Letters to the Editors

INTERPRETATION OF THE BATHGATE MAGNETIC ANOMALY,
MIDLAND VALLEY, SCOTLAND.

Sirs—The most striking and unexpected feature of the aeromagnetic map of the Midland Valley of Scotland One-Inch Geol. Surv. sheet 11 is the large sub-circular positive anomaly centred at NT co-ordinate [2900 6700], which, for convenience, I will henceforth refer to as the Bathgate magnetic anomaly. A depth estimate of 4.8 km has been given by Powell (1970) for the body causing this feature; this note presents an alternative interpretation.

Comparison of the anomaly contours with theoretical magnetic fields prepared by Vacquier et al. (1949) suggests that the causative body can be approximated by a vertical prism, of square plan section, magnetized by induction in the earth’s magnetic field and the interpretation has accordingly been performed by finding such a prism whose magnetic field gives the best least squares fit with the observed data. The use of the prism approximation for the body shape may appear to be an over simplification, however, as shown below, the use of a more sophisticated model is prevented by the effects of secondary magnetic features. Fig. 1 shows the results of the interpretation.

The north-south magnetic profile across the centre of the anomaly was regenerated with the detail shown by using cubic splines (Bhattacharyya 1968) to interpolate between values digitized from the magnetic contour map. A non-linear least squares algorithm based on the Rosenbrock (1960) method of rotating co-ordinates was used to fit the observed data to the theoretical magnetic field of an appropriate prismatic body calculated according to the theory published by Andreasen and Zeitz (1969). The parameters allowed to vary during the curve matching process were: prism depth, width, vertical thickness, body susceptibility contrast and a constant regional magnetic background level.

The section (Fig. 1) shows a distribution of igneous rocks deduced from the 1:253,440 (4 miles to 1 inch) IGS geological maps, and the discrepancies between the observed and calculated curves can be attributed to the magnetic effects of these rocks. The data used in the curve matching process was pre-conditioned by eliminating the magnetic values obviously due to the outcropping Old Red Sandstone lavas, however, determination of the magnetic effects of the other igneous features is more subtle. The theoretical magnetic anomalies computed by Vacquier et al. (1949) show that the magnetic anomalies due to thin sheets and prisms at the latitude of the Midland Valley are generally characterized by magnetic lows on their north side. Such effects associated with the Carboniferous volcanics could explain the discrepancy in the curve match between 650 and 670 km and the effects of the Midland Valley sill could explain the mismatch between 670 and 685 km.

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Fig. 1. Interpreted profile across the Bathgate magnetic anomaly. The section has been deduced from available geological maps. [NT 290 000E]. DAL = Dalradian, ORD = Ordovician, SIL = Silurian, ORS = Old Red Sandstone sediments, ORL = Old Red Sandstone lavas, CS = Carboniferous sediments, CV = Carboniferous volcanics, MVS = Midland Valley Sill, Cd = Carboniferous dyke, td = Tertiary dyke, S = serpentine, HBF = Highland Boundary Fault, SUF = Southern Uplands Fault. IF = Inchgotrick Fault, OF = Ochil Fault.
Old Red Sandstone lavas have been reported by Falcon and Kent (1960) in the Salsburgh bore hole (Fig. 1) which is located approximately 5 km west of the section line and magnetic effects from these lavas could account for some of the other irregularities in the measured profile.

Although magnetic interpretation is desirably an objective process, considerations such as have been discussed above often necessarily introduce subjective factors. The interpreted depth for the magnetic feature (9.9 km below the survey level of 300 metres above ground level is markedly deeper than the figure given by Powell and this is most likely due to Powell placing a greater emphasis on the steep gradient between 670 km and 680 km than I have. If the curve matching process had been constrained to give a better fit in this region then a shallower depth estimate would have been obtained.

As Armstrong and Paterson (1970) have estimated the thickness of the Old Red Sandstone to be 12 km in the Midland Valley (in the Strathmore region), the interpreted depth of 9.9 km is not unreasonable.

Powell based his interpretation on an upward continuation technique and I have computed upward continuation maps of the area (Gunn 1972). Upward continuation produces a visually satisfactory elimination of the interfering magnetic effects of smaller magnetic features, however, the spectral overlap which occurs between all magnetic anomalies precludes the complete elimination of these features without some distortion of the anomalies of interest. For this reason I have not used filtered results in my interpretation.

Conclusions on the origin of the Bathgate magnetic anomaly are largely speculative at this stage. The only other magnetic anomaly of comparable dimensions in the Midland Valley is due to the Tertiary igneous centre of Arran which is located on a well defined line of similar centres distinct from the isolated Bathgate anomaly. Powell infers, on the basis of a gravity high on its western flank, that the rock causing the Bathgate anomaly is denser than granite. This suggests a possible similarity with the Middle Old Red Sandstone Distinkhorn granodiorite (Macgregor and Macgregor 1948) which causes a magnetic high and a gravity high in data published by McLean and Qureshi (1966).

REFERENCES


Letters to the Editors


P. J. GUNN

*Geology Department,*
*University of Durham.*

present address:
*Geological Survey of Victoria,*
107 Russell Street, Melbourne,
*Victoria, Australia.*

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Sirs—As Dr. Gunn points out the interpreted depth to the top of the assumed prismatic body is sensitive to the contributions to the observed anomaly from other sources which are partially specified by the known geology. The least squares fitting model would carry more weight if these contributions could be assessed and subtracted first. Fig. 1 (National Grid line 290 000) is a poor basis for this as it misrepresents the potentially most important unit—the Lower Carboniferous lavas which are known to lie just over a kilometer deep in two bores (Rashiehill and Salsburgh; Anderson 1963) and are of this order of thickness. Correction for them and a similar correction to the gravity anomaly for Carboniferous sedimentary basins is being carried out and, hopefully, will lead to a more objectively controlled conclusion.

Reference


D. W. POWELL

*Geology Department,*
*University, Glasgow.*

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Evidence for Post-Hercynian Transcurrent Movement on the Great Glen Fault in the Moray Firth

Sirs—In a recent letter to this *Journal*, Bacon and Chesher (1975a) present a map of the Moray Firth showing the depth to a reflector horizon tentatively identified as the