I.O.S.

MAGNETIC ANOMALIES IN THE NORTHEAST ATLANTIC

BY
D.G. ROBERTS, M.T. JONES
AND P.M. HUNTER

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Wormley, Godalming,
Surrey, GU8 5UB.
(0428 - 79 - 4141)

(Director: Dr. A.S. Laughton FRS)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051 - 653 - 8633)

(Assistant Director: Dr. D.E. Cartwright FRS)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823 - 86211)

(Assistant Director: M.J. Tucker)

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WORMLEY

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**Present address:-*

The British Petroleum Co. plc
Britannic House
Moor Lane
LONDON, EC27 9BU

ABSTRACT

A pair of geomagnetic anomaly charts printed on a Mercator projection at a scale of 1:2.4 million is presented for the region of the northeast Atlantic from 32° to 62°N and from 0° to 31°W. The charts were compiled from observations along ship's tracks up to 1975. Magnetic anomalies were calculated with respect to the International Geomagnetic Reference Field 1965.0. These charts complement, and are at the same scale as, the bathymetric series "Bathymetry of the northeast Atlantic" prepared, or currently in preparation, at IOS and published by the UK Hydrographic Department.

INTRODUCTION

The total geomagnetic field measured at the sea surface is due primarily to the earth's main dipole and quadrupole fields modified by the magnetic field due to the earth's crust. By removing the longer wavelengths due to the main earth's field and by mapping the resultant anomalies, it is possible to obtain a quantitative description of the magnetic properties, and therefore the geology, of the crust.

Since the mid-1960s, when the link between magnetic anomalies over oceanic crust and the history of sea-floor spreading was first established, the measurement of the magnetic field at sea has become an important tool in the study of the evolution of ocean basins. Linear magnetic anomalies can be interpreted directly in terms of dateable isochrons frozen into the sea floor as it spreads away from its parent mid-ocean ridge. Distortions in the magnetic pattern may provide information on subsequent compressional and extensional tectonic events acting on the mature oceanic lithosphere, or even point to different spreading configurations in the seafloor's earlier history. Offsets in the lineations may also indicate fracture zones, while distinct changes in the characteristics of the magnetic anomalies may serve as indicators of the transition from oceanic and continental crust.

Mapping of the magnetic anomaly field thus provides invaluable reference material from which to study the timing and geometry of the evolution of the oceanic crust. With this in mind the authors embarked on a compilation of the magnetic data available for the region of the northeast Atlantic between 32° and 62°N, and from 31°W to the European continental margin. The tectonic evolution of this area has been dominated by sea floor spreading between the North American and Euroasian lithospheric plates. At the present time the spreading activity is focussed along the axis of the Mid-Atlantic Ridge which enters the region just west of the Azores. The Ridge then heads in a northerly direction before experiencing a westward offset at the Charlie-Gibbs Fracture Zone at about 52°N. North of the Charlie-Gibbs Fracture Zone it becomes the Reykjanes Ridge adjusting itself to a north-northeasterly direction and continuing through to Iceland.

South of the Charlie-Gibbs Fracture Zone a continental reconstruction by matching anomalies formed about the present-day spreading axis provides a reasonable first order fit between North America and western Europe, although mismatches do occur particularly at the Bay of Biscay (itself the site of an earlier spreading centre) and west of the Iberian peninsula (due primarily to a possible submerged wedge of continental crust). The evolution of this area was

also affected by the Pyrenean orogeny. A number of distinctive features show up in the area's bathymetry e.g. the Biscay Seamounts, the Azores-Biscay Rise and the King's Trough. (For a detailed description of the morphology of the area, see Laughton et al., 1975). Bathymetric features on the southern boundary of the Eurasian lithospheric plate (i.e. the Azores-Gibraltar plate boundary) are also linked to the movement of the African lithospheric plate. These features include the Madeira-Tore Rise, the East Azores Fracture Zone and a recent spreading centre in the Azores. North of the Charlie-Gibbs Fracture Zone a first-order continental reconstruction is more complicated and requires at least three distinct spreading axes - the present-day axis along the Reykjanes Ridge between Greenland and the submerged continental Rockall Plateau, an earlier phase of spreading about an axis which lay between Greenland and northeastern Canada along the Labrador Sea, and an axis along the Rockall Trough between the Rockall Plateau and the continental shelf of the British Isles.

CHART COVERAGE

The magnetic anomaly chart has been split into a North Sheet and a South Sheet with a two-degree overlap between the two sheets from 48° to 50°N.

The North Sheet extends from 48° to 62°N and 0° to 30°W and covers the area from the Reykjanes Ridge to the British Isles, including the Rockall Plateau and the Charlie-Gibbs Fracture Zone.

The South Sheet extends from 32° to 50°N and 0° to 31°W and covers the area from the Mid-Atlantic Ridge to Southwest Europe, including the Bay of Biscay, the Azores-Biscay Rise, the East Azores Fracture Zone and the Madeira-Tore Rise.

The two sheets have been designed to complement the partially-completed bathymetric series "Bathymetry of the northeast Atlantic" being prepared at IOS. They have been produced at the same matching Mercator projection with a scale of 1:2,400,000 at 41°N. To date, four bathymetric charts have been published*:

Bathymetry Sheet 1 (47-64°N, 12-37°W):	Reykjanes Ridge and Rockall Plateau: C6566.
Bathymetry Sheet 2 (47-64°N, 6°E-18°W):	Continental margin around the British Isles: C6567.
Bathymetry Sheet 3 (32-50°N, 0-31°W):	Mid-Atlantic Ridge to Southwest Europe: C6568.

* These charts are published by the UK Hydrographic Department, Taunton, and are available from chart agents.

Bathymetry Sheet 5 (10-37°N, 6°-30°W): Continental Margin off Northwest Africa: C6570.

The South Sheet coincides with the coverage of Bathymetry Sheet 3 and the northern part of Bathymetry Sheet 5, while the North Sheet encompasses the major oceanic parts of Bathymetry Sheets 1 and 2.

SOURCES OF MAGNETIC DATA

Two principal sources of magnetic data were used in the preparation of the chart: (1) original data collected by survey and research ships, plus (2) published, detailed surveys already available in a contoured form. Tracks on the chart indicate lines along which original data were used. In regions where pre-contoured detailed surveys exist, no tracks are shown and the area is delineated by a box on the chart. Where modification of the detailed survey has taken place, the tracks used are included across the survey box. Reference to the source of each detailed survey can be found in the right-hand margin of each sheet.

In addition to the detailed surveys, some 500,000 km of ship's track data were incorporated into the chart with digital values at intervals of about 2 km along each track. These data were collected over a period up to 1975 by a number of laboratories in both North America and Europe:

Bedford Institute of Oceanography, Canada
Cambridge University, UK
Centre National pour l'Exploitation des Oceans, France*
Deutsches Hydrographisches Institüt, Germany
Durham University, UK
Environmental Science Services Administration, USA
Hudson Laboratories of Columbia University, USA
Hydrographer of the Navy, UK
Institute of Oceanographic Sciences, UK
Lamont-Doherty Geological Observatory, USA
National Geophysical Data Center, USA
Naval Research Laboratory, USA
United States Naval Oceanographic Office, USA
University of Rhode Island, USA

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* Now known as L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)

Vening-Meinesz Laboratory, The Netherlands
Woods Hole Oceanographic Institution, USA

PREPARATION OF DATA

Although some digitisation of source material was necessary, most of the magnetic track data was already available in a digital form suitable for computer processing. These data were converted into a common format and the navigation and geomagnetic time series for each cruise were merged into a single file. At this stage, all total magnetic field values were converted to magnetic anomaly values by removing the International Geomagnetic Reference Field for epoch 1965.0 with its inbuilt correction for secular variation (see e.g. IAGA, 1969). The data was then stored on magnetic tape as a time series with geographic co-ordinates, distance along track, ship's course, total magnetic field and magnetic anomaly. No corrections were applied to the magnetic anomaly values for the effect of ship's heading, diurnal variation or magnetic storms.

Compilation of the magnetic anomaly data was carried out at a scale of 1:1,000,000 on a standard Mercator projection based on the Admiralty plotting sheets. Magnetic anomalies were computed and plotted as profiles along ship's track at a scale of 200 gammas/inch, and anomaly values at 100 gamma intervals were also plotted on the track itself. The anomalies were then manually contoured at an interval of 50 gammas. As the track spacing was invariably greater than the wavelength of the anomalies, particular attention was paid during contouring to the shape of the plotted anomaly profiles. In some areas of very low data density, no contouring was attempted.

Previously contoured data from published detailed surveys were transferred on to the 1:1,000,000 compilation sheets. They were generally incorporated with little or no modification except for the interpolation of intermediate contours so as to compensate for different reference fields. Checks for consistency were made with any available track data passing through the survey. The only survey requiring major modification was that by Vogt & Avery (1979) (see North Sheet, survey box 3) - other ship's tracks have been included in the survey box in this case. Because of the complexity of the contours over the relatively shallow Rockall Bank, only the + 200 and - 200 gamma contour lines were transcribed from the survey by Roberts & Jones (see North Sheet, survey box 4).

Footnote: 1 gamma = 1 nanotesla

For the production of the final chart, the resulting contours and the ship's tracks were reduced to a scale of 1:2,400,000 with the contour interval increased to 100 gammas. Edge matching was carried out at this scale.

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IAGA Commission 2 Working Group 4. 1969 International geomagnetic reference field 1965.0.
J. Geophysical Research, 74, 4407-4408.

LAUGHTON, A.S., ROBERTS, D.G. & GRAVES, R. 1975 Bathymetry of the northeast Atlantic: Mid-Atlantic Ridge to southwest Europe.
Deep-Sea Research, 22, 791-810.

VOGT, P.R. & AVERY, O.E. 1974 Detailed magnetic surveys in the northeast Atlantic and Labrador Sea.
J. Geophysical Research, 79, 363-389.

Insufficient Data

REYKJANES RIDGE

ICELAND

BASIN

Insufficient Data

Wyville-Thomson Ridge

ROCKALL PLATEAU

Rockall

ROCKALL TROUGH

PORCUPINE BANK

PORCUPINE SEABIGHT

Goban Spur

CHARLIE-GIBBS FRACTURE ZONE

FARADAY FRACTURE ZONE

Insufficient Data

MAGNETIC ANOMALIES IN THE NORTHEAST ATLANTIC — NORTH SHEET

REYKJANES RIDGE TO THE BRITISH ISLES

D.G.Roberts and M.T.Jones

Institute of Oceanographic Sciences, United Kingdom.

Scale
1:2,400,000 at 41°N

Projection
Mercator

International Geomagnetic Reference Field for Epoch 1965.0
I.A.G.A. (1969)

Magnetic contours
Interval 100 gammas

Sign denotes opposite trend of ambiguous contours

Symbol Key
Ships track

4 Detailed survey area boundary and reference number (cf. margin)

2000m Bathymetric contour

Index to adjoining sheet
NORTH
SOUTH

Source of magnetic data

The tracks on the chart indicate the lines along which data were collected. In regions where detailed surveys exist no tracks are shown and the area is delineated by a box. Where modification of the detailed survey has taken place the tracks used are included across the survey box. Additional data used to the detailed surveys were from:

a Bedford Institute of Oceanography, Canada.
b Cambridge University, U.K. ,
c Centre National pour l'Exploitation des Oceans, France.
d Deutsches Hydrographisches Institut, Germany.
e Durham University, U.K. ,
f Environmental Science Services Administration, U.S.A. ,
g Hudson Laboratories of Columbia University, U.S.A.
h Hydrographer of the Navy, U.K. ,
i Institute of Oceanographic Sciences, U.K. ,
j Lamont-Doherty Geological Observatory, U.S.A. ,
k National Geophysical and Solar Terrestrial Data Centre, U.S.A. ,
l Naval Research Laboratory, U.S.A. ,
m Rhode Island University, U.S.A. ,
n United States Naval Oceanographic Office, U.S.A. ,
o Vening Meinesz Laboratory, Holland.
p Woods Hole Oceanographic Institution, U.S.A. ,
q World Data Centre A. Oceanography, U.S.A. ,

Key to sources of areas of detailed survey

1 Le Bongne, E., Le Mouel, J-L. and Le Pichon, X. (1971) Aeromagnetic survey of south-western Europe. *Earth and Planetary Science Letters*. **12**, 287-299.
2 Heirtzler, J. R., Le Pichon, X. and Gregory Baron, J. (1966). Magnetic anomalies over the Reykjanes Ridge. *Deep-Sea Res*. **13**, 427-443.
3 Vogt, P. R. and Avery, O. E. (1974). Detailed magnetic surveys in the northeast Atlantic and Labrador Sea. *J. Geophys. Res*. . **79**, 363-389.
4 Roberts, D. G. and Jones, M. T. (1978). A bathymetric, magnetic and gravity survey of the Rockall Bank by H.M.S. 'Hecla' 1969. (In press). N.B. The contours shown in this detailed survey box depict the +200 gammas and the −200 gammas value contours only.
5 H.M.S. 'Hecate' 1967 Unpublished survey. (Hydrographic Dept.).

NORTH SHEET

SOUTH SHEET

North Sheet

FARADAY FRACTURE ZONE

Insufficient Data

Goban Spur

BAY OF BISCAY

Biscay Seamounts

ATLANTIC RIDGE

KINGS TROUGH

BISCAY RISE

AZORES-BISCAY RISE

MID ATLANTIC RIDGE

EAST AZORES FRACTURE ZONE

TORE RISE

MADEIRA

Galicia Bank

1 2 3 4 5 6 7 8 9 10 11

Insufficient Data

MAGNETIC ANOMALIES IN THE NORTHEAST ATLANTIC — SOUTH SHEET

MID-ATLANTIC RIDGE TO SOUTHWEST EUROPE

D.G.Roberts and M.T.Jones

Institute of Oceanographic Sciences, United Kingdom.

Scale
1:2,400,000 at 41°N

Projection
Mercator

International Geomagnetic Reference Field for Epoch 1965.0
I.A.G.A.(1969)

Magnetic contours
Interval 100 gammas

+100 +500 0 -500 -1000

Sign denotes opposite trend of ambiguous contours

Symbol Key
Ship's track

5 Detailed survey area boundary and reference number (cf. margin)

2000m Bathymetric contour

Index to adjoining sheet

NORTH

SOUTH

Cartography by David L. Fryer & Co., Henley-on-Thames, Oxon.