Reports

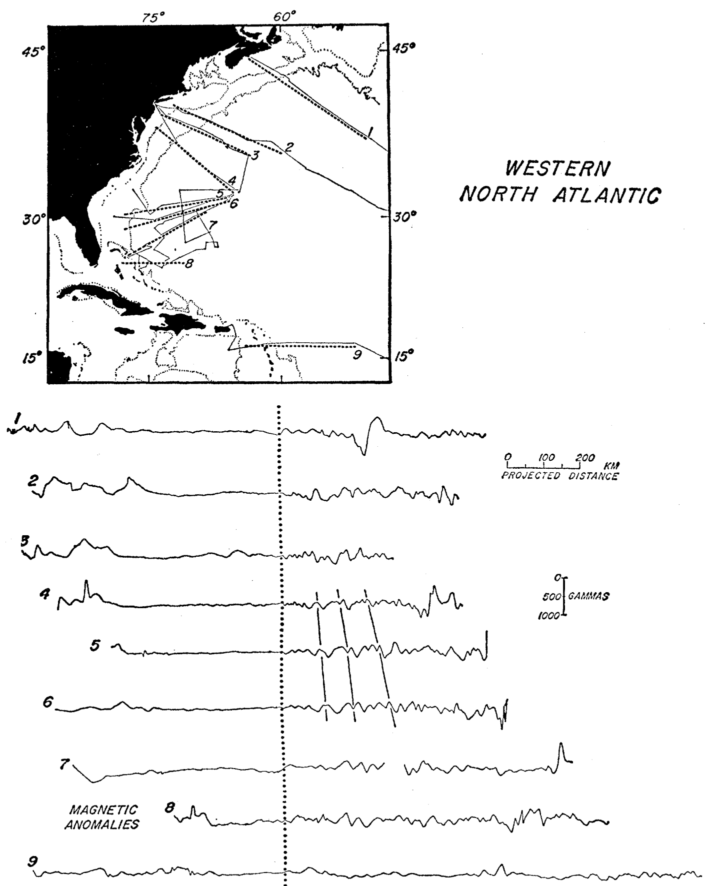
Magnetic Boundaries in the North Atlantic Ocean

Abstract. *Magnetic boundaries parallel the continental slope and separate undisturbed from disturbed magnetic regions on both sides of the North Atlantic. The boundaries lie 2000 to 2500 kilometers from the axis of the mid-Atlantic ridge and roughly equidistant from it. The undisturbed zone, lying on the continental side of the boundaries, may reflect the long period of no reversals in magnetic polarity that occurred during the late Paleozoic.*

A distinct line that separates disturbed from undisturbed magnetic regions in the western North Atlantic was first observed by King *et al.* (*1*); it was later mapped by Heirtzler (*2*). Vajk and Miller have suggested that three contrasting magnetic zones exist for the area, and they and Windisch *et al.* (*3*) investigated the possible relation of these zones to physiography and structure. In this report we present new data for the eastern North Atlantic which clearly demonstrate that a similar line separating disturbed and undisturbed magnetic zones exists in this eastern area and that it can be mapped over a greater range of latitude than in the west.

Figure 1 shows nine magnetic anomaly profiles across the western basin of the North Atlantic. The profiles are aligned with respect to the previously mentioned magnetic boundary and have been projected along the dashed lines shown on the accompanying index map. Projected profiles normally serve to remove distortions in the pattern of the anomaly caused by irregularities in ship tracks. The excellent correlation across several profiles of individual anomaly peaks adjacent to and east of the boundary is indicated. Though not definitive, additional anomaly correlations are strongly suggested.

Representative magnetic anomaly profiles for the eastern North Atlantic are shown in Fig. 2; these are also aligned



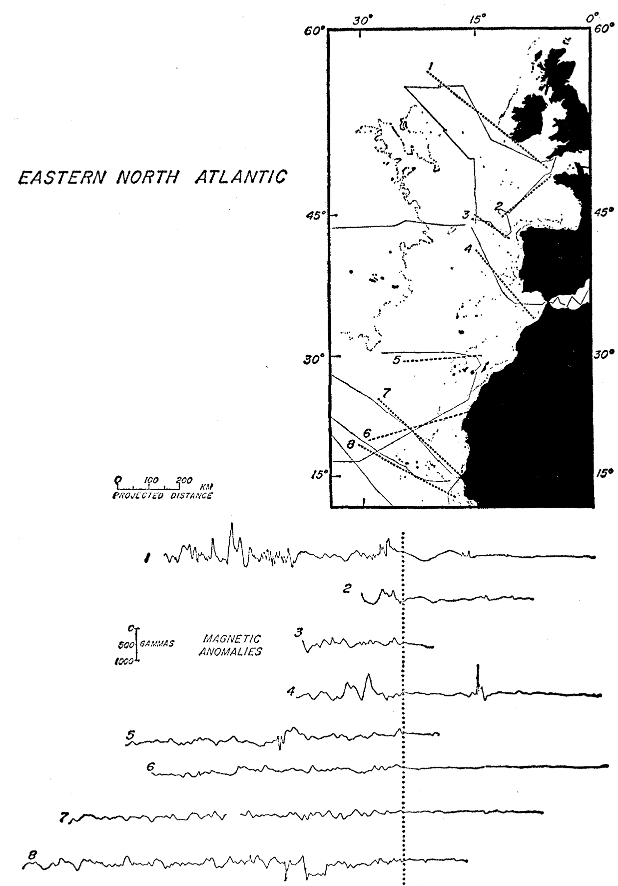


Fig. 1 (left). Projected magnetic anomaly profiles (1 to 9) for the western North Atlantic aligned in relation to the boundary separating undisturbed from disturbed magnetic regions. Solid lines on the index map show track lines; dashed lines, the azimuth and length of the projected profiles. The 100-fm and 2000-fm contours are shown. Fig. 2 (right). Projected magnetic anomaly profiles (1 to 8) for the eastern North Atlantic aligned in relation to the boundary separating undisturbed from disturbed magnetic regions. Solid lines on the index map show track lines; dashed lines, the azimuth and length of the projected profiles. The 100-fm and 2000-fm contours are shown.

with respect to the obvious boundary. Profile 4 is disturbed within the "smooth" zone where the ship passed over an isolated seamount. Similar disturbances are indicated on profile 8 about 300 km northwest of the boundary where the ship crossed the Cape Verde platform, a source of known volcanic peaks. Individual anomaly correlations are not evident for this group of profiles.

Figure 3 (bottom) shows the magnetic anomalies and corresponding topography as observed along the track of *Vema 17*, crossing the North Atlantic from Africa to Nova Scotia. This profile shows that there is no obvious topographic expression of the magnetic boundary. It is not perpendicular to the mid-Atlantic ridge and has not been projected. Fig. 3 (top) is a map of the magnetic boundary for both sides of the North Atlantic. Several control points, in addition to those determined from the profiles shown in Figs. 1 and 2, have been included to better delineate the boundary. Pre-Pleistocene bottom samples as compiled by Burckle and Saito (*4*), the eastern extent of the seismic reflecting horizons of Ewing *et al.* (*5*), and the fracture zones of Sykes are shown for comparison (*6*).

The magnetic boundaries closely parallel the 2000-fm (3660-m) isobath, as shown on the map. The eastern boundary nearly coincides with this isobath except in the extreme north, while the western boundary lies roughly 300 km to the east of the isobath. South of 40°N latitude the boundaries lie about 2000 to 2500 km from the axis of the mid-Atlantic ridge and roughly equidistant from it. The distances between the ridge axis and the boundary vary greatly because of the large offsets of the ridge axis and the uncertainty in deciding between which points to measure. If one extends the trace of the fracture zones to the boundary and then measures the distances from the ridge axis to the boundary in the directions defined by the fracture zones, the western boundary appears to lie about 200 km further from the ridge axis than the eastern boundary does. In spite of this difficulty, the rough equidistance of the boundaries from the ridge and the presence of anomalies subparallel to the western boundary as shown in Fig. 1 each suggest that the boundaries may relate to the process of spreading of the ocean floor, as proposed by Deitz, by Hess, and by Vine and Matthews (*7*). As one possible explanation, we speculate that these boundaries might

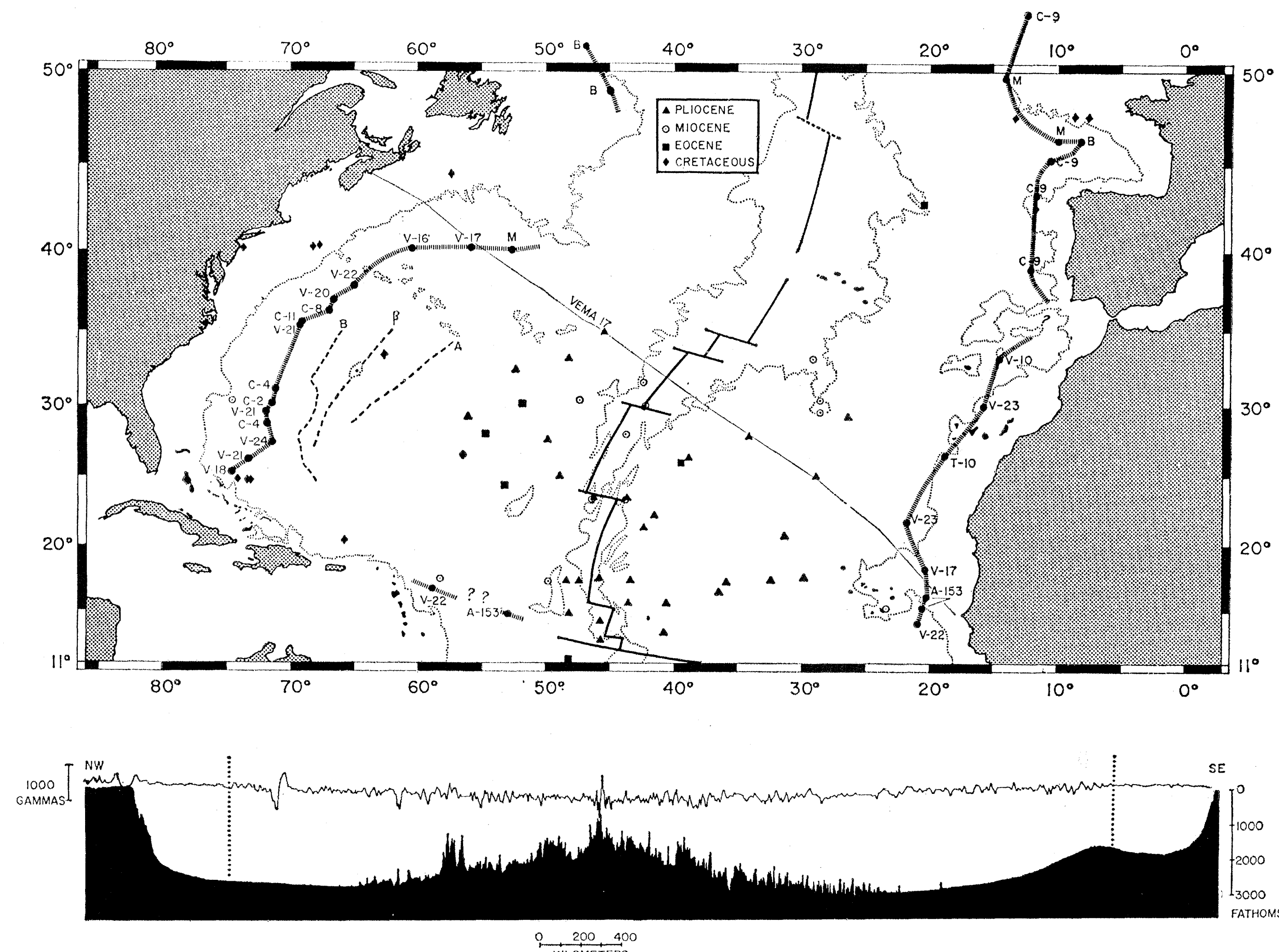


Fig. 3. (Top) Map of the North Atlantic showing the location of the magnetic boundaries near the continental margins. Control points are labeled according to the cruises as follows: R.V. *Vema* (*V*), R.V. *Robert D. Conrad* (*C*), R.V. *Atlantis* (*A*), U.S.S. *Michelson* (*M*), U.S.S. *Bowditch* (*B*), and *Theta* (*T*). The 2000-fm contour is shown. Axis of the ridge, fracture zones, pre-Pleistocene bottom samples, and eastern extent of seismic reflecting horizons A, β, and B are given for reference and comparison. (Bottom) *Vema 17* profiles of topography and magnetic anomaly between Africa and Nova Scotia.

mark a front in an advancing ocean floor pushing ahead an older, less magnetic sea floor. If we assume a spreading rate of about 1 cm/year (*8*) and assume this to be uniform and constant [although we are aware that this is a hazardous assumption (*9*)], we can extrapolate the age of this front as 200 to 250 million years, or Middle Triassic to Middle Permian. This age appears to fit reasonably well with the inferred age and distribution of the seismic reflecting horizon B of Ewing *et al.* [The seismic reflecting horizon B is inferred to be of late Jurassic age (*5*).] Irving (*10*) reports a long period of about 50 million years (the Kiaman magnetic interval) during the late Paleozoic when the field was consistently of reversed polarity. When viewed in relation to spreading of the ocean floor, a long period during which no changes in magnetic polarity occurred should be manifested by a zone of smooth or undisturbed magnetic field. It is entirely possible, therefore, that the undisturbed magnetic zones lying toward the continental side of the boundaries shown in Fig. 3 represent the expression of an ancient sea floor formed during the late Paleozoic and that the boundary itself marks the approximate position of the isochron separating the Paleozoic and the Mesozoic eras. The possible relation of the magnetic quiet zone to the Permian has been independently proposed in a study by Windisch *et al.* (*11*) which incorporates magnetic and seismic profiler data. The smooth zone is roughly 400 km wide, and, if the zone does represent a period of no changes in magnetic polarity and if 1 cm/year is a good average spreading rate, then this width and rate establishes a minimum time of 40 million years during which changes in polarity did not occur. The observation is in agreement with Irving's results.

It is not yet clear whether the western magnetic boundary extends as far south as the points labeled *V-22* and *A-153* east of the Lesser Antilles arc. It is clear, however, that the distinct magnetic boundaries on both sides of the North Atlantic do not continue into the South Atlantic, but this is perhaps not surprising in view of the faster spreading rates deduced for the South Atlantic (*12*).

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Far-Infrared Surveys of the Sky

Abstract. *A series of far-infrared surveys of the sky is searching for thermal radiation from interstellar grains and for other localized sources of far-infrared radiation. A balloon-borne germanium bolometer, cooled by liquid helium, is used in associaton wth a telescope and spectral filters. During two initial flights the response to a black-body source was mainly between 300 and 360 microns. Approximately half the celestial sphere was surveyed, includng most of the northern Milky Way. The angular resolution was 2 degrees. Moon was the only source of thermal radiation detected. The upper limit on the differential flux, relative to background, from other sources was 2 × 10^{-23} watt per square centimeter per hertz, corresponding to an antenna temperature of 0.6°K in the Rayleigh-Jeans approximation, or 10°K for a black body.*

We report on the first two balloon flights of a series searching the sky for extended emission regions and bright point sources in the far infrared (25 μ to 1 mm); strong absorption by water vapor prevents study from sea level. Farmer and Key (*1*), studying the solar spectrum from a 5200-m mountain top, found no trace of solar emission between 40 and 300 μ, while the narrow peak found at 350 μ corresponded to about 5-percent transmission.

This spectral region of five octaves, almost entirely unexplored, is of interest for a variety of reasons. The unknown emission process giving rise to the continuum of the brightest quasar, 3C273, appears to peak here (*2*); in fact, most of the energy from 3C273 seems to be radiated in the infrared. At slightly shorter wavelengths other processes appear to give variable emission from regions surrounding red giant stars (*3*). It has been predicted (*4*) that the thermal radiation of interstellar grains may be observable in this region and probably not outside it.

Already-existing measurements can be used to provide an upper limit for the flux from possible objects radiating in this spectral region. Upper limits on the background flux at 340 and 560 μ have been derived from a study of interstellar molecular lines (*5*); the limits are 2.5 × 10^{-20} and 2.5 × 10^{-21} watt cm^{-2} hz^{-1} $steradian^{-1}$. Hence a single object outside the solar system, providing as much as 3 × 10^{-19} or 3 × 10^{-20} watt cm^{-2} hz^{-1} at these wavelengths, could have escaped detection by this method. Similar, perhaps slightly tighter but less convincing

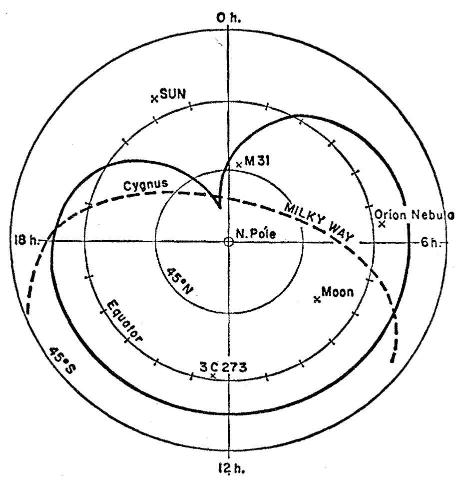

Fig. 1. The region of sky surveyed during the flight of 21 February 1967. Interesting features are indicated; Moon alone was detected.