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THE MAGNETISATION OF ROSEMARY BANK SEAMOUNT, ROCKALL TROUGH NORTH EAST ATLANTIC

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NATURAL ENVIRONMENT RESEARCH COUNCIL
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INTRODUCTION

Rosemary Bank is a small seamount situated in the northern part of the Rockall Trough immediately to the south of the consortium test well in Block 163/61. The Rockall Trough is thought to be underlain by oceanic crust of Cretaceous age (Roberts, 1975; Roberts et al., in press) but a Permian age has also been suggested by Russell (1976) and Russell and Smythe (1978). As evidence in support of a Permian age, the latter authors cite and interpret the results of an early palaeomagnetic study of Rosemary Bank by Scrutton (1971). In that study Scrutton modelled the magnetic field over the seamount and considered that the results indicated a Mesozoic age but acknowledged the results were 'very uncertain'. Obviously the age of the seamount has some importance but an independent determination of the age of basalts dredged from the Bank has not proven possible as these are badly weathered (Cans: pers. comm.). Jones et al. (1974) have obtained a minimum age of Maastrichtian for nearby Anton-Dohrn Seamount from micropalaeontological studies.

In view of the 'very uncertain results' obtained by Scrutton and the unusual interpretation of a Permian age, the magnetic field over Rosemary Bank was modelled using a three-dimensional program ~~derived~~ developed by Talwani (1965) in an attempt to reduce the uncertainty in the range of ages. We report here the results of that study.

BACKGROUND

Rosemary Bank is a flat topped seamount and has an average minimum depth of about 500m with some small peaks rising to 370m. The seamount was first surveyed by Ulrich (1964). A subsequent more detailed survey of the bathymetry, gravity and magnetic field over the seamount with an east-west track spacing of 1-3 miles was made by the Hydrographer of the Navy (1967).

Seismic profiles across the seamount show that the moat encircling the base of the seamount is of non-depositional origin and that the total of the sub-surface and bathymetric relief is between 3 and 4km (Roberts, 1975; Roberts et al., 1974).

MAGNETIC DATA

The observed total magnetic field anomaly was reduced to the IGRF (Scrutton, 1971; Hydrographer of the Navy, 1967). The anomaly field shows a high frequency positive anomaly close to the centre of the seamount superimposed on a large low frequency negative anomaly (Figure 1). To eliminate the influence of the high frequency anomalies which were initially considered as noise superimposed on the major negative anomaly of the seamount, eight profiles across the seamount in the current direction of the horizontal component of the earth's magnetic field were smoothed by eye. Inherent in this non analytical approach is the assumption that the seamount is not uniformly magnetised and that the body of normally magnetisated rocks is small compared to those that are reversed. The three central profiles spaced 8km apart shown in Figure 2 demonstrate the influence of the high frequency component of the anomaly field and the smoothed anomaly. The smoothed magnetic anomaly contour map is shown in Figure 3.

MAGNETIC MODELLING

A three dimensional magnetics programme (Talwani, 1965) was used to model the total magnetic anomaly field over the seamount. Input to the model consisted of a polygonal representation of the bathymetry mapped from H.M.S. Hecla (Hydrographer of the Navy, 1967). No allowance was made for sediment cover on the exposed flanks of the seamount as seismic profiles show sediments are absent or lie in thin isolated pockets (Roberts, 1975; Roberts et al., 1974).

A number of models were computed assuming the flanks of the seamount extended through a range of depths to 10km. The magnetic vector used in the model was the resultant (Ires) of remanent plus induced magnetisation. The inclination of the earth's field was taken at 72° and the declination as 15° west of north. All remanent magnetisation vectors were assumed to have zero declination. Stereographic great circle plots of the magnetic vectors for remanent inclinations of 20°, 40° and 50° are shown in Figure 4 together with the resultant magnetic vectors produced by adding four intensities of induced magnetisation corresponding to Koenigsberger ratios (Q) of 1, 2, 4 and infinity.

RESULTS

The calculated anomaly that was most consistent with the observed data was obtained by models that used an assumed depth to the base of the seamount of 1.5km.

Models using depths to the base of the seamount of between 2 and 10km produced high amplitude negative anomalies and steep magnetic gradients particularly along the southern margin of the seamount that are incompatible with the observed field. As the actual sub-surface relief of the seamount is between 2 and 3km, several attempts were made to improve the fit by varying the magnetic parameters of the model. These resulted in a poorer fit and one example is shown in Figure 5.

Results of four model calculations using a 1.5km depth and resultant magnetisation vectors of 20° to 50° inclination are shown in Figures 6 and 7. The magnetisation used in each model of $-12Am^{-1}$ was assumed from successive iterations and is consistent with the evidence of basic igneous rocks given by dredging, gravity models and measurements on other seamounts (Cann, pers. comm.; Scrutton, 1971; Ade-Hall, 1964). The differences in the magnitude of the computed anomaly for each model are not great but in interpreting the model results, the shape of the smoothed anomaly has some importance. For low inclination of resultant magnetisation, a more asymmetric anomaly is calculated than is observed. This is true irrespective of whether the positive anomaly to the south is thought to be produced entirely be the seamount. For remanent magnetisation vectors of between 20° and 50°, the introduction of induced magnetisation reduces the inclination of the resultant vector suggesting that Q may be considerably greater than the ratio of 1.0 estimated by Scrutton (1971).

The closure of anomalies to the south is modelled using high inclinations and, together with the similarity in form to that observed, suggests that the resultant magnetisation has a fairly high inclination and therefore a low induced magnetisation. From this it is proposed that the resultant magnetisation vector of Rosemary Bank compatible with the best fit has an inclination of not less than 40°. That the inclination of the remanent component of this vector cannot be less, and is dependent on the Q value, can be illustrated as follows. If the seamount was entirely reversely magnetised the remanent inclination would be 40°. If induced magnetisation in the present direction of the earth's field is included, the remanent magnetisation would need to have a greater inclination in order to achieve the best fit from the resultant vector. This is also illustrated by the change in Ires with decreasing Q corresponding to increasing intensity of induced magnetisation. The inclination of 40° is compatible with formation of the seamount in Late Cretaceous-Early Tertiary time (Habicht, 1979). Although declination of the resultant magnetic vector did not significantly alter the model, it appears that easterly declinations are unlikely.

Additional models were computed in an attempt to model the high frequency positive anomalies not included in the interpretation of the smoothed anomaly. These anomalies have a minimum wavelength of 3.5km and an amplitude of 1000 nT and are clearly produced by normally magnetised bodies in contrast to the reverse magnetisation of the bulk of the seamounts. However, no acceptable fit for these bodies could be found. The presence of these anomalies indicates a subsequent phase of igneous activity that took place after the formation of the bulk of the seamount during a period of reversed polarity so that the normally magnetised bodies intrude and/or overlie the reversely magnetised rocks so producing these complex anomalies.

DISCUSSION AND CONCLUSIONS

Rosemary Bank Seamount is not uniformly magnetised and the best fit of the reversely magnetised component of the magnetic anomaly requires relatively high inclinations of 40 to 50° for the remanent magnetisation. If induced magnetisation in the present direction of the earth's field is included, the remanent magnetisation would need to have a greater inclination in order to achieve the best fit from the resultant vector. These high inclinations are not compatible with formation and magnetisation of the seamount in Permian, Triassic or Jurassic time which would require inclinations close to 14°, 22° and 30° respectively (Habicht, 1979). The inclinations are most compatible with formation of the bulk of the seamount formed during a period of reversed polarity in Late Cretaceous-Early Tertiary time (Habicht, 1979). The evidence of normally magnetised rocks indicates subsequent igneous activity but there is no means of demonstrating that the igneous activity was continuous through the normal and reverse polarity intervals and indeed it may not have been so. The results of the magnetic anomaly modelling suggest that the base of the seamount is situated at about 1.5km depth. This depth is shallower than the observed depth of basement in the Rockall Trough (Roberts, 1975) but results from Pacific seamounts (Harrison _et al._, 1975) have indicated that intensity and not direction of magnetisation is sensitive to the depth of the model.

The inferred Late Cretaceous-Early Tertiary age for Rosemary Bank is not compatible with the Permian age interpreted and used inferentially by Russell and Smythe (1978) to support a speculative Permian age for spreading in the Rockall Trough. The new data can be best understood in terms of two hypotheses compatible with the known history of the Rockall Trough. Firstly, spreading in the Rockall Trough is considered to have taken place between Albian and Campanian time from an anlaysis of the seismic reflection and magnetic data (Roberts et al., in press) and Rosemary Bank Seamount may have formed during the final phases of the spreading. Secondly, Rosemary Bank may represent one of the many volcanoes formed during the widespread volcanic episode that preceded the initiation of spreading between Greenland and the Rockall Plateau and is revealed by the volcanism of the Faeroes, East Greenland, N.W. Britain and the Rockall Trough (Roberts et al., in press; Roberts et al., 1979; Brooks, 1980). In terms of this hypothesis, the seamount post-dates the spreading of the Rockall Trough and any sedimentation that took place in the post spreading interval between Albian and Palaeocene time. The discrepancy between the depth of the seamount from magnetic modelling and the observed sediment thickness can be interpreted in terms of this hypothesis and the presence of an older sedimentary section under the seamount.

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FIGURE CAPTIONS

FIG. 1. Bathymetry and observed magnetic anomaly indicating smoothing profiles, contour interval 100 nT.

FIG. 2. Profiles over the centre of the observed anomaly showing the selected smoothed anomaly form. Profiles are 8km apart on bearing 345°.

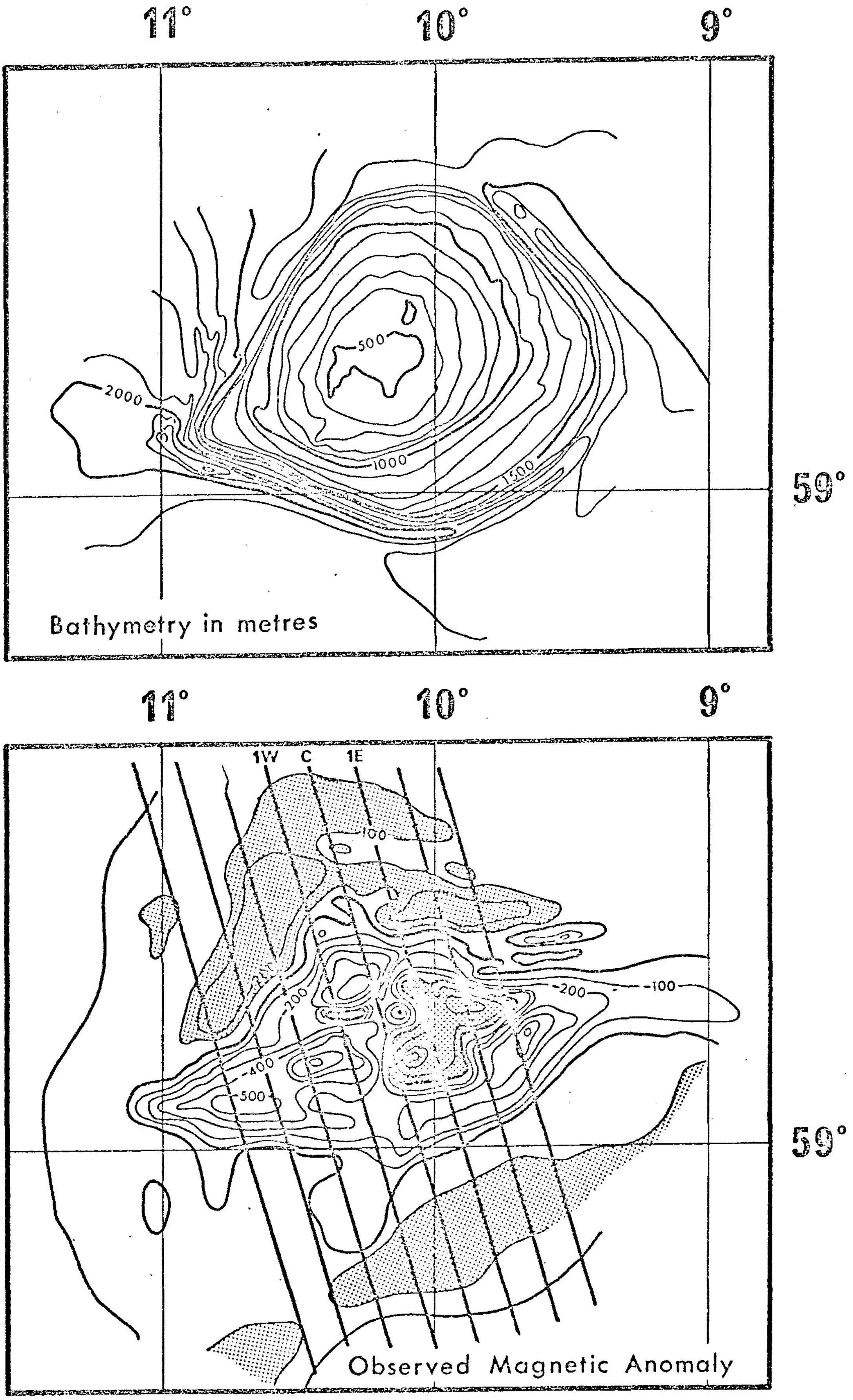
FIG. 3. Bathymetic model with contour polygons 100 metres thick down to 1400 metres, the base extending to 1500 metres and the smoothed observed magnetic anomaly.

FIG. 4. Great circle plots of magnetisation vectors produced by three remnant inclinations and four Q values. Declination: induced = -15; remnant = 0.

FIG. 5. Model magnetic anomaly for resultant magnetisation vector of 40° with the model base, 2.5km below sea level.

FIG. 6. Model magnetic anomalies for resultant magnetisation vector of 20° and 30° inclination. Model base 1.5 km

FIG. 7. Model magnetic anomalies for resultant magnetisation vectors of 40° and 50° inclination. Model base 1.5 km



Bathymetry in metres

Observed Magnetic Anomaly

Fig 1

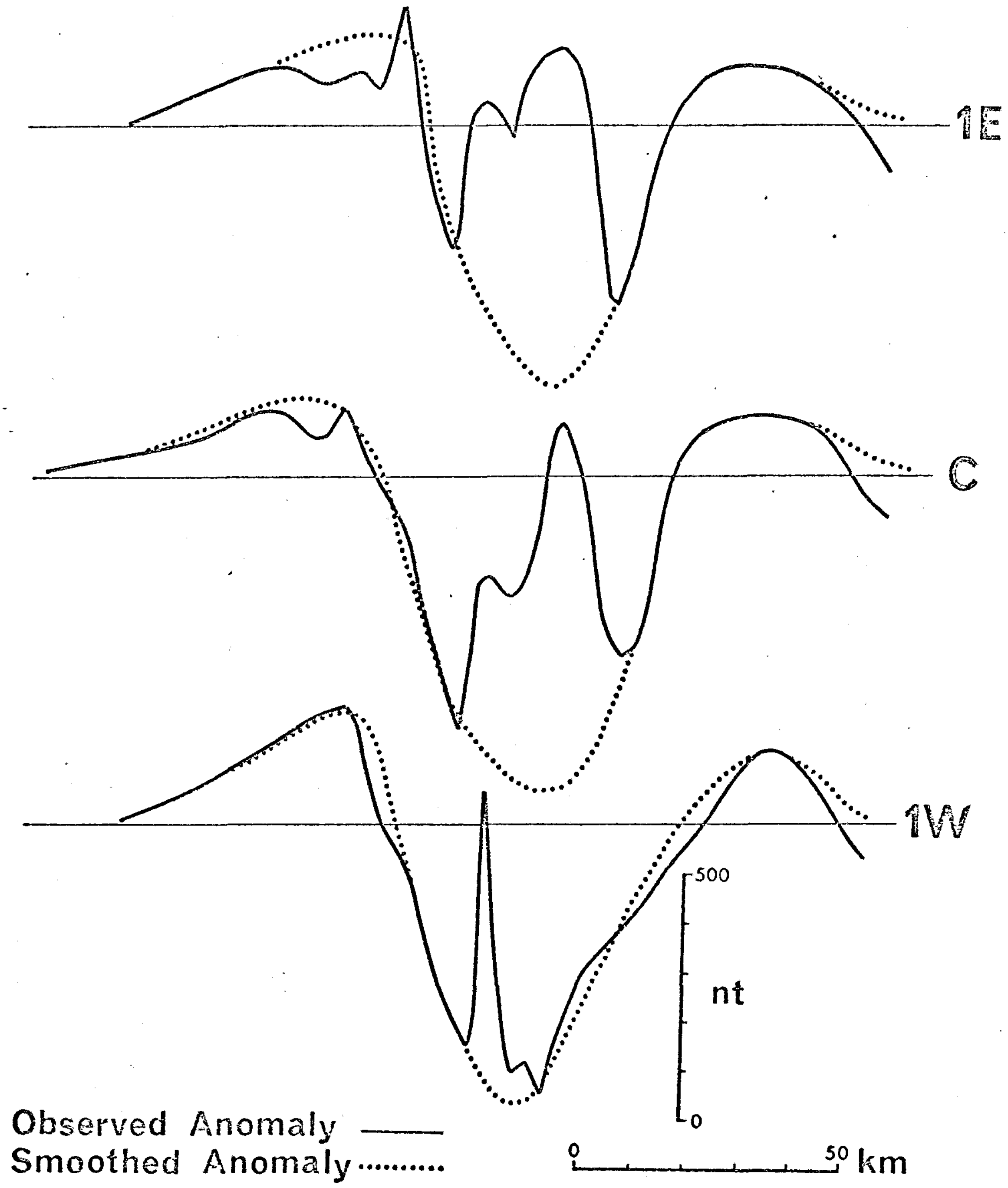


Fig 2

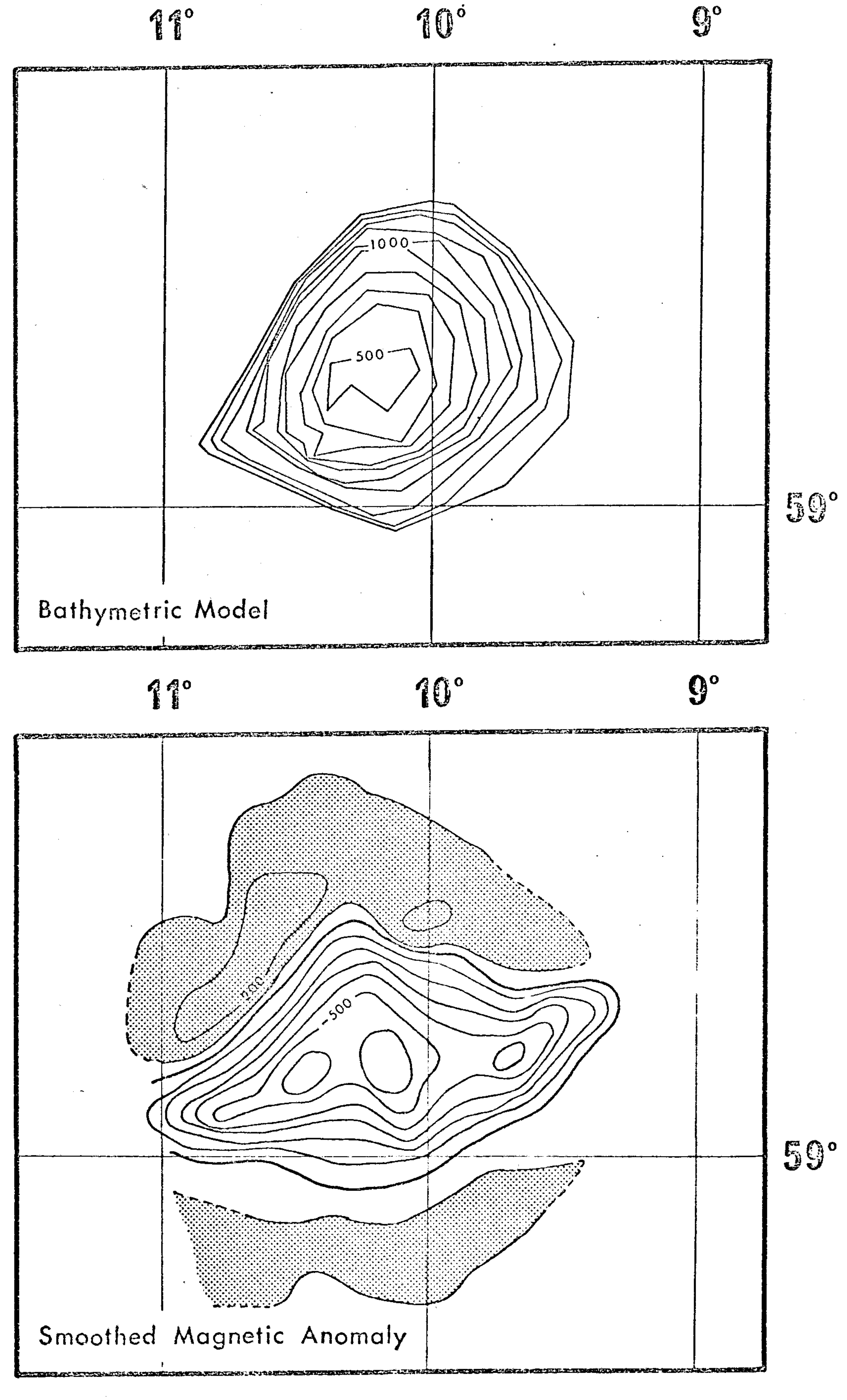

11°
10°
9°
1000
500
59°
Bathymetric Model
11°
10°
9°
200
500
59°
Smoothed Magnetic Anomaly

Fig 3

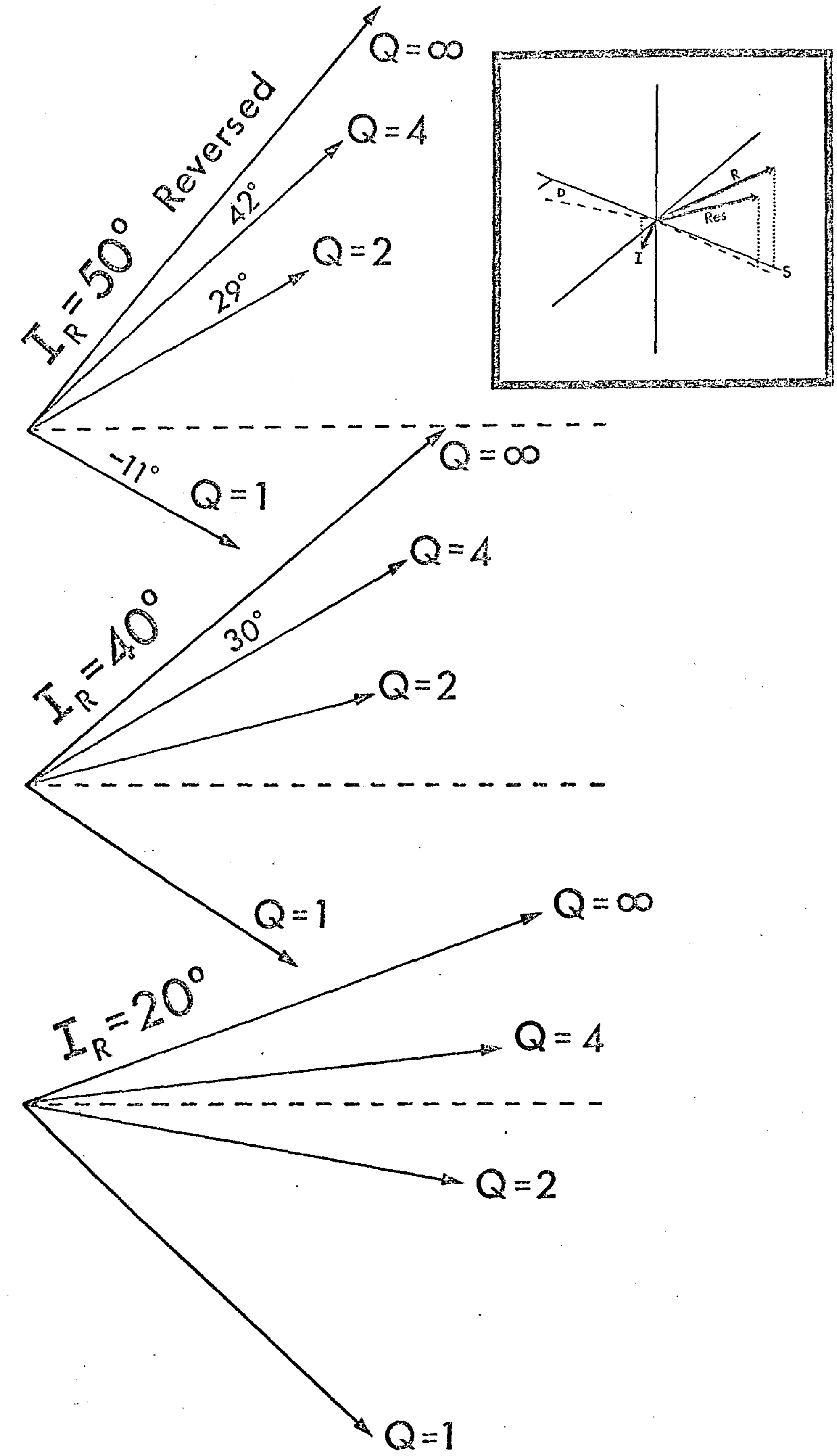

$I_R = 50°$ Reversed
Q = ∞
Q = 4
42°
Q = 2
29°
-11°
Q = 1
D
R
Res
I
S
$I_R = 40°$
Q = ∞
Q = 4
30°
Q = 2
Q = 1
$I_R = 20°$
Q = ∞
Q = 4
Q = 2
Q = 1

Fig 4

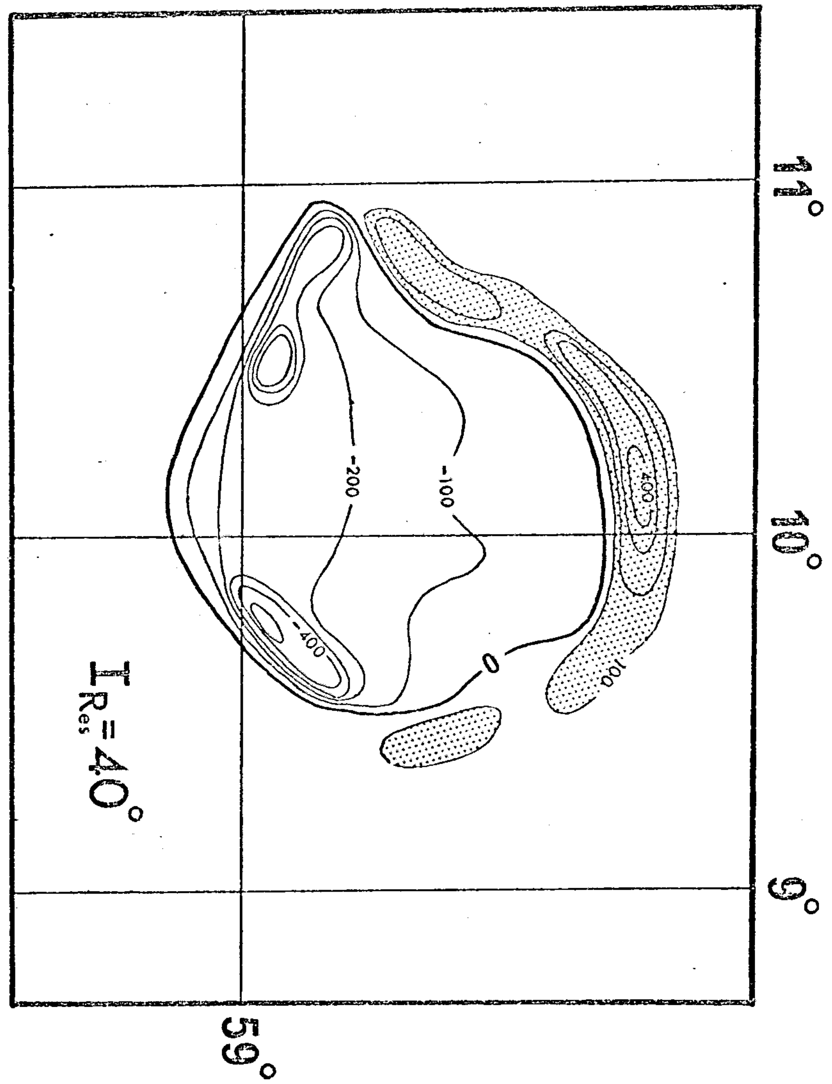


Fig 5

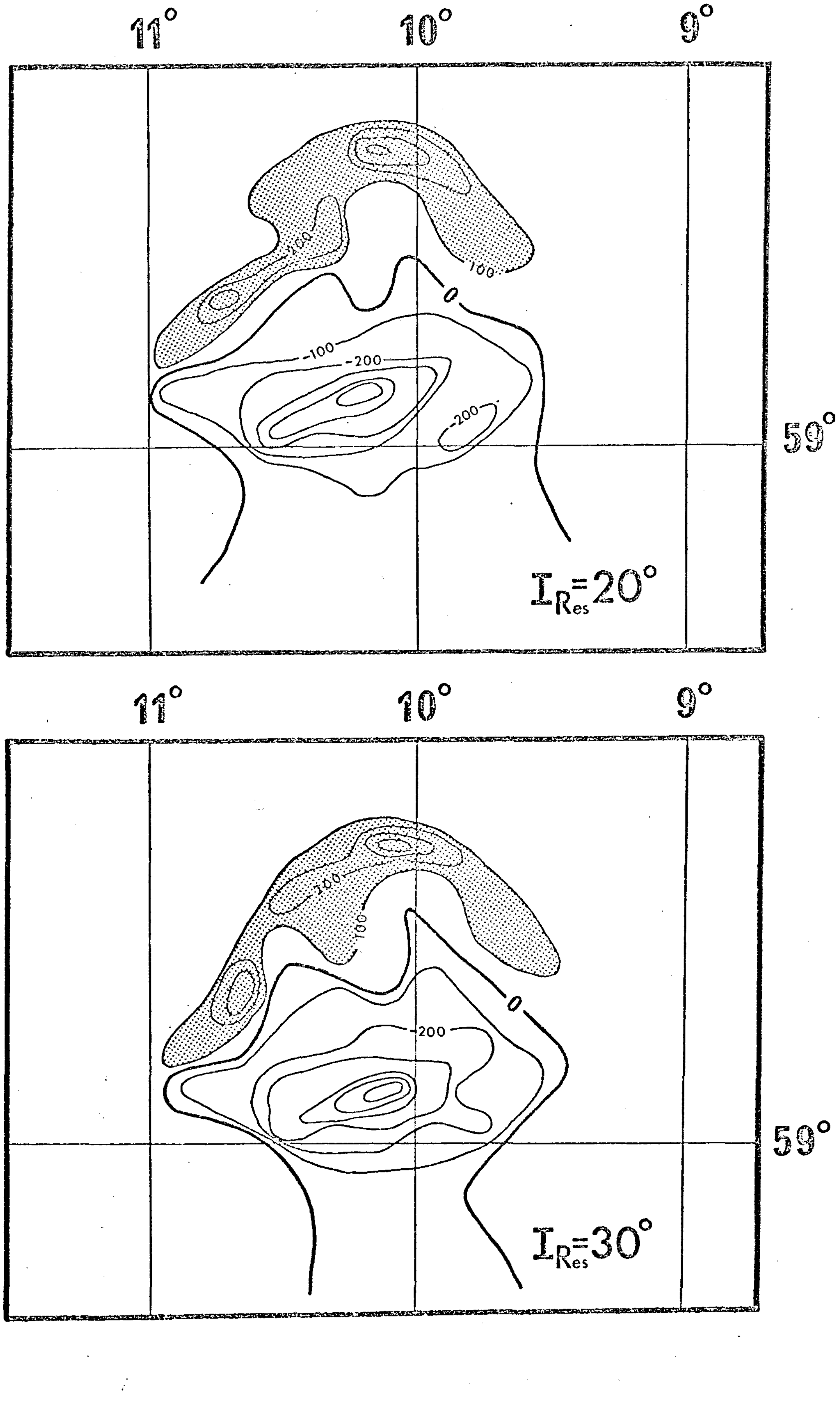


Fig 6

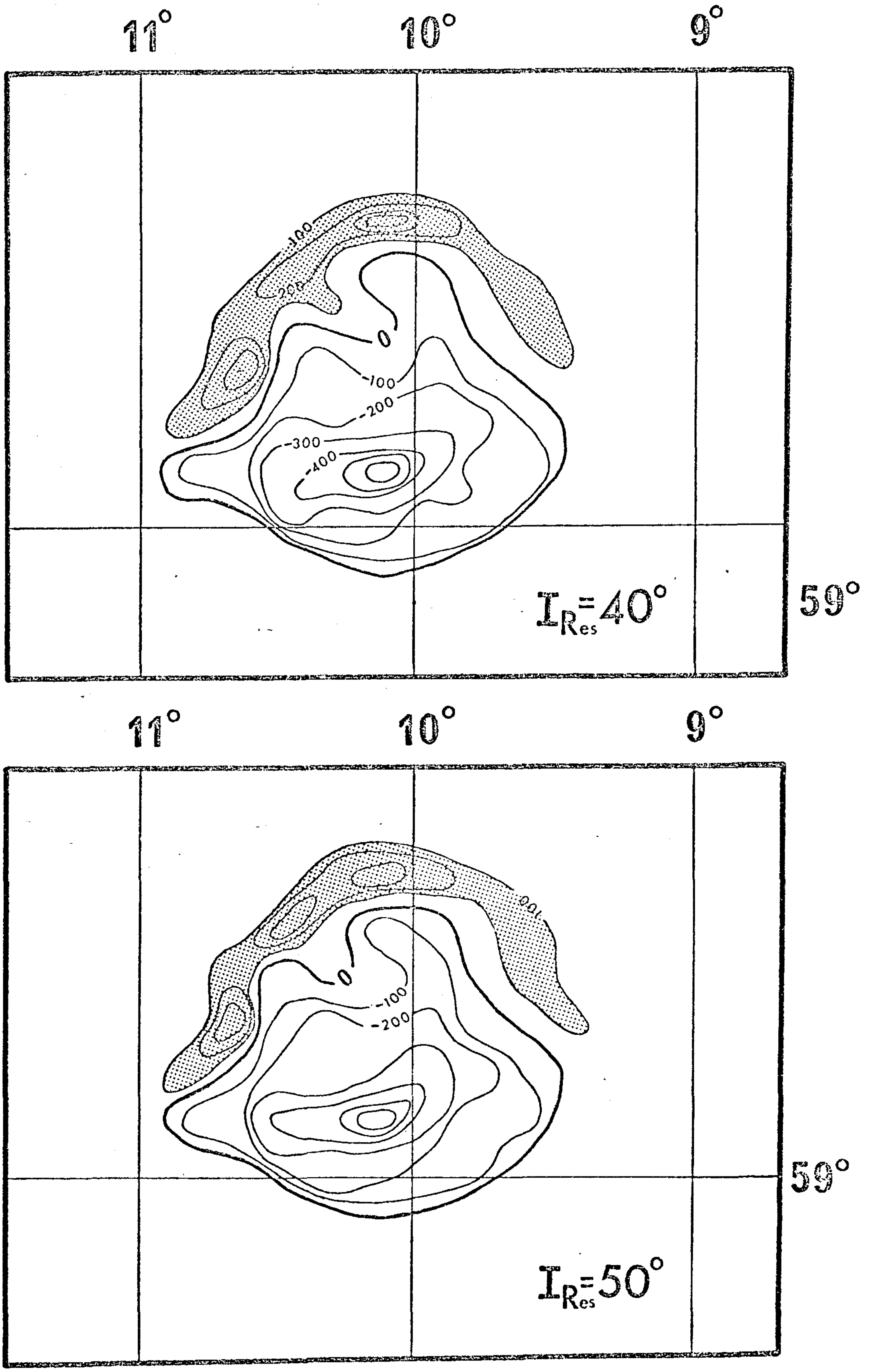

11°
10°
9°
100
200
0
-100
-200
-300
-400
I_Res=40°
59°
11°
10°
9°
100
0
-100
-200
59°
I_Res=50°

Fig 7