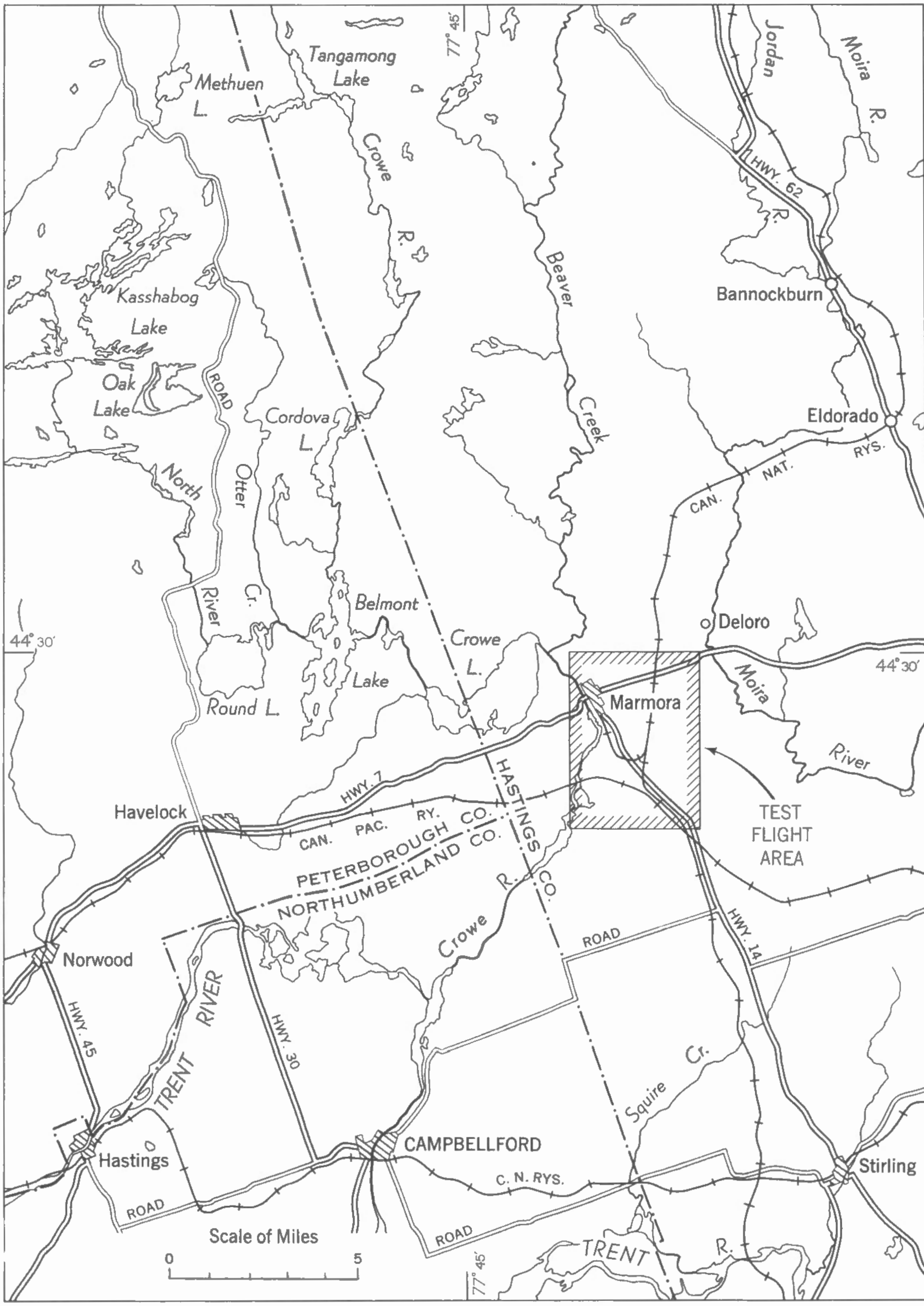
Several methods of determining the grade and tonnage of the orebody from the magnetic data were tried, but the results were not in agreement with known values. The body as determined from drilling was about 1,200 feet by 2,400 feet in plan, with the longer axis lying nearly northwest. The average thickness of the cap rock is about 100 feet; below this, the orebody is about 500 feet in vertical thickness. The ore is not sharply outlined but has assay limits. Grade calculations from aeromagnetic data alone varied by as much as a factor of two, depending on the thickness assumed for the body. It is possible to determine the approximate length, width, and depth of the body from the magnetic data, but no reliable determination of the thickness could be made. To calculate the grade, the volume of ore must be known.

A full discussion of the geophysical case history of this deposit is given by Wahl and Lake[2].

References

1. Rice, H. R.: Bethlehem's Marmora Mine; Can. Mining J., Nov. 1952, pp. 69-72.

2. Wahl, W. G. and Lake, S.: Methods and Case Histories in Mining Geophysics; 6th Commonwealth Mining and Metallurgical Congress, 1957.



G. S. C.

Figure 1. Index map showing position of Marmora test flights

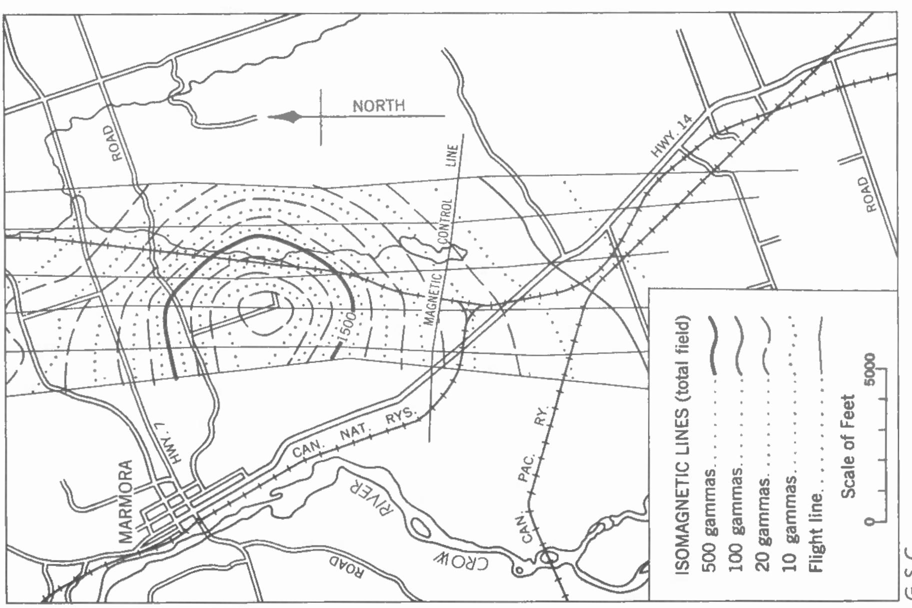


Figure 2. Flight elevation 5,000 feet

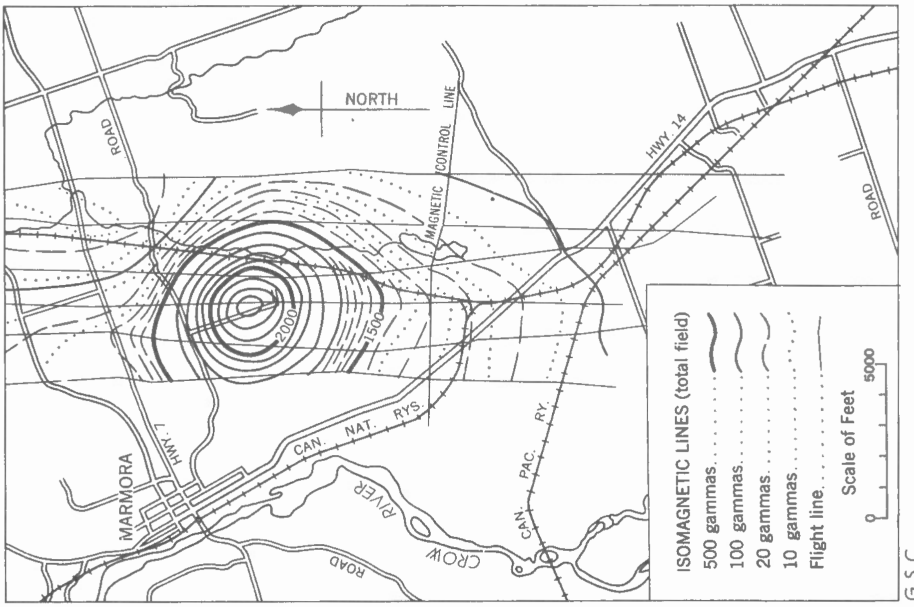


Figure 3. Flight elevation 2,000 feet

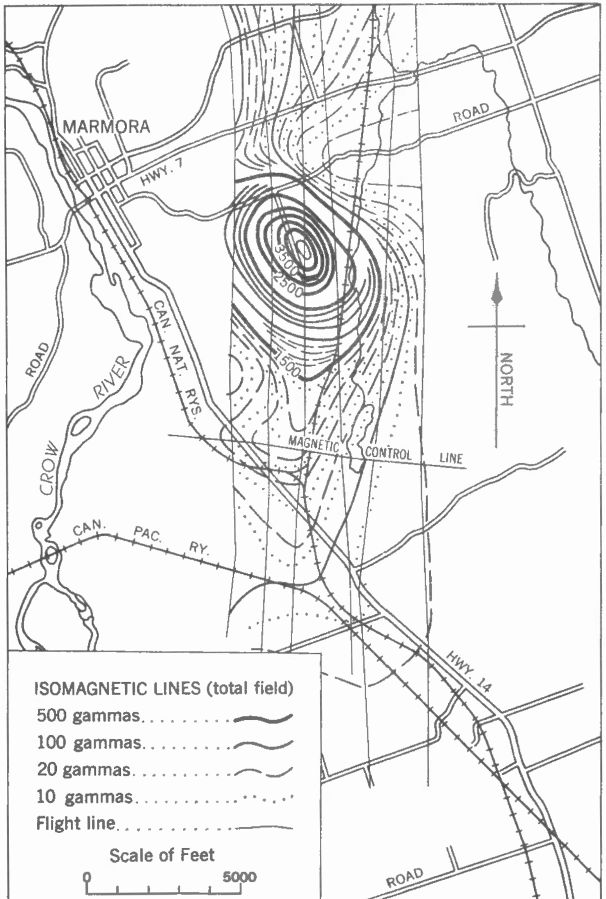


Figure 4. Flight elevation 1,000 feet

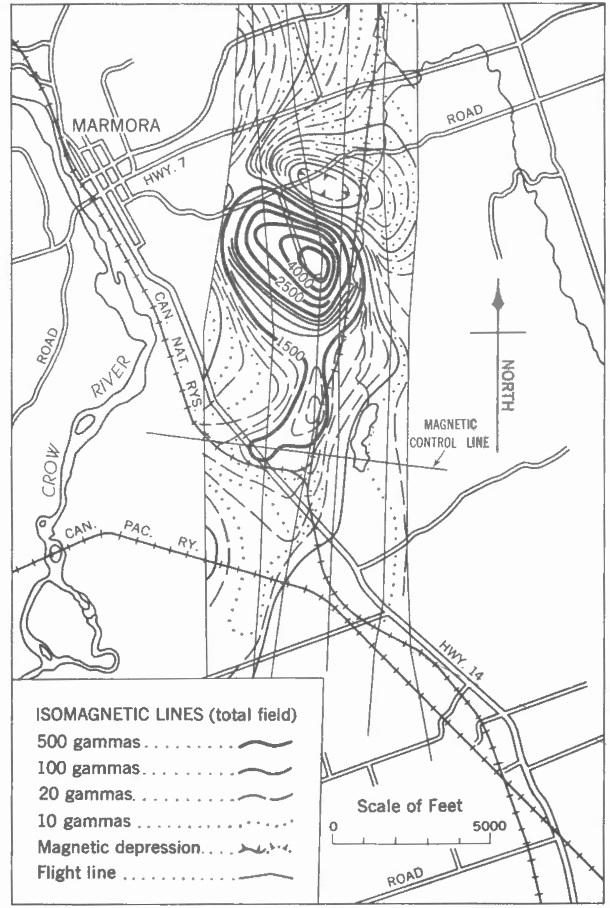
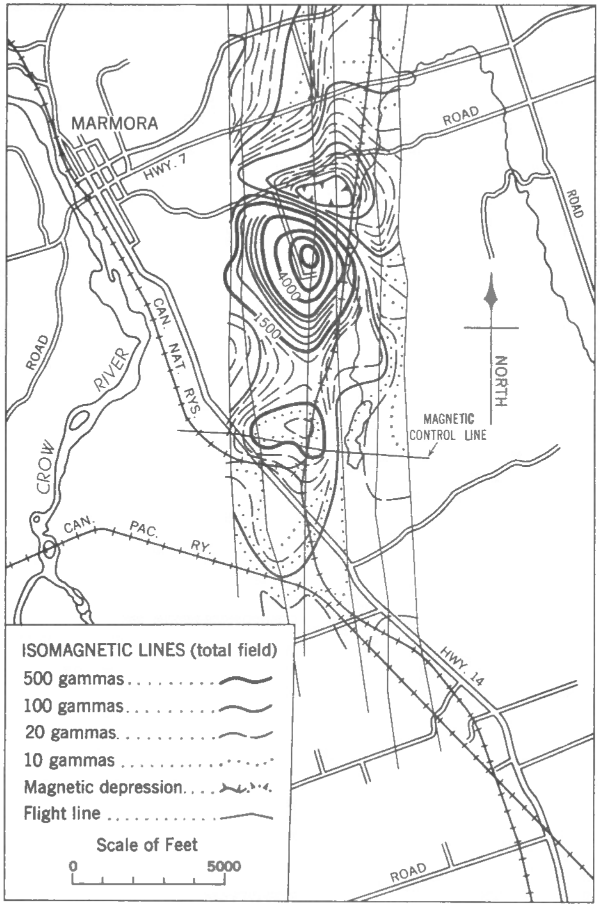


Figure 5. Flight elevation 500 feet



G. S. C.

Figure 6. Flight elevation 400 feet

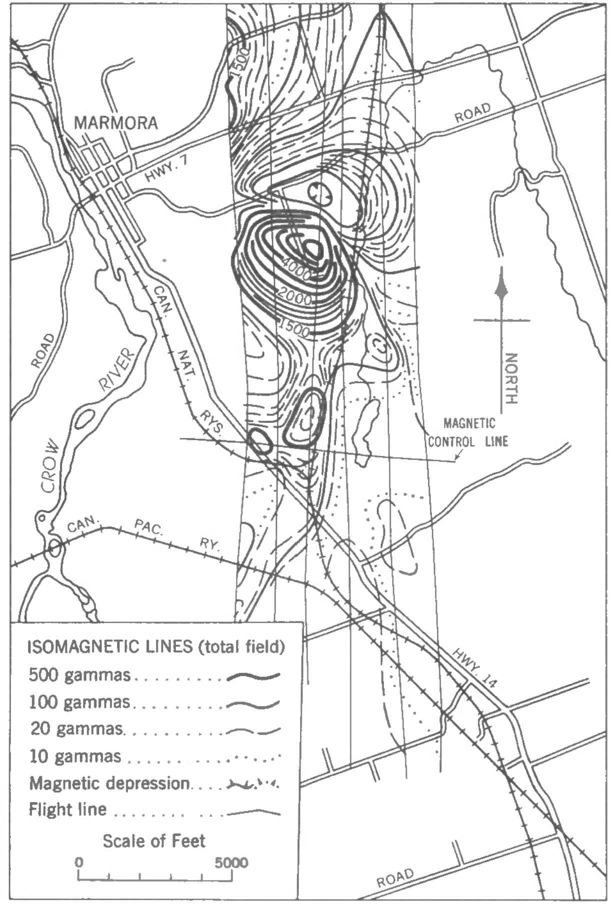


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Figure 7. Flight elevation 300 feet

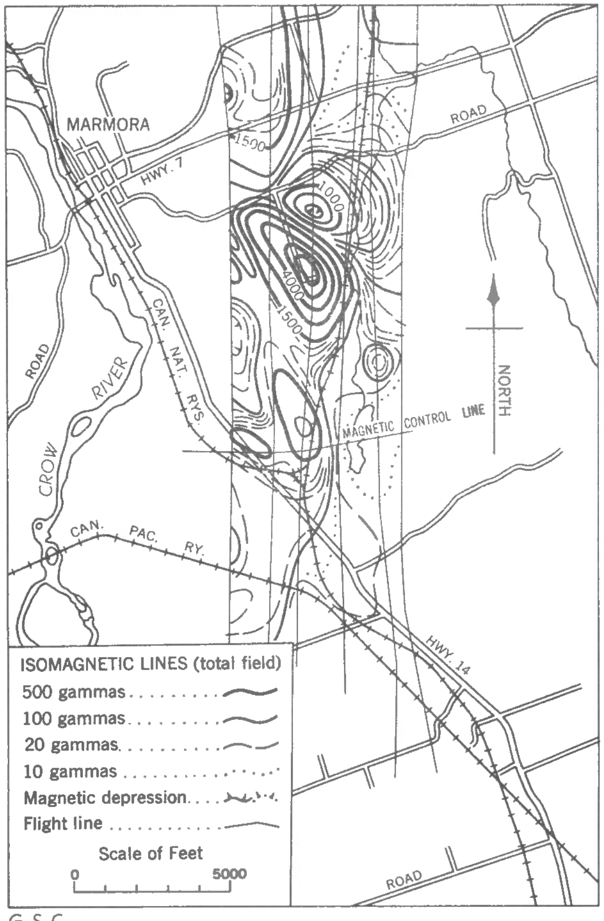

Figure 8. Flight elevation 200 feet

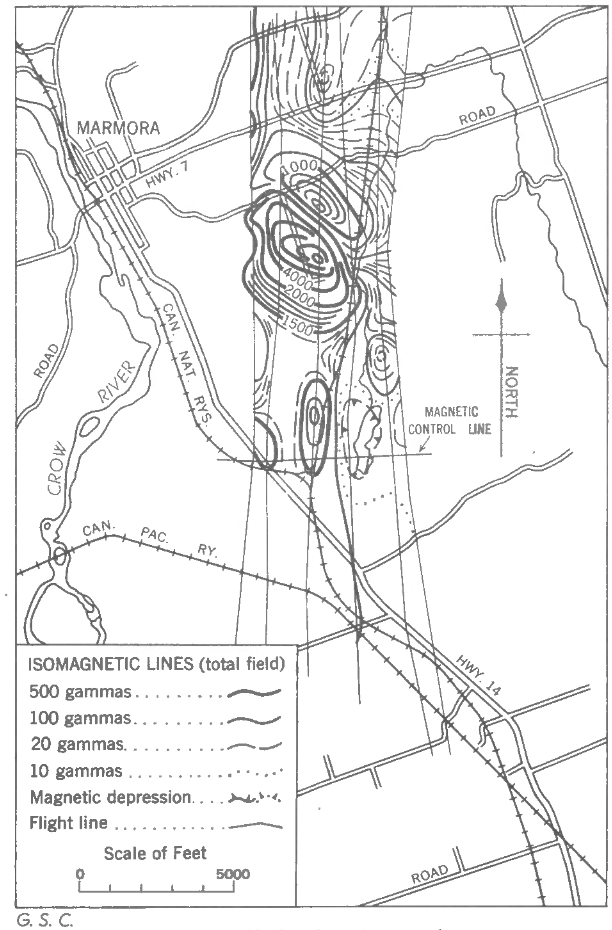

Figure 9. Flight elevation 100 feet

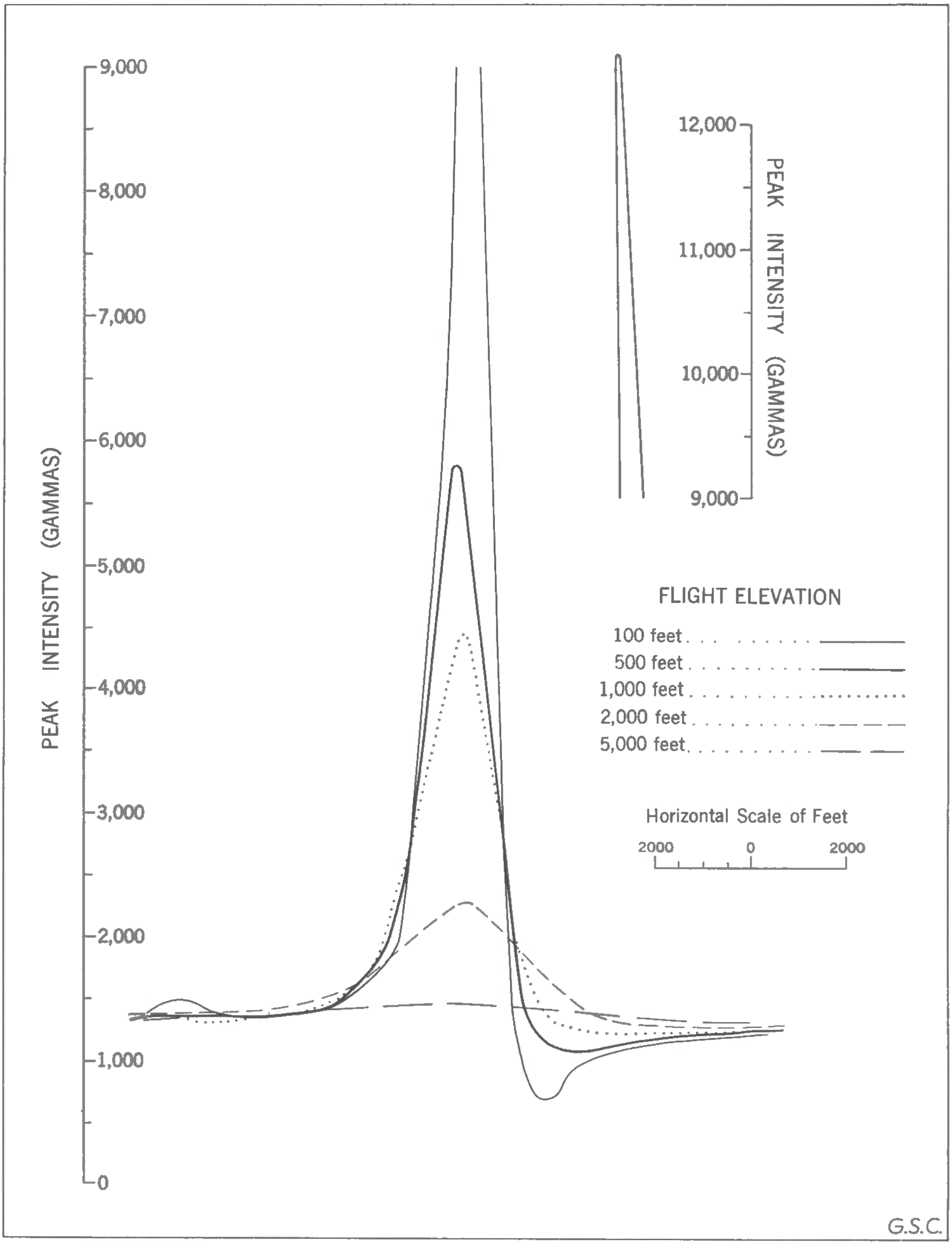

Figure 10. Profiles across peak of Marmora magnetic anomaly

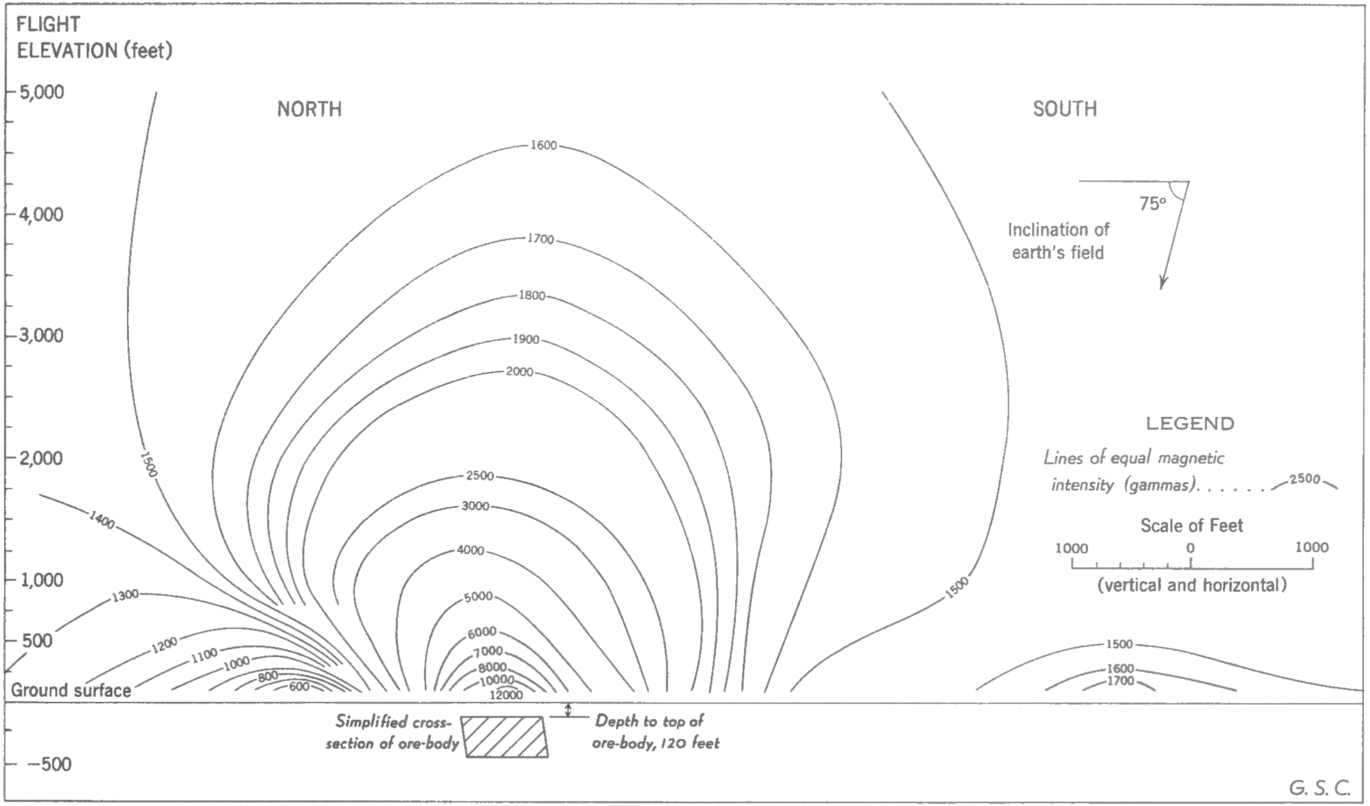

Figure 11. Marmora anomaly, vertical section of the magnetic field

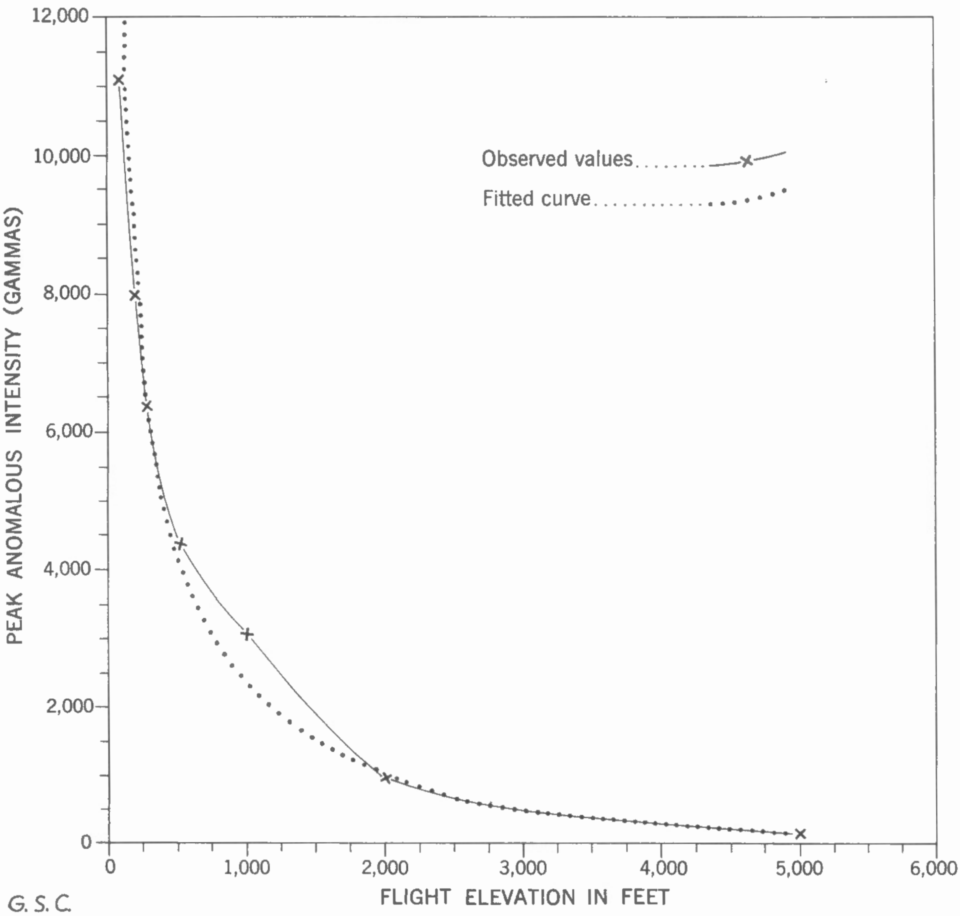

Figure 12. Relation between anomaly intensity and flight elevation