ROCK-MAGNETIC DATA AND ITS USE IN GEOPHYSICAL INTERPRETATIONS1/

By

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ABSTRACT

The following paper discusses the importance of remanent magnetism in the interpretation of magnetic anomalies. Examples are given, and methods are presented for combining magnetic measurements made on individual specimens. Finally, a comparison is made between a ground magnetometer traverse and a curve resulting from combining values of induced and remanent magnetism as measured of individual specimens.

This paper concerns the use of rock-magnetic data in the interpretation of anomalies in the geomagnetic field. Of special concern is the use of measurements of direction and intensity of remanent magnetism and of susceptibility.

Magnetic measurements made with a ground magnetometer include components of the earth's magnetic field and the field associated with the remanent and induced magnetism of a rock mass. Generally, that of the earth's field is compensated for in the measuring instrument, such that only the anomalous quantity present at the site is recorded. This method can produce a more accurate determination in that an anomaly of 100 gammas would be hardly noticed against a background of 50, 000 gammas, whereas, with a background of zero, 100 gammas is easily determined. It is this anomalous condition deviating from the background that is our main interest in this paper. The anomaly is a distance dependent factor, and given sufficient elevation at which the measurement is made, the effect would be insignificant.

In considering measured anomalies it has been common practice, in the past, to treat it as a function only of the induced magnetism of a mass of material. The induced magnetism being a function of the intensity of the earth's field and the susceptibility. The anomalous magnetism of a mass in reality includes not only induced magnetism but also a component of remanent magnetism. If total anomalous magnetism or total magnetism of a mass is the

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1/ Text of paper as originally presented at the 1964 NATO Advanced Study Institute "Procedures in Paleomagnetism" held at the University of Newcastle, Newcastle upon Tyne, England.

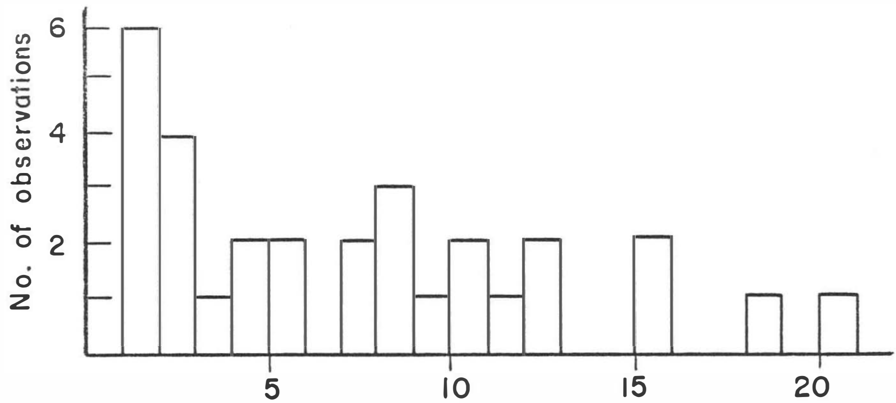

Figure 1.--Ratio of remanent to induced magnetism of some massive hematites (DuBois, 1962).

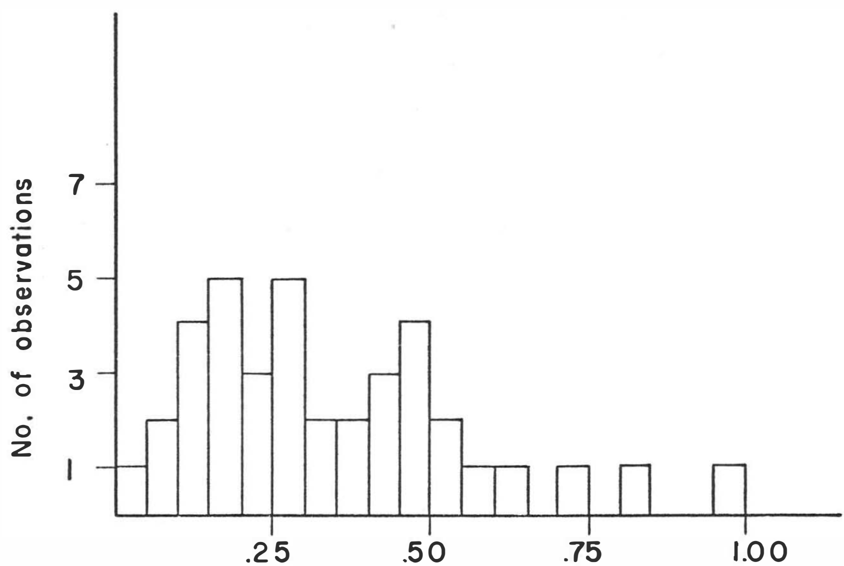

Figure 2.--Ratio of remanent to induced magnetism of some massive serpentines (DuBois, 1963).

sum of the induced and remanent magnetism, it is necessary to know the relative magnitudes of these two quantities in order to decide whether the remanent term can be neglected. The quantity "Q" as used by the rock-magnetist is the ratio of remanent to induced magnetism and provides a basis for this discussion. Q varies considerably for different rock masses, from values of 0.1 and lower upward to values of 100 or larger for other masses (figs. 1 and 2).

Not only is the intensity of remanent magnetism important, but so is the direction. A customary stereographic plot would give adequate information for a point consideration of the data but would be inadequate for a consideration at a lower elevation. Cases of combined reversed and normal magnetism in the same mass are especially important. Figure 3 is an example of a stereographic plot of the direction of the remanent magnetism, and figure 4 is a different type of plot of the same data but plotted as a function of position in the outcrop. This method of presentation of data brings out the existence of magnetic cells or areas with similar directions of magnetism.

Figure 5 is a stereographic plot of some hematites having both normal and reversed directions, which provide an example for the consideration of remanent, induced, and total magnetism. The average intensity of the remanent magnetism for the southwest group is 423×10^{-6} emu/cc, and for the northeast group it is 185×10^{-6}. These data can be averaged for purposes of geophysical considerations by simply weighting each vector as one, the procedure used in paleomagnetism, or by weighting each according to intensity. Figure 6 gives the results of these calculations. This treatment of the data is adequate to give a single vector for the entire mass. It is, however, not adequate for a detailed treatment.

Figure 7 is a curve showing the results of a vertical intensity ground magnetometer traverse taken across a large outcrop and presents the anomaly from this situation. Figure 8 shows the results of magnetic measurements made on individual specimens collected along the traverse. Curve 1 shows the intensity of the vertical component of the remanent magnetism, curve 2 that of the induced magnetism, and curve 3 that of the total magnetism. Curve 3 is determined by a vector sum, weighting each component according to its intensity. In most cases the total magnetism is controlled by the induced magnetism, but at several points the remanent and induced magnetism combine to give large values for the total. The effect of ignoring remanent magnetism in a consideration of the total magnetism in this situation is obvious. Figure 9 is presented to compare rock-magnetic measurements with the results of the ground magnetometer survey. A good agreement is noted in broad aspects as well as in small-scale inflections.

In conclusion, the usefulness of measurements of remanent magnetism in the understanding of magnetic anomalies has been suggested. A sum of intensity weighted vectors is shown to be useful, and the summary of data for individual stations seems to be significant. An intensity weighted average may be compared to a unit weighted average as some indication of a lack of stability in that if the two averages are similar, there is no bias for the stronger specimens.

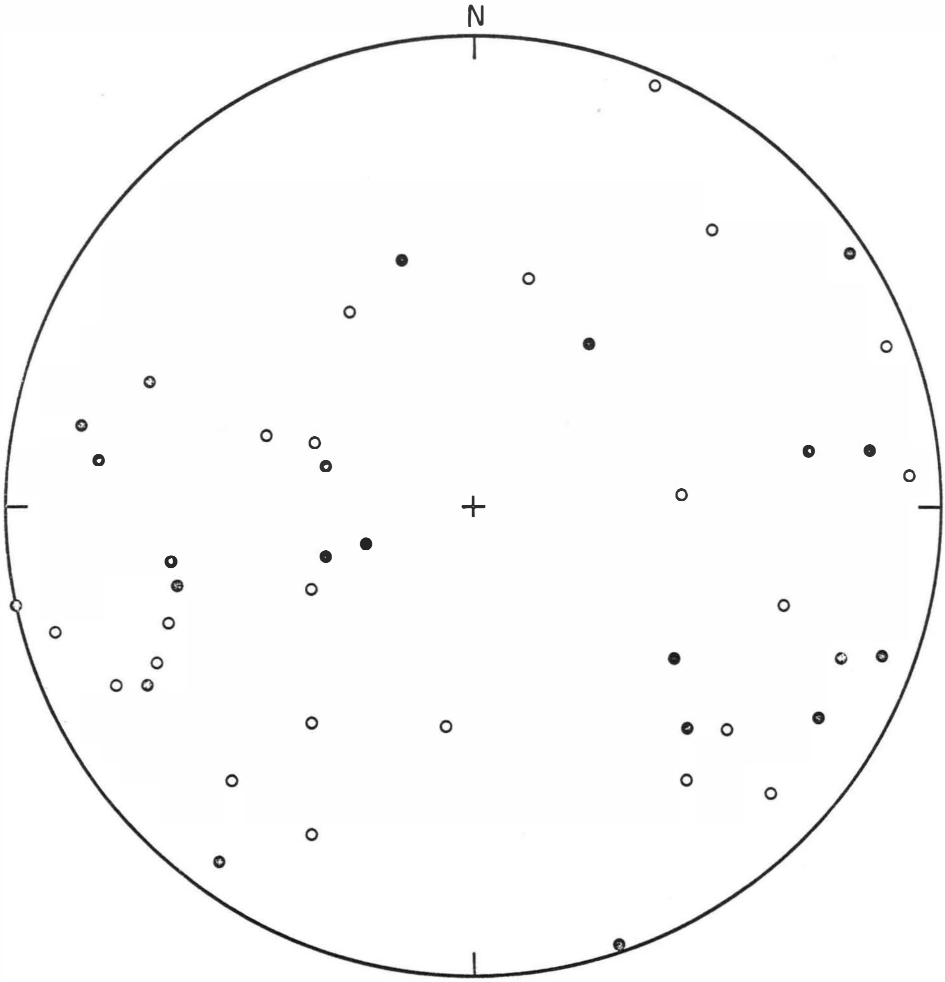

Figure 3. --Direction of remanent magnetism (DuBois and Carey, 1964).

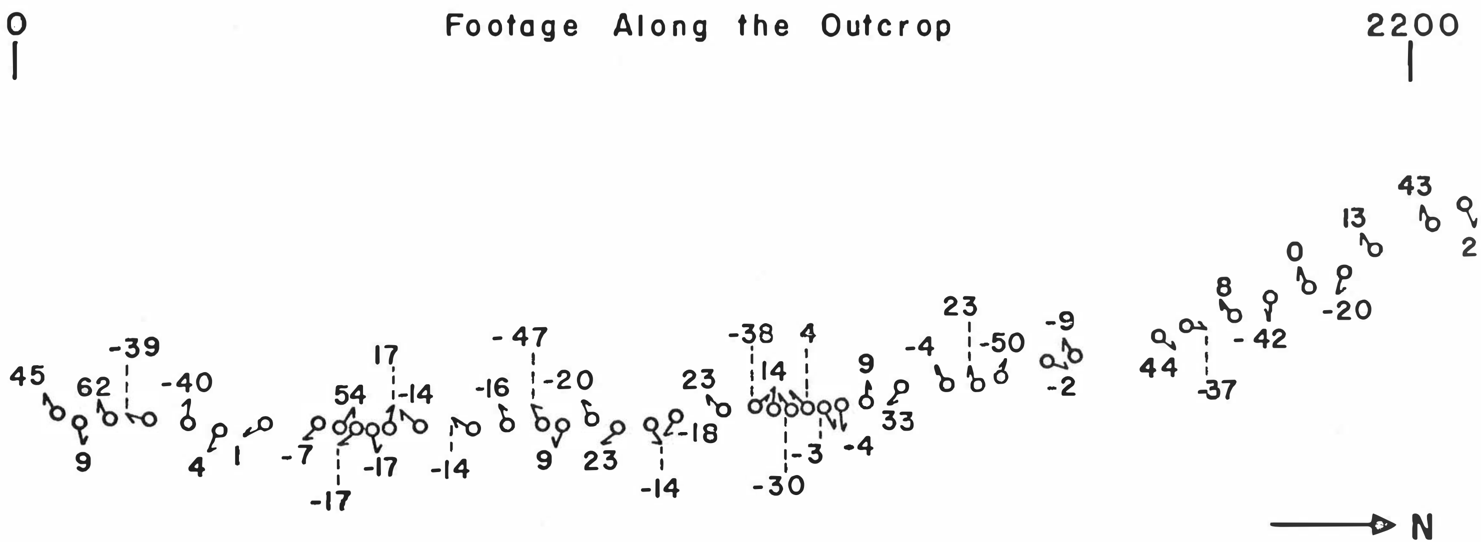

Figure 4. --Direction of remanent magnetism (DuBois and Carey, 1964).

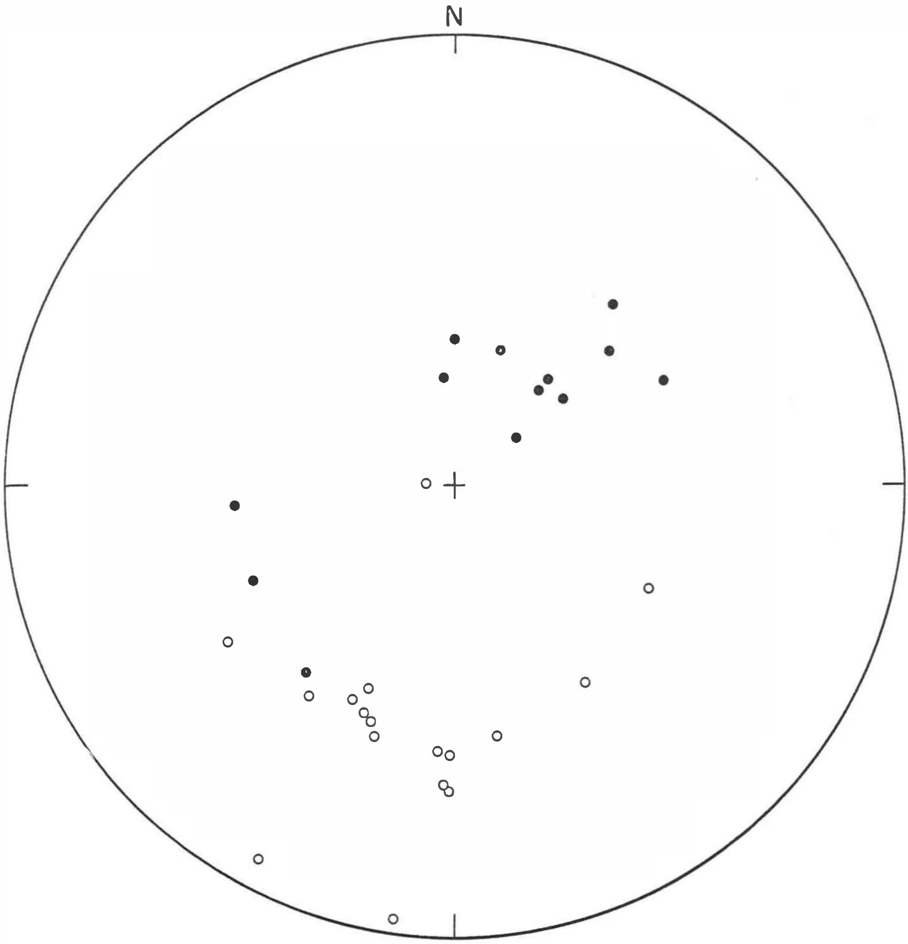

Figure 5. --Direction of remanent magnetism (DuBois, 1962).

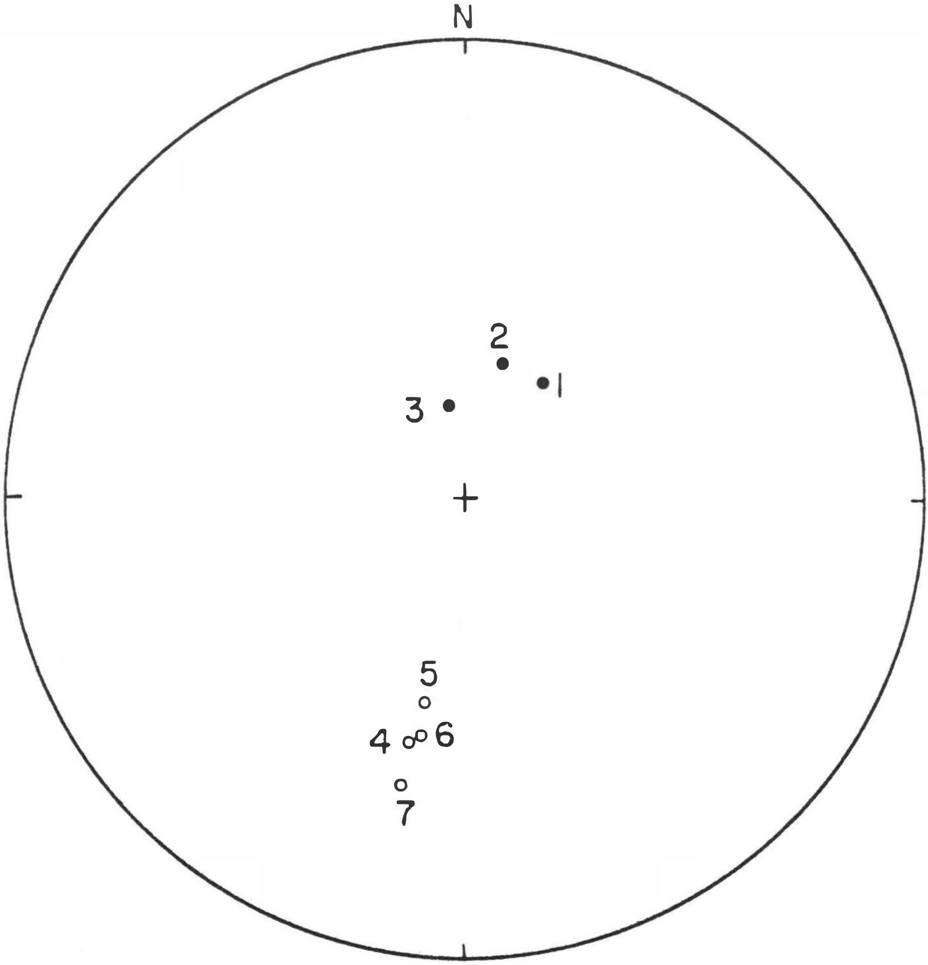

Figure 6.--Average direction of magnetism of massive hematites. (1) Average direction of northeast remanent magnetism, each sample given unit weight; (2) average direction of northeast remanent magnetism, each sample weighted according to intensity; (3) direction of induced magnetism; (4) average direction of southwest remanent magnetism, each sample given unit weight; (5) average direction of southwest remanent magnetism, each sample weighted according to intensity; (6) average direction of both northeast and southwest remanent magnetism, each sample weighted according to intensity; (7) average direction of remanent and induced magnetism, each sample weighted according to intensity (DuBois, 1962).

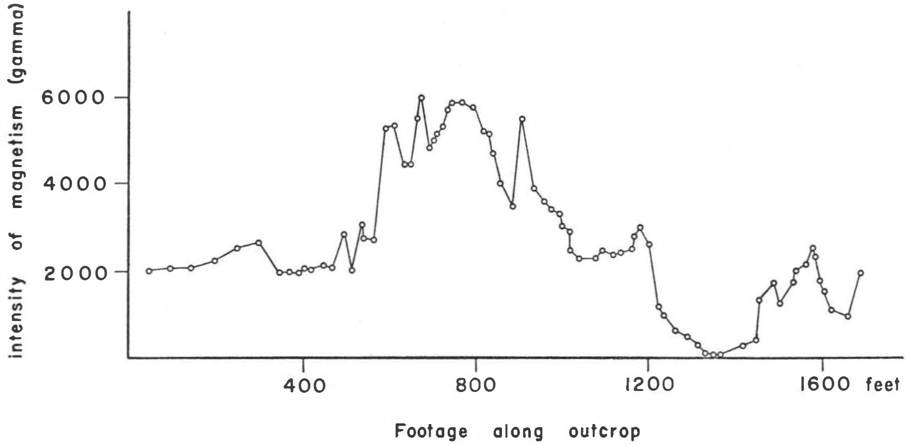

Figure 7. --Vertical-intensity ground magnetometer profile (DuBois, 1963).

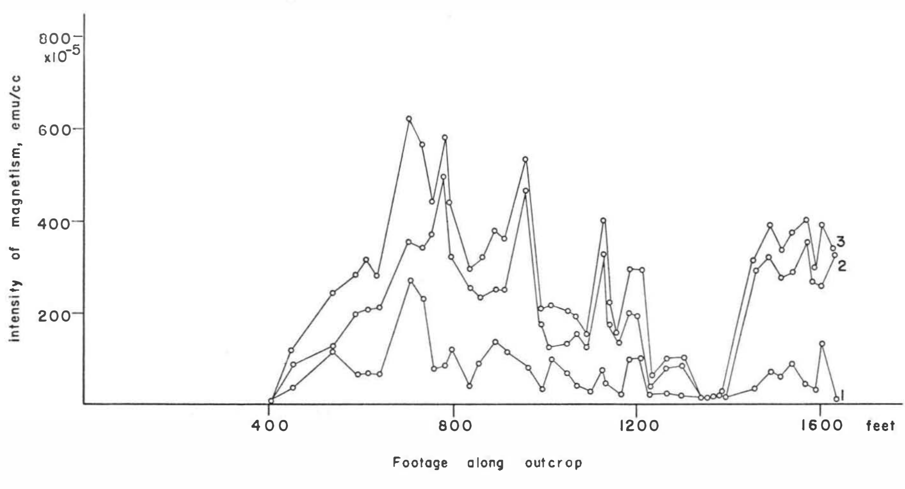

Figure 8. --Plot of intensity of vertical components of remanent, induced, and total magnetism as measured from individual specimens. Curve 1 is the intensity of the remanent magnetism, curve 2 is the intensity of the induced magnetism, and curve 3 is the total magnetic intensity (DuBois, 1963).

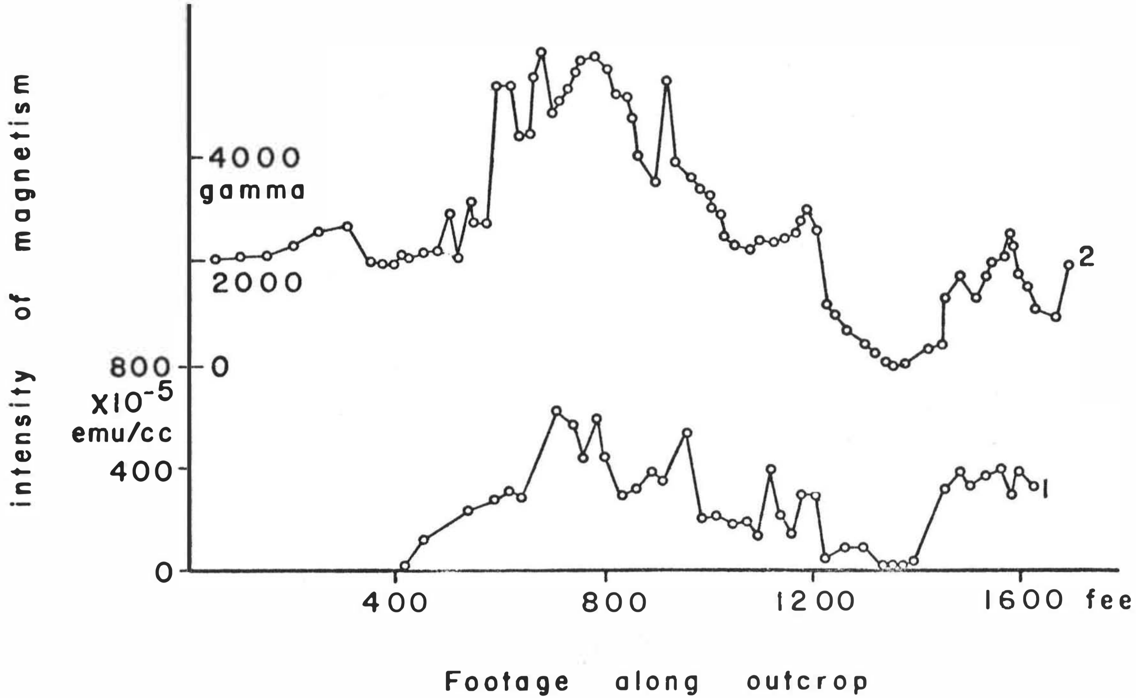

Figure 9.--Plot of intensity of magnetism as determined from individual specimens and from vertical-intensity ground magnetometer measurements. Curve 1 is the intensity of the vertical component of magnetism determined from individual specimens, and curve 2 is the intensity ground magnetometer measurements (DuBois, 1963).

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