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TECHNICAL REPORT

A STUDY OF AEROMAGNETIC DATA NEW ENGLAND SEAMOUNT AREA

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ABSTRACT

A detailed aeromagnetic survey of a 38,000 square mile area off the coast of New England was conducted by the Oceanographic Office in 1957. The survey area contains the continental shelf, slope and rise related to Georges Bank, and the northwest end of the New England-Bermuda seamount chain. Analysis of the survey data indicates that the features included in the group extending from Kelvin to Bear seamounts are highly magnetized, in the order of 0.01 cgs units, and that the seamounts have little sedimentary cover. The nature of the magnetic anomalies over the seamounts extending from Panulirus to Mytilus indicates that these features are composed of a less magnetic material. Based on the correlation between magnetic anomalies and bottom features, it is probable that the survey area contains several seamounts or seaknolls that are at present uncharted. The anomalies over the continental margins are linear in form and reflect structural trends and possible faulting in the basement beneath Georges Bank.

FOREWORD

The seamount chain extending from Bermuda to Georges Bank is one of the major features of interest in the ocean areas adjacent to the east coast of the United States. The U.S. Naval Oceanographic Office, in its quest for a better understanding of the ocean environment, has conducted airborne and shipboard magnetic surveys covering approximately 70% of this seamount chain. This report presents the results of one of these surveys.

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FIGURES

I. INTRODUCTION

During May 1957, a detailed aeromagnetic survey of a 38,000 square mile area (fig. 1) off Cape Cod was conducted by Project MAGNET. Continuous total magnetic intensity (fig. 4) and inclination data (fig. 5) were recorded with a Vector Airborne Magnetometer (Schonstedt and Irons, 1952), along tracks spaced approximately five miles apart (fig. 2). The flight altitude was 1000 feet, and navigational control, provided by Loran A, was maintained within two miles. This report presents the data from the survey, and an examination of the geologic features which may contribute to the magnetic anomalies.

The survey area covers the northwest end of the New England-Bermuda seamount chain (Northrop et al, 1960) and a portion of the continental margins associated with Georges Bank. Figure 3, based on relatively sparse sounding information, illustrates the general bathymetry. Computations involving the shape of seamounts however, are based on the more valid B.C. 0707N and B.C. 0708N charts. As indicated on figure 3, the survey area is separated into 3 geographic zones, which display diverse magnetic characteristics. Zone 1 is characterized by large amplitude anomalies and includes the seamounts extending from Kelvin to Bear. Zone 2 has relatively small amplitude anomalies and contains the seamounts to the south of Zone 1. Zone 3 generally defines the continental margins and is distinguished by linear anomalies, parallel to the coast.

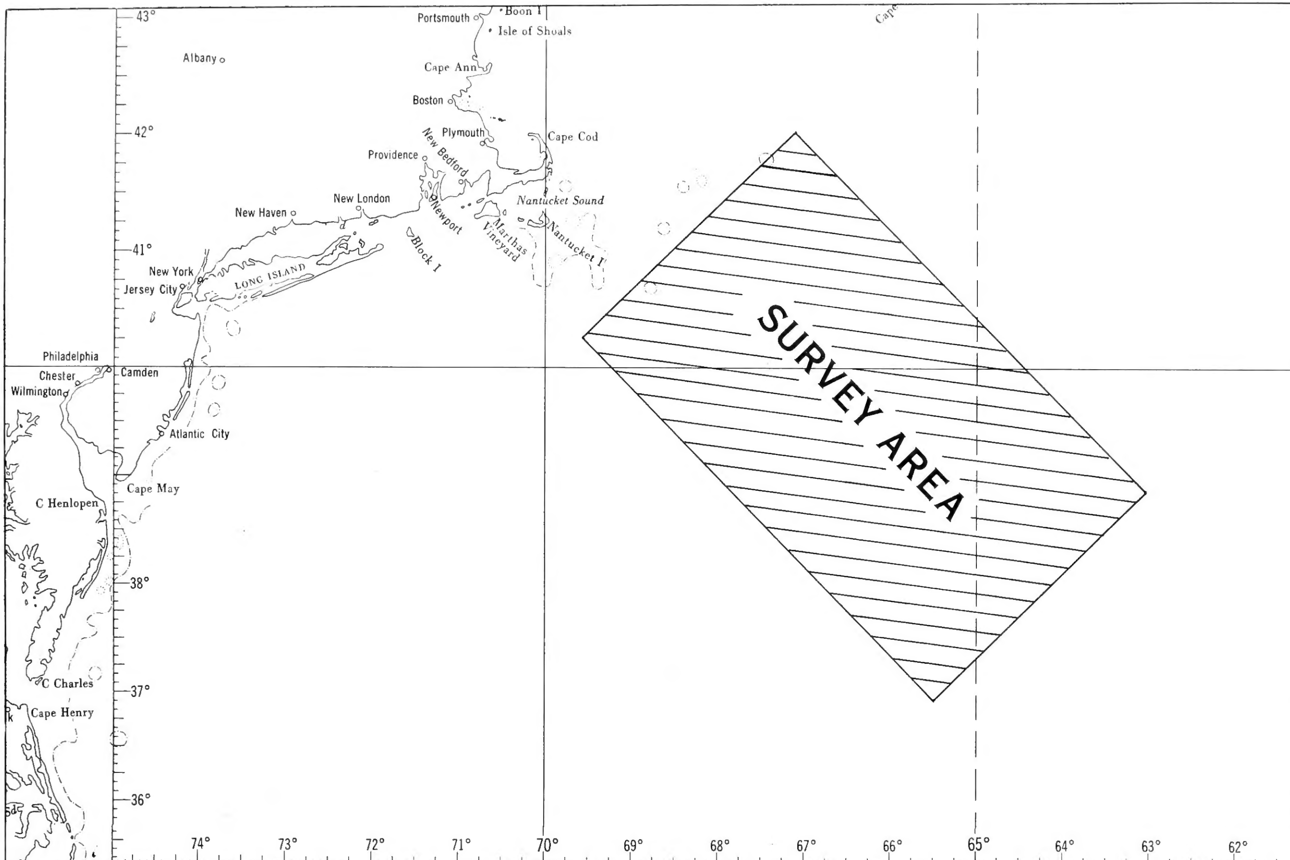

FIGURE 1 — NEW ENGLAND SEAMOUNT AREA
AEROMAGNETIC SURVEY—1957
LOCATION CHART

NEW ENGLAND SEAMOUNT AREA
AEROMAGNETIC SURVEY—1957
TRACK CHART

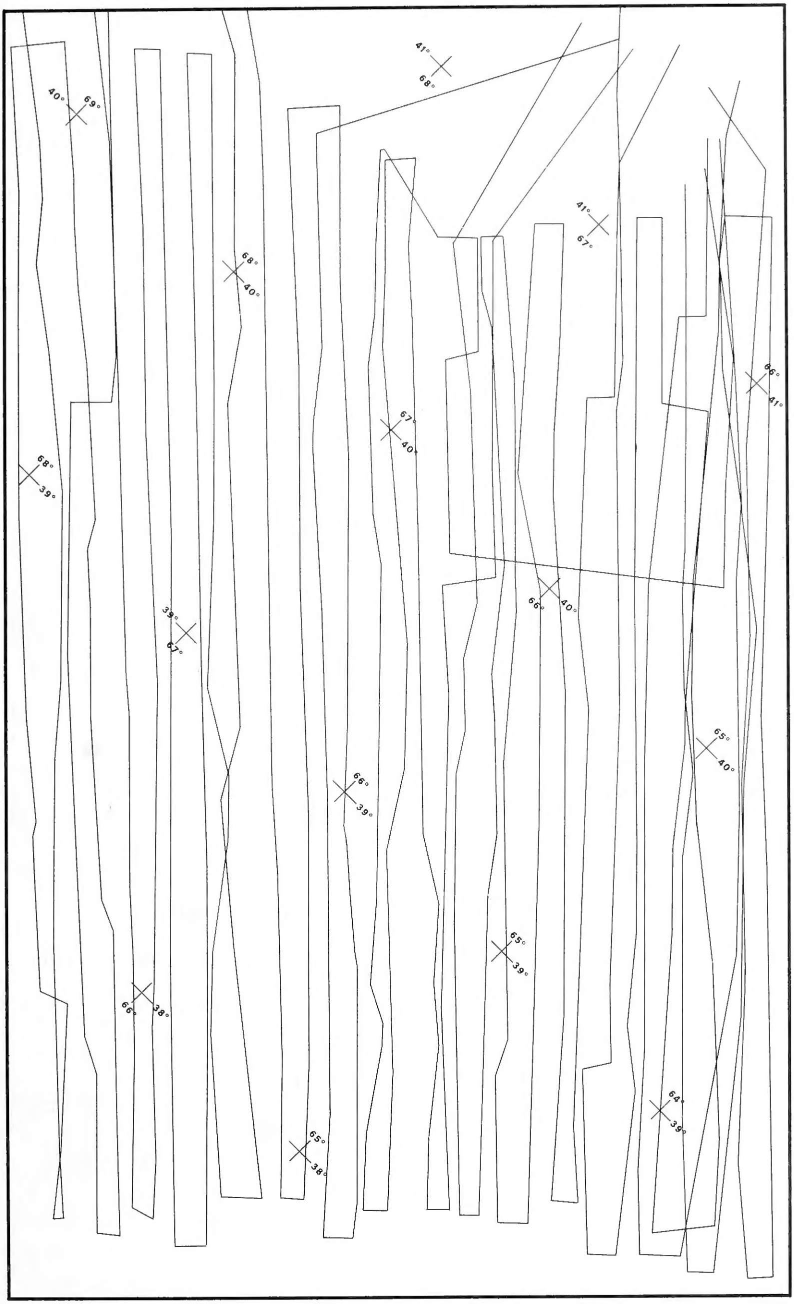

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FIGURE 2

In this report, the Zone 1 anomalies are interpreted with the aid of intensity of magnetization computations and a two-dimensional profile matching technique. In addition, the total magnetic intensity and inclination data associated with the seamounts are used to calculate their respective horizontal and vertical component anomalies (figs. 6 and 7). The difference between the Zone 1 and 2 anomalies is examined and the anomalies of Zone 3 are discussed in terms of regional geology and other geophysical studies of the continental margins.

II. DATA REDUCTION

Figures 4 and 5 depict the observed total magnetic intensity (F) and inclination (I) respectively, for the complete survey area. The total magnetic intensity contours (fig. 4) were determined from data scaled directly from the original records, whereas the inclination contours (fig. 5) are a graphically smoothed representation of the measured data. This smoothing was necessary due to noise generated by aircraft motions. No corrections were applied to these charts to remove temporal variation effects.

The residual horizontal intensity (H_R, Fig. 6) and anomalous vertical intensity (Z_A, fig. 7) were determined for the seamounts of Zone 1 by calculating the scalar difference between observed and regional components. Using observed total intensity (F) and observed inclination (I), the "observed" components were found from H = F cos I and Z = F sin I. Regional component values were determined, in the same manner, from graphically estimated regionals of (F) and (I).

Due to the large angle of inclination, over each seamount, the anomalous vertical intensity (Z_A) resembles the total magnetic intensity in shape and magnitude, whereas the residual horizontal intensity closely follows the inverse of the inclination pattern.

III. ZONE 3 ANOMALIES

The magnetic features (fig. 4) associated with the continental margins (Zone 3 - fig. 3) are linear in nature and form a part of a system of anomalies which extends along the coast, from Florida to Newfoundland (Drake et al, 1963). Seismic refraction studies, north of Cape Hatteras, indicate a major structural system, beneath and parallel to the continental margins, consisting of two sedimentary troughs separated by a basement ridge (Drake et al, 1958). Relative to figure 3, an inner trough is located beneath Georges Bank with sediment up to 12,000 feet in thickness. A basement ridge occurs near and generally parallel to the 100-fathom curve, and an outer trough, with up to 15,000 feet of sediment is located under the continental slope and rise. Drake et al (1963), noting a truncation of basement contours and an offset in the magnetic anomaly pattern near 40°N latitude suggested the existence of a right lateral transcurrent fault along this parallel.

Previous work then, indicates the geologic factors which may contribute to the anomalies over the continental margins. In order to magnify and delineate the magnetic trends of Zone 3, the total magnetic intensity (fig. 4) was subjected to a Gram or Chebyshev orthogonal polynomial fitting technique (Van Voorhis and Davis 1964). Specifically, the total intensity along selected track lines, terminated just below Physalia seamount, was fitted with a 5th-degree polynomial. The residual (the difference between the observed intensity and the polynomial curve) was then contoured at a 50-gamma interval (fig. 8). Due to the high degree of the polynomial, the amplitudes of the residuals are quite different from those which would be obtained from removal of an earth's regional field. For the purposes of this report, emphasis is placed only on the trend characteristics as brought out by this procedure.

The trends associated with observed anomalies are designated as A, B and C on figure 8. The trends of the right half of the area strike 40-45° east. A and B terminate against the seamount features, and the A continues at a strike of 70-80° east along 40°N latitude. The apparent offset in A, of about 30 miles, is attributed to the aforementioned transcurrent faulting. Trend C is continuous along the top of the area.

Depth estimates and the general correlation between the direction of the anomaly trends and the basement structural trends reflected by the 100- and 1000-fathom curves (fig. 8) indicate that the source of the anomalies is in the basement. Anomaly A, referred to in the literature as the "slope anomaly," has been studied in some detail in other areas. Since this feature lies near the basement ridge, King et al (1961) and Drake et al (1963) used profile matching, based on seismically derived topography of the ridge to determine the origin of the anomaly. They concluded that compositional changes within the basement, rather than topography were the principal cause. Watkins and Geddes (1964) related the basement structure to an island arc system and attribute the anomaly to both intrusive and extrusive rocks withi~ the basement.

The Oceanographic Office has begun a detailed aeromagnetic survey of the Atlantic coastal area from Maine to Florida. Questions concerning the nature of the coastal anomalies and their relationship to the continental margins may be more readily answered with the data from this survey.

IV. SEAMOUNT ANOMALIES

Whereas the features over Zone 3 are related to deep seated basement phenomena, the anomalies seaward of the slope are directly correlative with bottom topography. The features over the seamounts of Zone 1 display total magnetic intensity anomalies (fig. 4) of 1000-1400 gammas, and the anomalies over the Zone 2 seamounts range from 100-200 gammas. The origin of the seamounts is believed to be related to fracture with associated volcanism.

Oceanographic Office surveys which illustrate that anomalies of varying amplitude are to be found over other features of the New England-Bermuda chain include a shipboard marine survey of the seamounts from Kelvin southeast to approximately $34^{o}25'$N, $56^{o}40'$W (Walczak, 1964). In addition, aeromagnetic surveys have been conducted of an area northwest of Bermuda (Davis and Heckelman, 1964) and of Plantagenet Bank (Young and Kontis, 1964).

A. Zone One Anomalies

Since the shape of the seamount contours (fig. 3) resemble their respective magnetic contours (fig. 4) it is likely that these seamounts represent the general configuration of the volcanic source material. To investigate this further, a two-dimensional model computation (Heirtzler et al, 1962) was applied to Kelvin Seamount.

The use of a two-dimensional technique implies that the length of the anomaly being considered is much greater than its width. Since the length-to-width ratio of the Kelvin anomaly is only about 3:1, some error is introduced. According to Press and Ewing (1952) however, the error is small.

Figure 9 shows the best fit obtained from matching observed profiles (F_R, Z_A, and H_R) across the peak of Kelvin seamount with profiles derived from a theoretical source body. The trapezoidal model is essentially a cross section of the observed topography, and the calculated anomalies are the result of a total magnetization (induced plus remanent) in the same direction as the present inducing field. The computed and observed total intensity anomalies agree very well, and the computed H_R and Z_A exhibit the same general characteristics of the "observed" components, except for a slight displacement to the south. In order to match amplitudes, an apparent susceptibility (K_{APP}) of 0.016 cgs or its equivalent of 0.0086 cgs units in apparent magnetization was required. This relatively large value is explained in terms of a large component of remanent magnetization acting together with the induced magnetization. Although the solution of figure 9 is not unique, the model is reasonable and indicates that there is little sedimentary cover over the volcanics.

Using another approach, intensity of magnetization calculations were made for Kelvin with the three-dimensional technique of Vacquier (1962). Computations were made using both airborne and shipboard marine data, and the results (Van Voorhis and Walczak, 1963) indicate an intensity of magnetization of 0.01 cgs units, with a large component of remanence in a direction different from the present inducing field.

It is likely that the other seamounts of Zone 1 are magnetized to this order of magnitude. A hand method (Rikitake, 1952) which represents the volcanoes as right circular cones, was used to obtain rough approximations of the magnetization of Bear, Physalia, Retriever, Picket, and Massey seamounts. These computations resulted in apparent magnetizations of 0.007 - 0.010 cgs units for these features.

B. Zone Two Anomalies

Relative to the Zone 1 anomalies, the features (fig. 4) over the Zone 2 seamounts are quite small (100-200 gammas). Although the seamounts in Zone 2 are at a deeper depth, this is not sufficient to explain the difference in anomaly magnitude. The Zone 2 seamounts are interpreted as representing an auxiliary fracture zone with a more acidic phase of volcanism than that of the Zone 1 seamounts. It is noted that the bottom feature associated with the 370-gamma anomaly located at 39°17'N, 64°33'W (fig. 3) was found to have a peak sounding of 2380 fathoms. The magnitude of this anomaly is characteristic of the Zone 1 features.

Upon comparing figure 4 with the bathymetry (fig. 3) it should be realized that figure 3 is based on rather sparse sounding information, and in some cases, bottom features may be displaced or missing entirely. Since each charted feature has a corresponding magnetic anomaly, it is probable that small seamounts or knolls exist in those areas displaying closed magnetic anomalies.

NEW ENGLAND SEAMOUNT AREA
BATHYMETRIC CONTOUR CHART

CONTOUR INTERVAL 200 FATHOMS

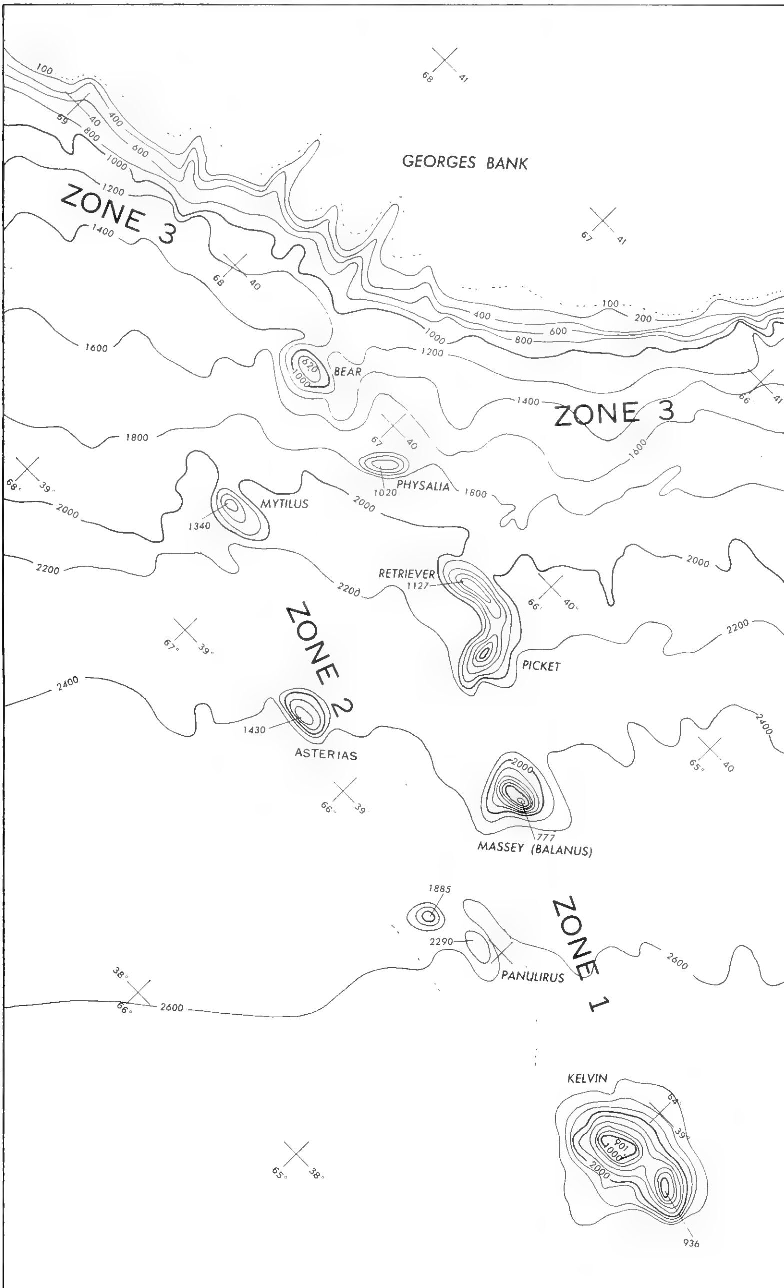

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FIGURE 3

NEW ENGLAND SEAMOUNT AREA
AEROMAGNETIC SURVEY—1957

OBSERVED TOTAL INTENSITY

Contour Interval 50 Gammas

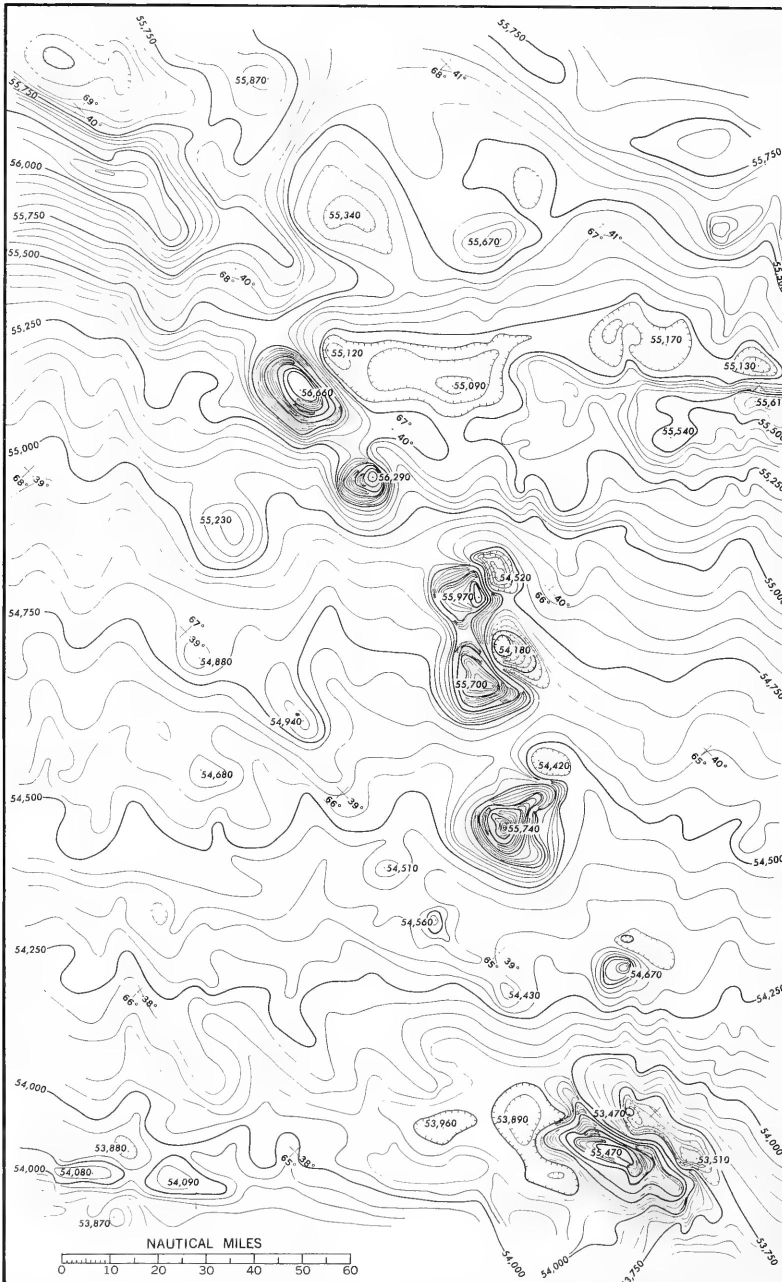

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FIGURE 4

NEW ENGLAND SEAMOUNT AREA
AEROMAGNETIC SURVEY—1957

OBSERVED MAGNETIC INCLINATION

Contour Interval 12 Minutes

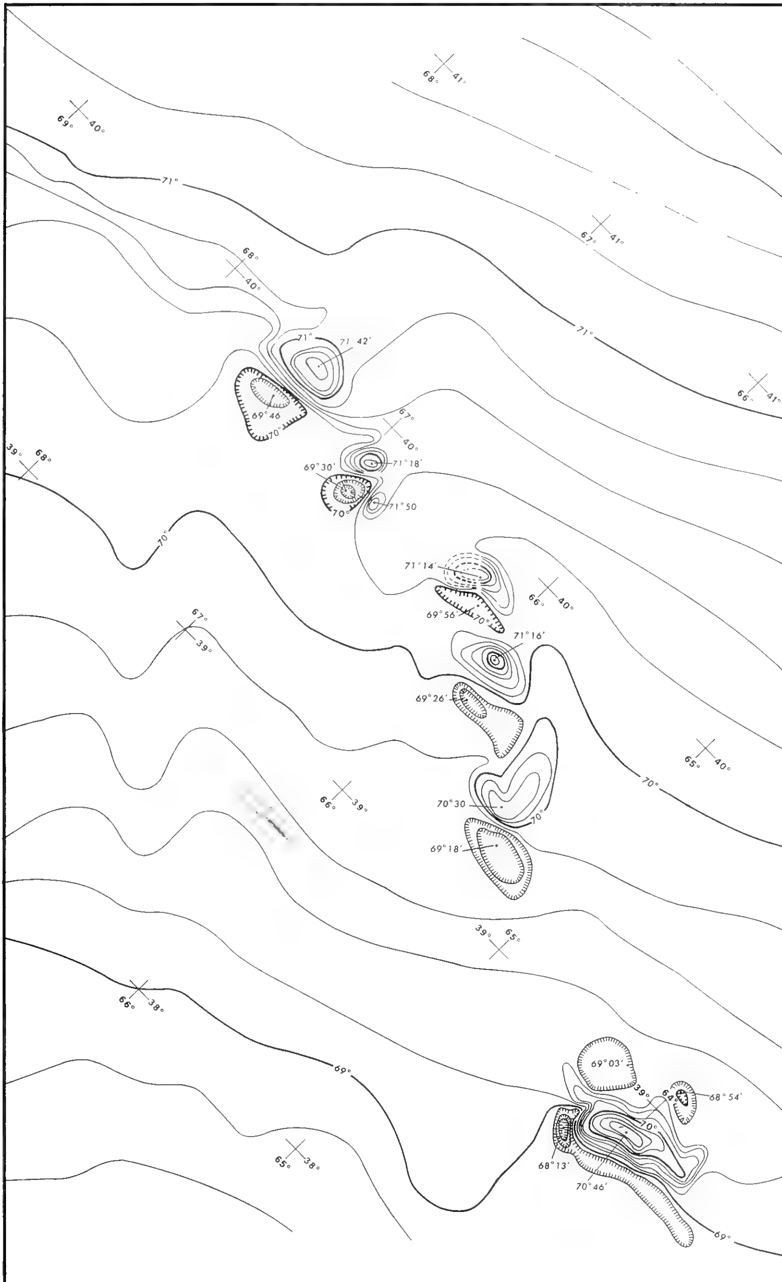

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FIGURE 5

NEW ENGLAND SEAMOUNT AREA
AEROMAGNETIC SURVEY—1957

RESIDUAL HORIZONTAL INTENSITY

Contour Interval 100 Gammas

Magnetic contours with flight lines

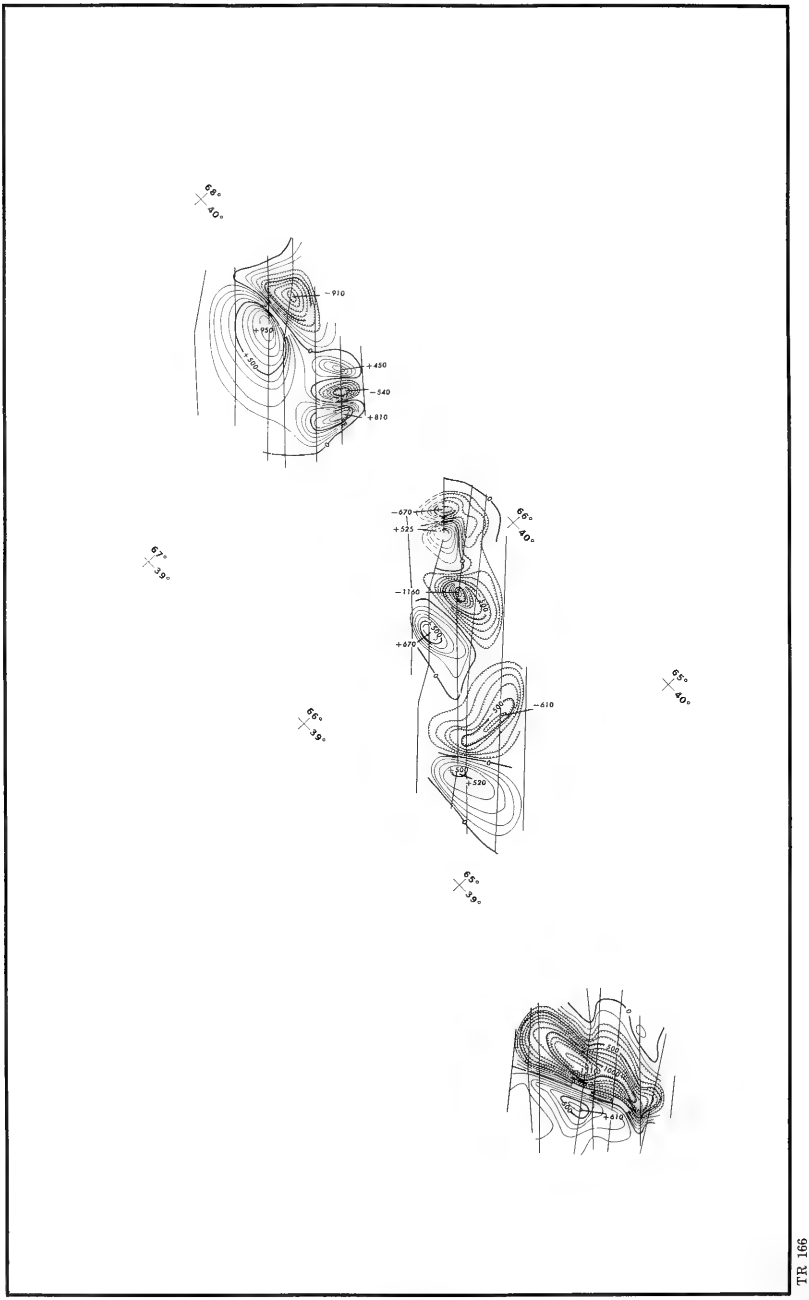

FIGURE 6

NEW ENGLAND SEAMOUNT AREA
AEROMAGNETIC SURVEY—1957

ANOMALOUS VERTICAL INTENSITY

Contour Interval 100 Gammas

Magnetic contours with flight lines

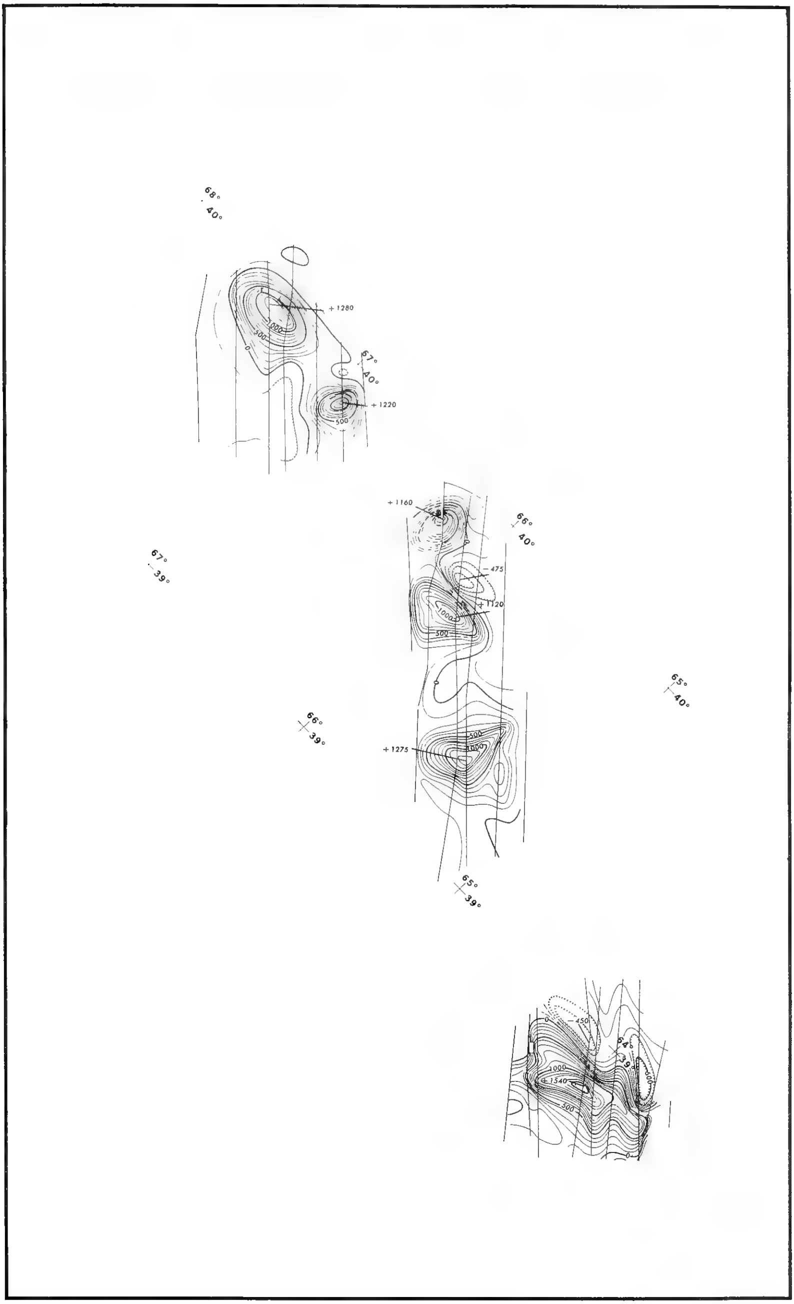

FIGURE 7

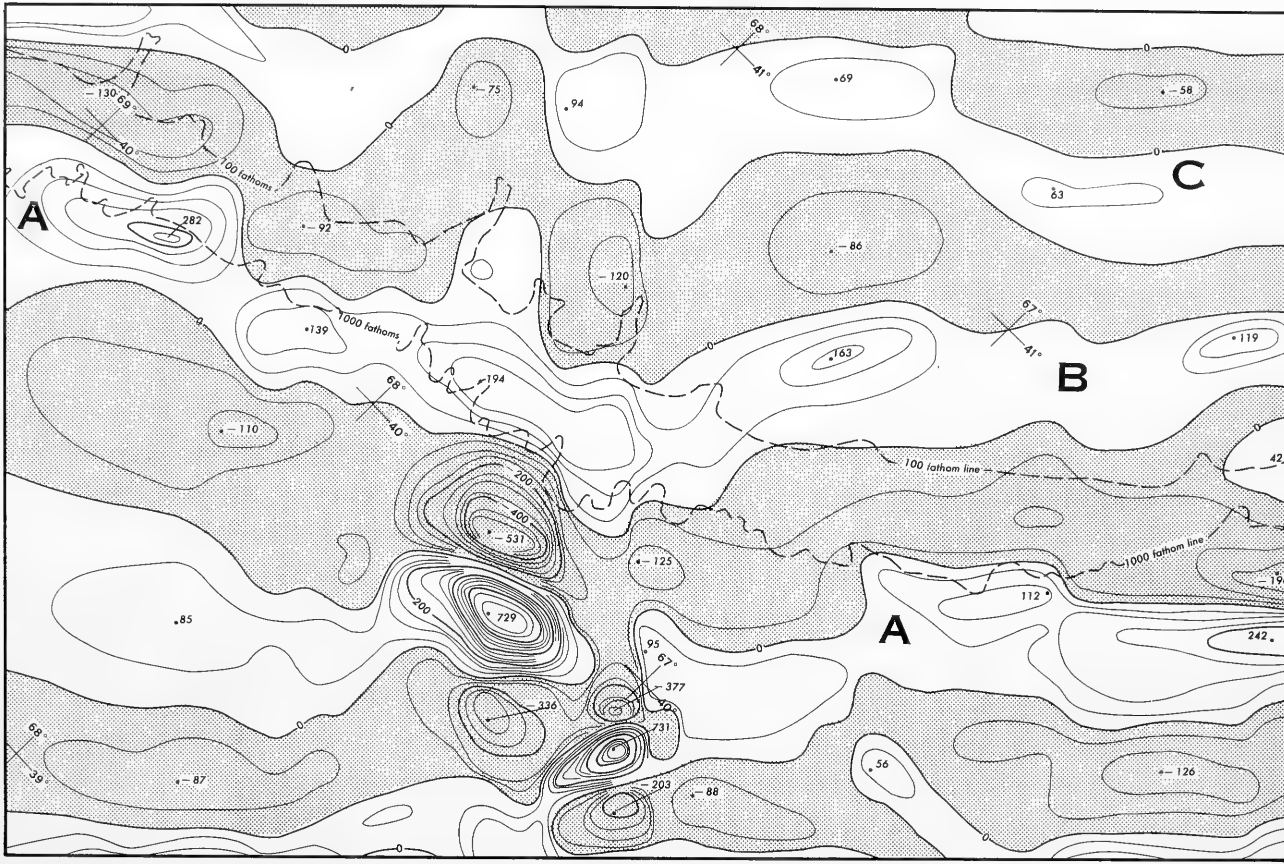

FIGURE 8 —NEW ENGLAND SLOPE AREA—RESIDUAL TOTAL INTENSITY
(5th Degree Chebyshev Polynomial Removed)
Areas of Negative Intensity
Contour Interval 50 Gammas

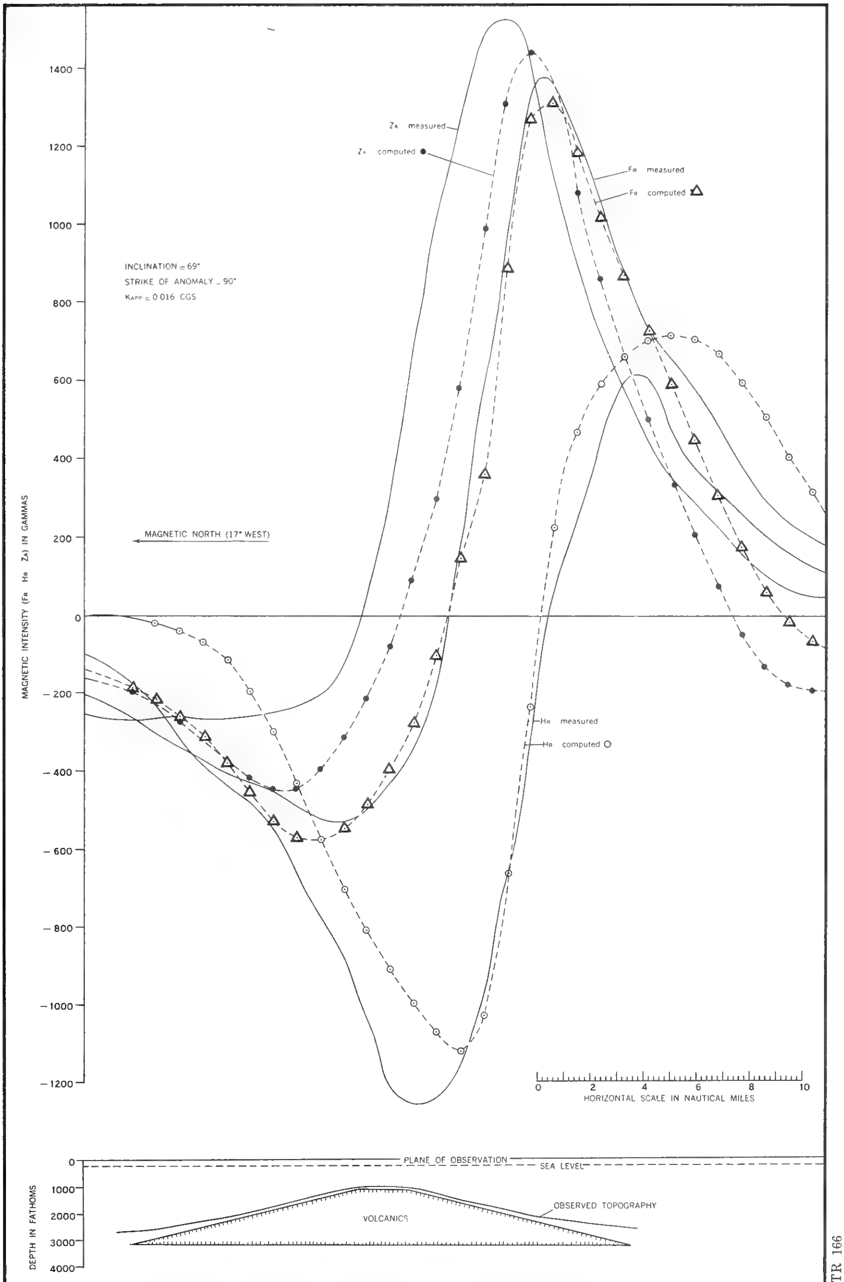

FIGURE 9 —KELVIN SEAMOUNT—OBSERVED VERSUS COMPUTED PROFILES FOR TWO DIMENSIONAL MODEL

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2. New England Seamount Area - Magnetism

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