THE USE OF MAGNETIC INTENSITY IN MAPPING GREENSTONE CONTACTS IN THE CATOCTIN FORMATION, BUENA VISTA QUADRANGLE, VIRGINIA

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INTRODUCTION

Buena Vista is located in central Virginia on the western flank of the Blue Ridge province. The purpose of this project is to examine the magnetic characteristics of the rocks in the Catoctin, and to determine to what extent a magnetometer can assist in the location of contacts, particularly the predominant volcanic greenstones of the Catoctin. The study was conducted along several forest service roads (Figure 1), concentrating on four lines running across the contacts between the Blue Ridge basement complex and the Catoctin Formation; and between basalt flows and sedimentary rocks in the Catoctin Formation.

THE CATOCTIN FORMATION

The Catoctin Formation is Early Cambrian in age--dated at about 570 MA (Bartholomew, et al, 1991, p.72); directly above the Catoctin is the Cambrian age Unicoi. Precambrian basement from the Pedlar Massif is thrust over the Catoctin by the Blue Ridge thrust along the eastern edge (Spencer, in press).

The Catoctin is composed of altered volcanic greenstones, arkoses and tuffaceous sandstones. There are some iron-cemented granule conglomerates as well. The thickness and structural attitude of the Catoctin is difficult to assess, as there are very few primary structures in the greenstones. However, the formation thickens rapidly to the east and southeast (Werner, 1966, p.14).

The greenstones are generally massive, fine-grained and dark green. In the study area they are typical of the uppermost greenschist facies. The flows are thought to have originated from the many feeder dikes that cut through the Grenville basement rocks. In the Buena Vista quadrangle the greenstones trend northeast - southwest. The sedimentary units are several inches up to 100 feet in thickness. The arkose is a white, pink or light-green medium to course grained rock. Some of the arkoses are cross-bedded. The tuffs are a few inches up to five feet in thickness and are maroonish to reddish brown in color. These rocks are very fine grained and have a southeast dipping slaty cleavage.

PROCEDURE

Magnetic intensity readings were taken along several lines in the Buena Vista, Virginia quadrangle using a proton-precession magnetometer (Figure 1). Time of day , visible contacts or outcrops of greenstone, as well as the location of culverts or other metal objects were recorded. Observations were made at intervals of twelve to 100 feet, depending on the variations in the readings. Readings were also retaken at the beginning of the line to close the loop, thus controlling drift. The intensities were then plotted and compared with the mapped contacts of the greenstones, as well as to the locations of the culverts (Figure 2). Although some anomalies result from proximity to metal culverts, many coincide with greenstones; others do not coincide with contacts of greenstones. Six greenstones, most from locations coinciding with anomalies, and three samples of sedimentary rocks within the Catoctin were sampled for use in determining the magnetic properties of the Catoctin. The samples that were taken along lines AA and BB are labeled with numbers on Figure 2.

Magnetic susceptibility readings were conducted at the University of Delaware on all nine samples using a Bartington Magnetic Susceptibility Meter. The susceptibility of the greenstones range between 2017×10^{-6} and 9166×10^{-6} m^3. The sedimentary samples also have variable susceptibilities, although their readings are much lower, ranging from 237×10^{-6} to $4500 \times 10^{-6} m^3$.

The natural remnant magnetization (NRM) of the samples was measured using a spinner magnetometer. According to M.W. McElhinny (1973) the natural remnant magnetization is "the fossil magnetism of rock measured initially" (p.17). The NRM of a sample can be acquired through cooling through the Curie point, chemical action during the formation of iron oxides, as well as the alignment of detrital magnetic minerals (McElhinny, 1973, p.17). The intensity of the greenstones is considerably higher than that of the sediments.

Next, the samples were exposed to an alternating field--a strong, declining AC field and a weak, biasing DC field, which produced an anhysteretic remnant magnetization (ARM). The anhysteretic remnant magnetization is proportional to grain size and concentration of magnetic minerals in the sample. The readings for the greenstones are all very high, but more importantly, one of the sedimentary samples, a graywacke, also shows an exceptionally high ARM. This same sample also exhibits a high susceptibility reading.

Finally, experiments were conducted to determine relative amounts of magnetite and hematite. Experiments conducted by D.W. Collinson (1956) show that the bulk of a sample's natural remnant magnetization is caused by minerals such as magnetite and hematite (McElhinny, p.101). The Isothermal Remnant Magnetization (IRM) was taken by exposing the samples to a DC field capable of saturating magnetite and hematite. A field of one Tesla is standard, but due to the high amount of hematite in the samples , a field of 1.7 Tesla was initially used. The hematite in two of the sedimentary samples, one arkose and one tuff, were still not saturated at this point , so the field was taken to two Tesla. A reverse field capable of saturating magnetite is then applied. The standard of -0.3 Tesla was used, but again this was not sufficient for the two sedimentary samples above, so a field of -0.7 Tesla was applied . The remaining remnant intensity after the reverse field is applied is considered to result from the presence of hematite. The isothermal remnant magnetization of these samples shows a relatively high proportion of hematite. However, what was surprising is that the arkose and the tuffaceous sandstone both show extremely high amounts of hematite. These are the two samples that show relatively low susceptibilities. Although magnetite has a much higher susceptibility than hematite, the presence of hematite requires a much higher field strength to bring the saturated sample's intensity to zero. Therefore, it is possible that the magnetism in the greenstones and the graywacke is caused more from magnetite, whereas the arkose and the tuff each receive their magnetism from hematite.

CONCLUSIONS

The experiments conducted show that a considerable amount of magnetic material is present in the Catoctin formation. High concentrations of magnetite and/or hematite account for some of the anomalies. Anomalies on the order of a few tens to a few hundreds are associated with culverts, whereas much larger anomalies are associated with greenstones. The magnetic readings across outcrops can possibly be explained by the dip on the greenstones. Example anomalies in several texts give similar results for readings over dipping dikes. The readings under outcrops A, C and G (figure 2) are all similar to those given over an eastward dipping dike. Outcrops D and H all appear to be vertical dikes from their signatures. Outcrops E and F run along strike, which may account for the unusual anomalies in these locations. Outcrops C ,D and E are all located fairly close to one another--the possibility exists that their signatures are overlapping, which may be skewing the anomaly to some degree. An anomaly is also located directly beneath the location of sample 7 (Figure 2). Sample 7 is an arkose which contains a large amount of hematite, which probably accounts for the strong signature. Another large anomaly is located between outcrop A and the next outcrop (unlabled). The mapping of the greenstone contacts is not exact--some dikes have been projected across the road, where no actual outcrop may exist. In this case, and in the case of outcrops which do not have a strong signature, it is possible that the mapped contact may be off. As for the outcrops that do not have a readily identifiable signature, the possibility exists that the concentration of the magnetic minerals in that particular location is not high enough to give a characteristic reading, or the intensity is similar to that of the surrounding sedimentary rocks, making the distinction of a contact difficult.

This analysis is still in progress. Continued experimentation on the presence of magnetic minerals is being conducted in hopes of determining the cause of the anomalies. Some samples are currently being analyzed in Liverpool, England and Palisades, New York. Samples will also be analyzed using a scanning electron microscope to obtain a representative petrology for the Catoctin as a whole, to be compared with previously published results. The results from the SEM analysis will also help to determine the concentration of magnetic minerals at the sites where the samples were taken, which will help to coordinate the presence of greenstones with anomalies. Modeling of the anomalies will also be done to compare with example anomalies over dipping beds. This will then be compared to the known dip of the greenstones to determine coordination.

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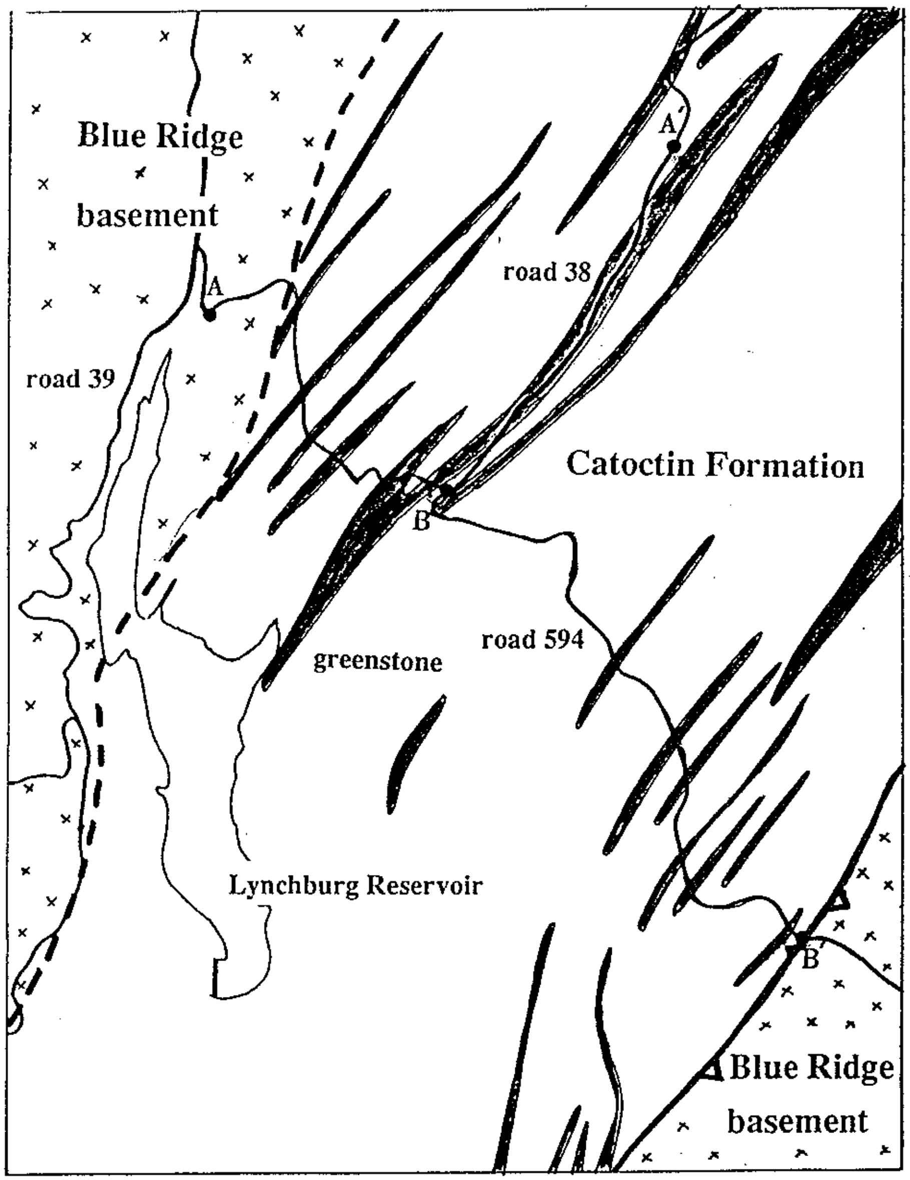

Figure 1. Location of traverses. The first section of line AA ends at the junction of Forest Service road 39 and FS road 594. The second section of this line runs northeast along FS road 39. Line BB starts at this junction and ends at the Blue Ridge thrust. Geology is simplified after Spencer (in press).

MAGNETIC INTENSITY VERSUS DISTANCE

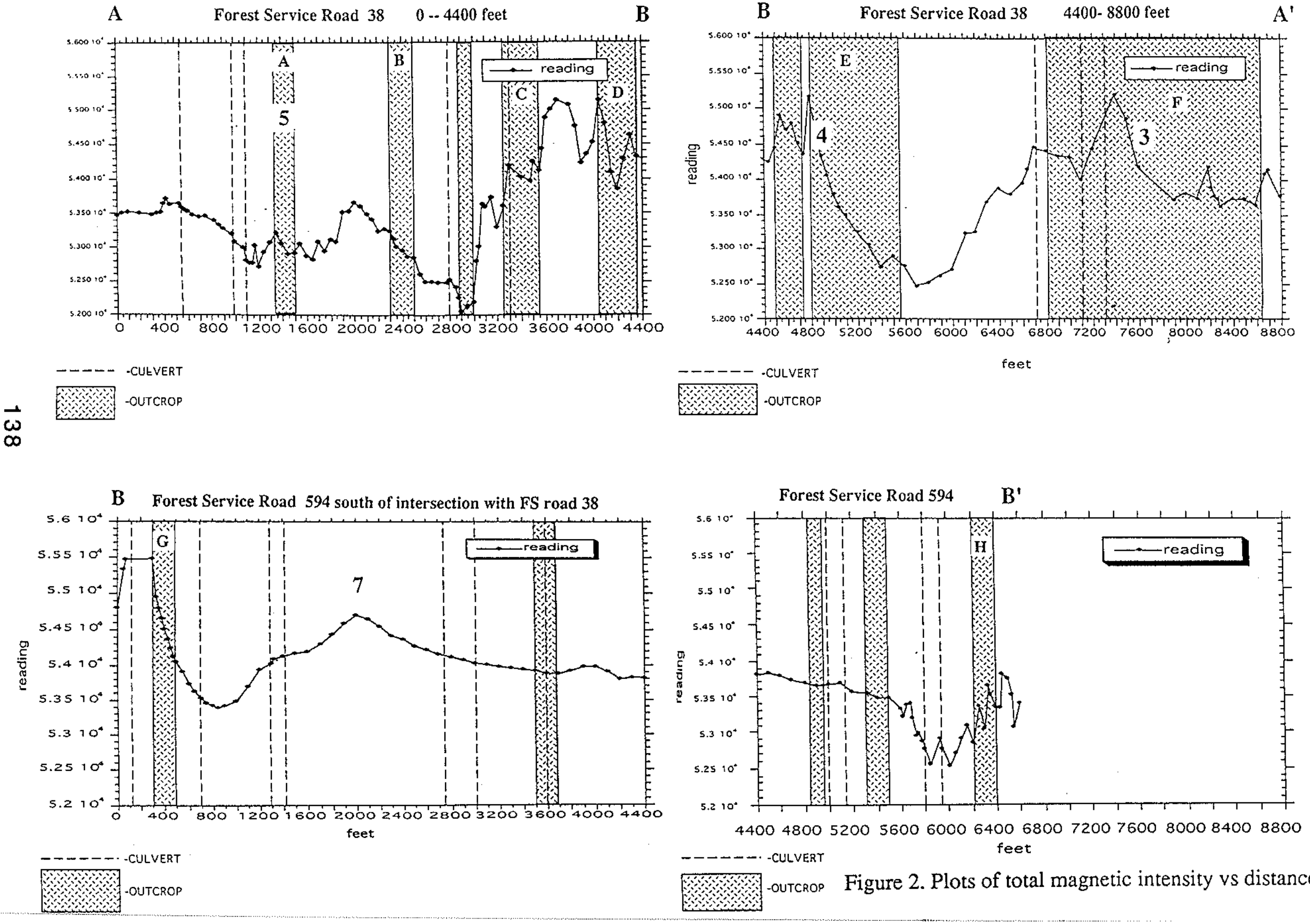

Figure 2. Plots of total magnetic intensity vs distance.