MAGNETIC MODELLING
IN THE DAVIS STRAIT AND NORTHERN LABRADOR SEA

by

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ABSTRACT

The Davis Strait is a constricted passage lying between Baffin Island and Greenland. Davis Strait separates the waters of Baffin Bay and the Labrador Sea. There have been disagreements as to the nature of the crust in underlying the Davis Strait.

Detailed marine magnetic data from the Davis Strait were gathered on geophysical surveys carried out by the Bedford Institute of Oceanography in 1980-81. The data show north-south lineations over most of the area.

Wu (1984) interpreted the data and suggested that the magnetic anomalies were produced by seafloor spreading. The subsurface structure of the Davis Strait has been modelled based on Wu's (1984) interpretation. Of all the Davis Strait models, the one which produced a calculated magnetic profile closest in fit to the observed magnetic data is based on a modified version of Wu's (1984) interpretation. Models were also developed in the northern Labrador Sea where more data are available and the anomalies are better identified.

The models seem to indicate that seafloor spreading has occurred in the Davis Strait. However, the process of spreading in the Davis Strait region appears, necessarily, to be more complicated than is indicated by Wu's (1984)

simple model.

INTRODUCTION

Davis Strait is a constricted passage separating the waters of Baffin Bay to the north and the Labrador Sea to the south. Davis Strait lies between the coasts of southern Baffin Island and west Greenland. A sill with water depths between 400 and 800 metres constitutes the central part of the Strait. (See figure 1). This is a key area in defining the manner of separation between Greenland and North America.

There have been several theories for the geological evolution of Baffin Bay and the Labrador Sea. In one category are the fixist and related oceanization theories, which maintain that continents have always had their present geographic locations relative to each other (Kerr, 1981). One fixist theory, that of Meyerhoff (1973), suggests that the North Atlantic Ocean has been in its present position since the Middle Proterozoic. Grant (1980) proposes that the Labrador Sea and Baffin Bay have been formed by vertical crustal movements and are underlain by continental crust. Van der Linden (1975) is of the opinion that a small area of the Labrador Sea may have been formed by seafloor spreading, but a much wider zone of the Labrador Sea has been formed by crustal thinning and foundering of continental fragments. Umpleby (1979) proposed that the Labrador Sea and Baffin Bay were formed by the collapse of undations and, therefore, no

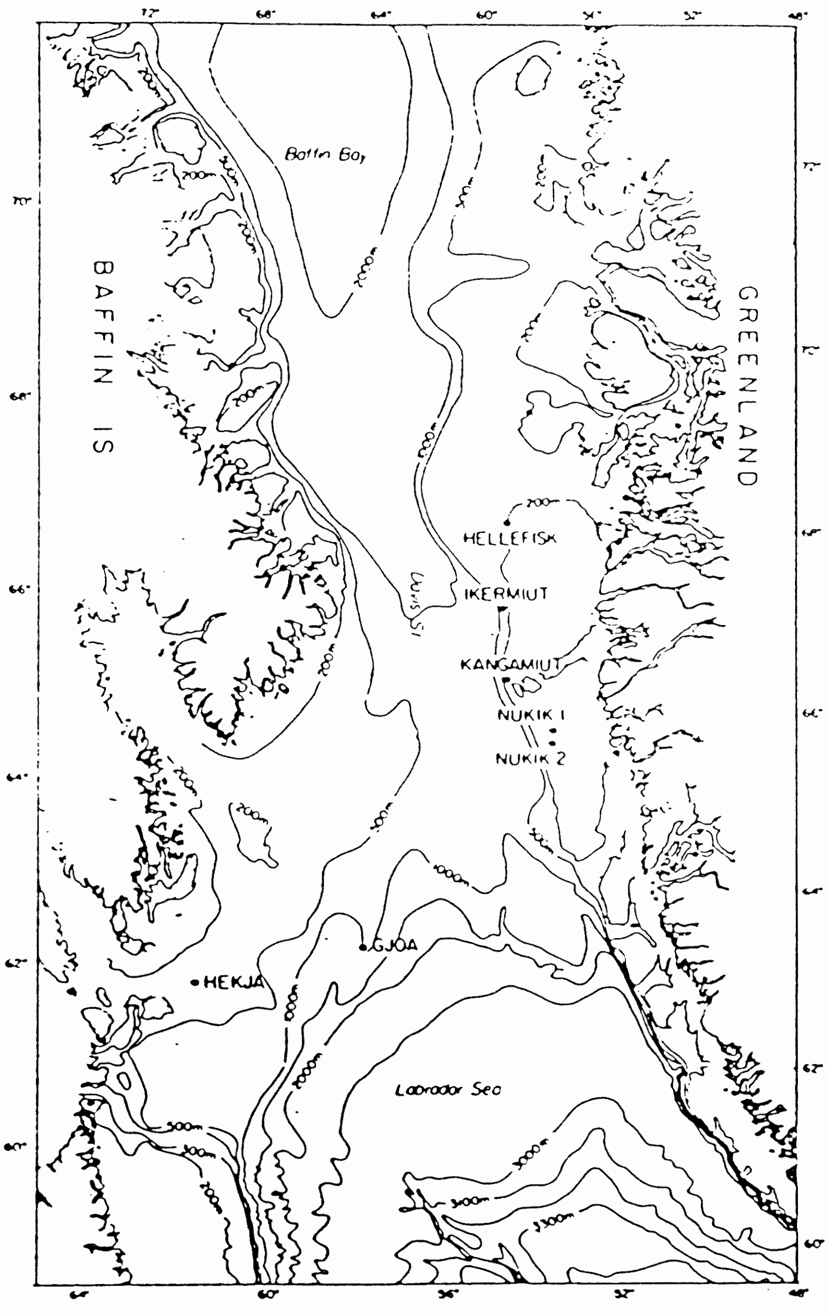

Figure 1. General bathymetry of the Davis Strait region. Also shown are the locations of deep exploratory wells drilled off Greenland and Baffin Island . Wu (1984).

new crust was formed between North America and Greenland.

Another category of theories for the geologic evolution of Labrador Sea-Baffin Bay is that of seafloor spreading and continental drift. Many workers (Keen et al, 1972; Johnson et al , 1969; Hyndman 1973, 1975; Kristofferson and Talwani, 1977; Srivastava 1978; Srivastava et al, 1981; Srivastava and Tapscott, 1985) believe that oceanic crust formed by seafloor spreading at mid-ocean ridges in Baffin Bay and the Labrador Sea as Greenland drifted laterally away from Baffin Island.

A third theory, intermediate between the extremes of fixist and drift theories, is that of Kerr (1967, 1981), who proposed that oceanic areas, formed between Baffin Bay and the Labrador Sea, have been formed by a combination of the movement apart of the plates by rotation, and subsidence and oceanization of a very large intervening segment of continental crust.

Studies of the Davis Strait area may help to resolve the controversy over the origin of Baffin Bay and the Labrador Sea. In the Davis Strait region itself, there is disagreement as to the nature of the crust. In accordance with the theories mentioned above, some workers (Meyerhoff, 1973; Grant, 1980; Van der Linden, 1975; Umpleby, 1979; Kerr, 1967, 1981) believe that Davis Strait is underlain by continental crust which may have been modified. Other workers believe that Davis Strait is underlain by oceanic crust formed by seafloor spreading at an active ridge (Keen et al, 1972; Clarke and Upton, 1971) or by a mantle plume or hot spot (Hyndman, 1973, 1975).

Plate tectonic reconstructions of Kristoffersen and Talwani (1977) and Srivastava (1978) require the generation of some ocean crust in the Davis Strait. However, due to the oblique motion through the strait, it is possible that the crust in this region could contain a fragment of continental crust derived from the North American or Greenland plates as they separated (Srivastava et al, 1982).

Seismic refraction measurements in the central part of Davis Strait (Keen and Barrett, 1972) show the crust to be thicker than normal oceanic crust and thinner than normal continental crust (Srivastava et al, 1982). Before data were collected in 1980-81, the available, widely spaced magnetic anomaly profiles showed a noisy pattern without typical seafloor spreading features.

MAGNETIC DATA

Detailed marine magnetic data were collected on geophysical surveys carried out by the Bedford Institute of Oceanography in 1980-81. Positioning during the surveys was accomplished using a combination of satellite and Loran-C navigation. Data reduction was carried out at sea using standard methods (Shih _et al_, 1978). The 1980 IGRF (International Geomagnetic Reference Field) was used to derive the magnetic anomaly. Figure 2 shows a computer plot of magnetic profiles along ship tracks.

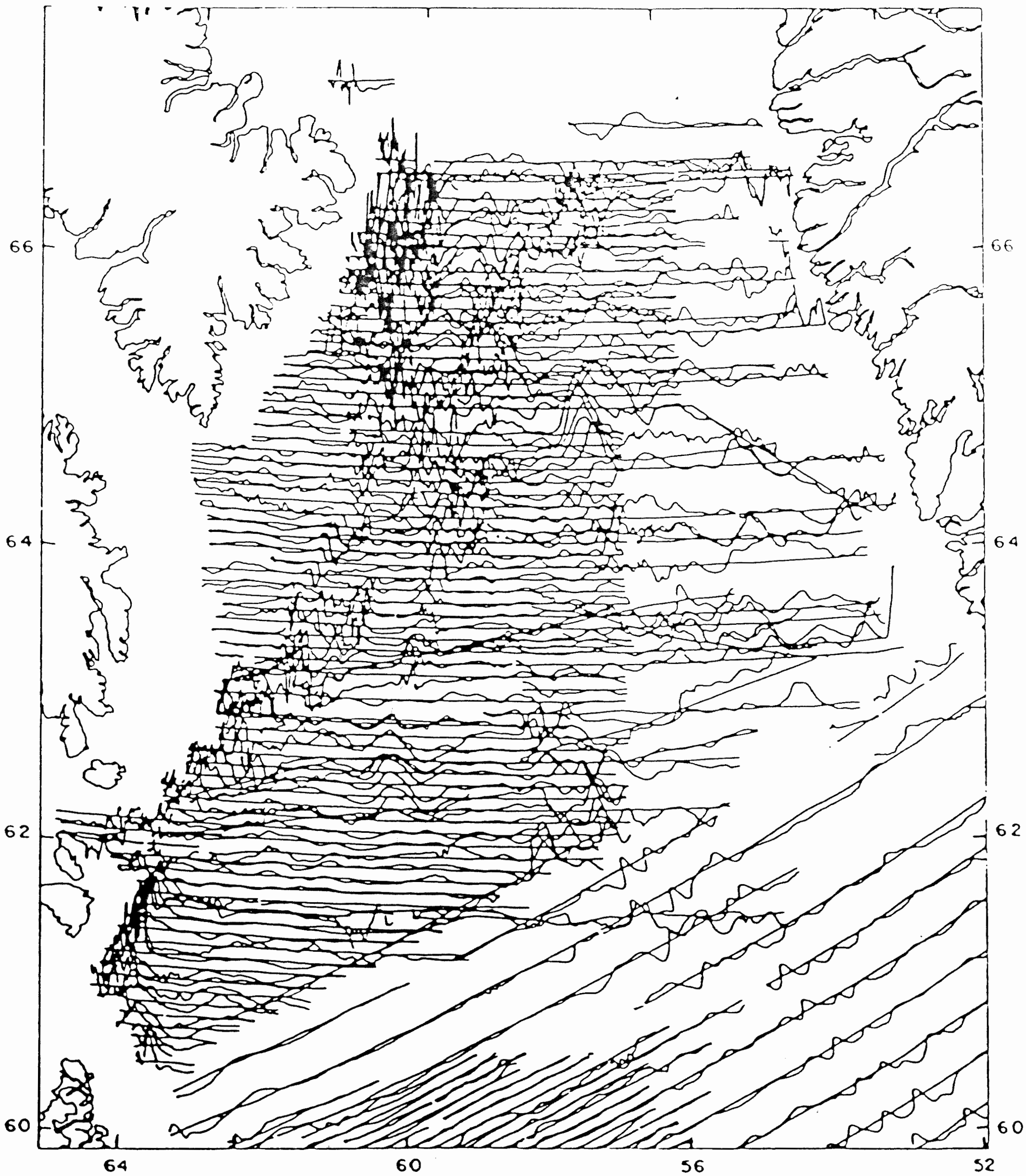

Figure 2. Map of magnetic profiles along ship tracks in the Davis Strait. Wu (1984).

INTERPRETATION

A. INITIAL INTERPRETATION BY WU (1984)

Davis Strait magnetic data, collected during 1980-81, were analyzed. Wu (1984) correlated some positive magnetic anomaly bands with the geomagnetic polarity time scale of Harland *et al* (1982), as shown in figure 3. Positive anomalies 13, 21, 22, 23, 24 and 25 were identified, but anomalies 14-20 were difficult to identify on account of frequent polarity changes. North-south oriented magnetic anomaly bands were correlated with identified anomalies in the northern Labrador Sea. Wu (1984) reports that the central anomaly zone coincides with a prominent gravity low. However, as shown in figure 4, the central anomaly zone appears to lie to the west of the gravity low. Wu (1984) believes that these results imply that the anomalies were formed by seafloor spreading, with the gravity low marking an extinct spreading center. It has been suggested that seafloor spreading in southern Davis Strait started during magnetic anomaly 27 or anomaly 28 and ceased at the time of anomaly 13.

Wu (1984) reports asymmetric spreading in the Davis Strait: spreading rates to the east of the ridge are higher than those to the west. In southern Davis Strait (63 N), Wu (1984) reports spreading rates of 8.4 mm/yr east of the

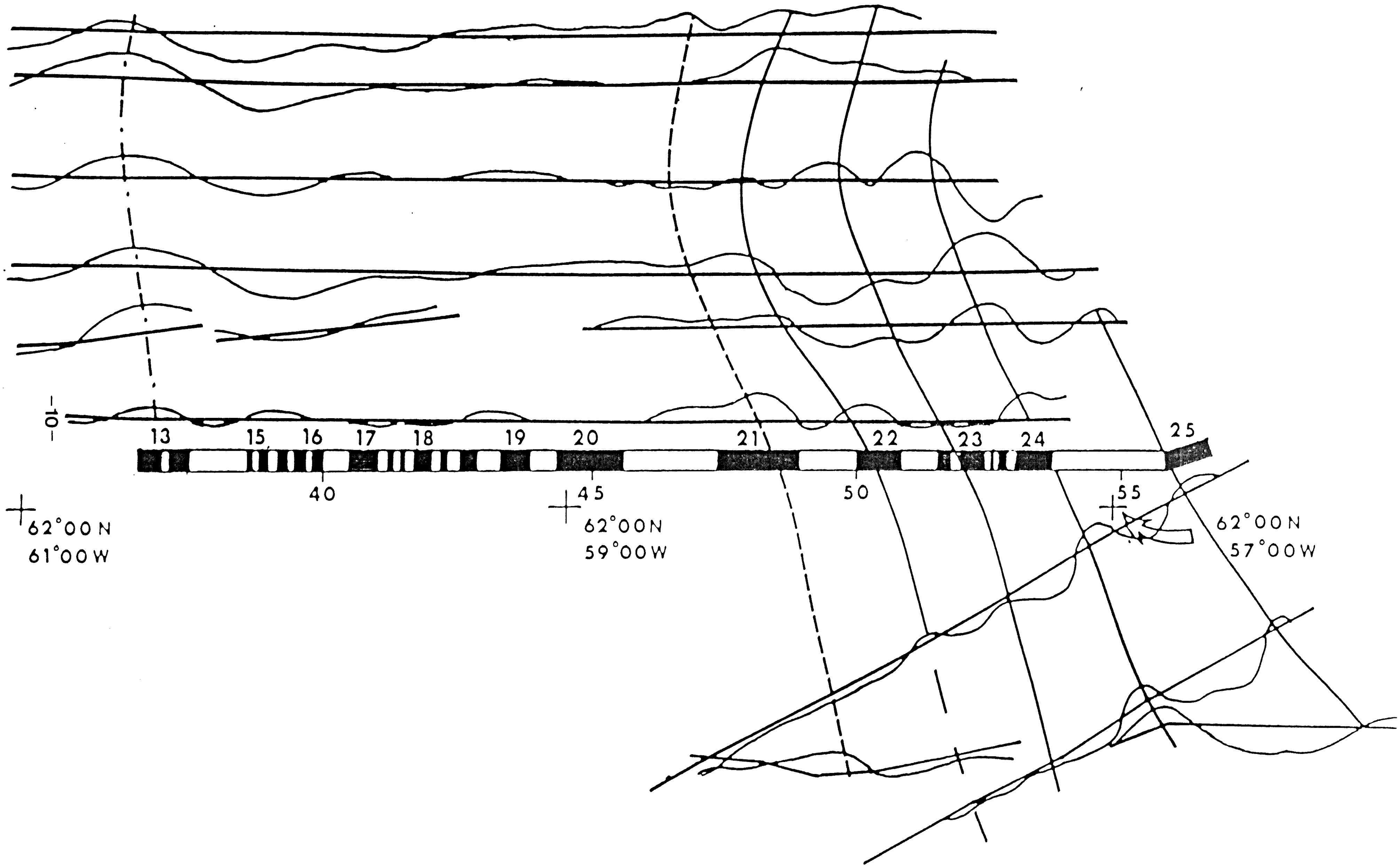

Figure 3. Wu's (1984) comparison of magnetic profiles with the polarity time scale. The numbers 13 to 25 are polarity chrons of anomalies and the numbers below are age (Ma).

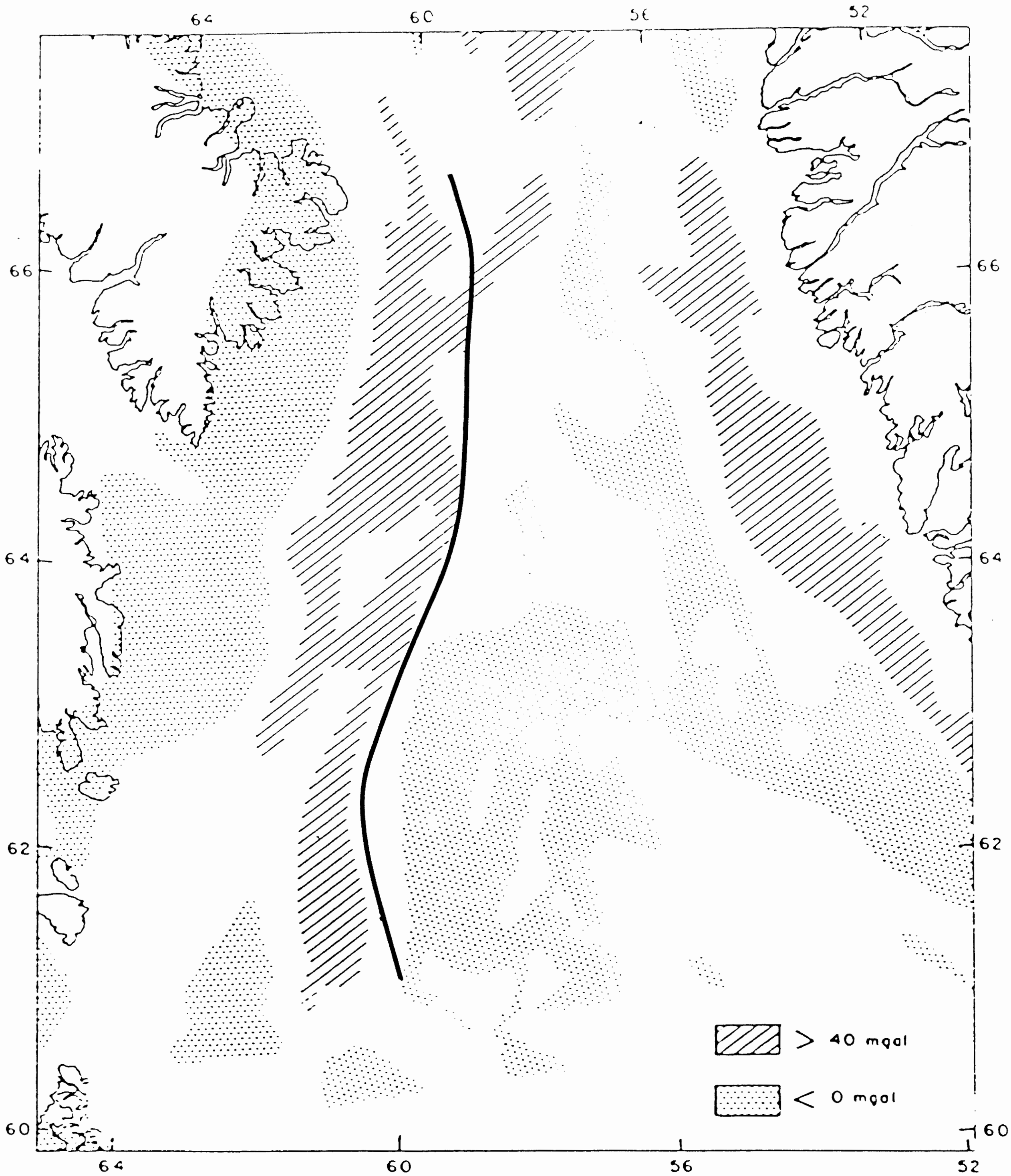

Figure 4. Map of gravity anomalies in the Davis Strait. The solid line shows the location of the central anomaly zone. Wu (1984).

spreading center and 2.7 mm/yr to the west. In the north (66 N), spreading rates were reported to be 4.5 mm/yr to the east of the spreading center and 2.1 mm/yr to the west. Wu (1984) reports that the decreasing rate from south to north is consistent with a decrease in distance to the pole of rotation. This is in conflict with the results of Srivastava (1978), who reports decreasing rates of spreading from north to south in the Labrador Sea and a pole of rotation located at latitude 13.00N and longitude 2.00E for anomalies 13 to 21 in the Labrador Sea.

The trends of Wu's (1984) interpreted fracture zone(s), shown in figure 5, form an oblique angle with the direction of magnetic lineations. He suggests that this is a result of oblique spreading about the ridge in Davis Strait.

B. PROBLEMS WITH WU'S (1984) INTERPRETATION

As mentioned earlier, Wu (1984) encountered difficulties in identifying the magnetic anomalies. No attempt has been made by Wu (1984) to calculate magnetic anomalies for the given interpretation and compare the calculated and observed magnetic profiles.

In this thesis, calculated magnetic profiles, produced from models based on Wu's (1984) interpretation will be compared with the observed magnetic profiles. The modelling

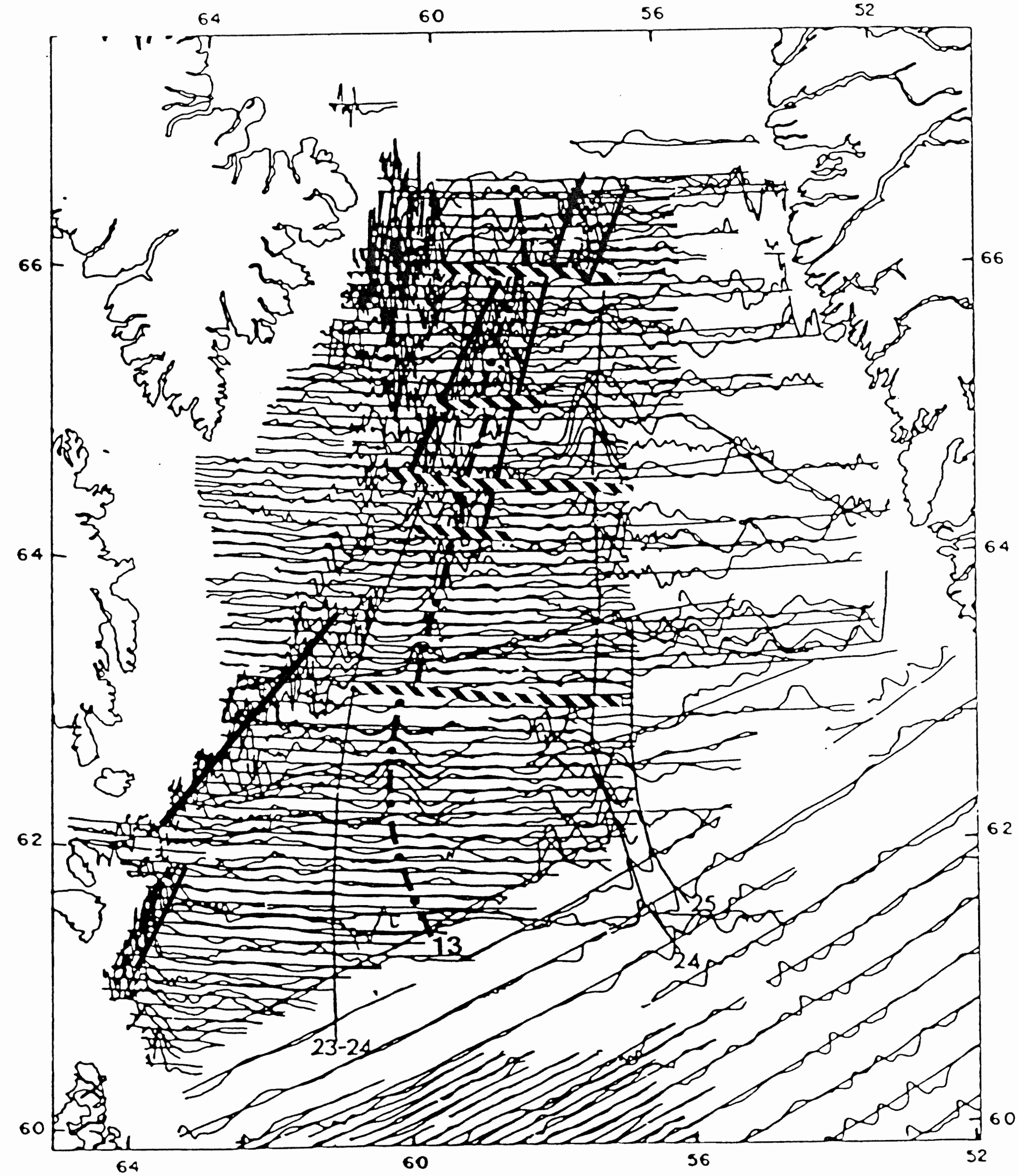

Figure 5. Map showing the inferred anomaly numbers and the geological interpretation of magnetics as given by Wu (1984). (Thin solid lines = magnetic lineations; heavy solid lines = faults; dashed lines =fracture zones; diagonal slash = extinct ridge axes).

method will also be tested in the northern Labrador Sea where anomalies are better identified.

A magnetic modelling program, based on a program developed by Talwani and Heirtzler (1964), was used to calculate the magnetic anomalies over a two dimensional strip model. A listing of this program can be found in Appendix 1. In figure 6, from Vaquier (1972),

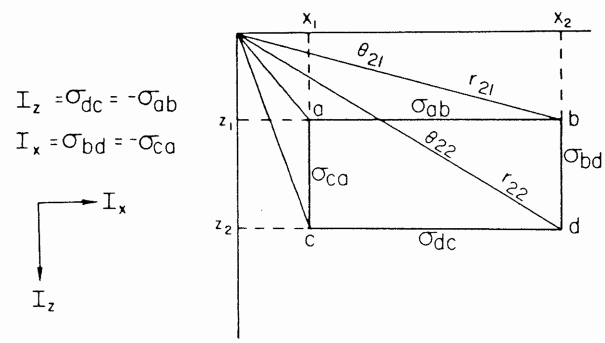

Figure 6. The rectangle abcd represents the section of a uniformly magnetized parallelopiped infinitely long in the y-direction. (Vacquier,1972).

the rectangle abcd represents a section through one of the magnetized strips in the model. The contributions of each face to the horizontal and vertical magnetic intensity are summed to give an expression for the rectangular strip. For the horizontal magnetic intensity:

$$\Delta H_x(abcd)=2I_x(\theta_{21}+\theta_{12}-\theta_{11}-\theta_{22})+2I_z(\log\frac{r_{21}}{r_{11}}-\log\frac{r_{22}}{r_{12}})$$

and for the vertical magnetic intensity:

$$\Delta Z(abcd)=2I_x(\log\frac{r_{12}}{r_{11}}-\log\frac{r_{22}}{r_{21}})+2I_z(\theta_{11}+\theta_{22}-\theta_{21}-\theta_{12})$$

Angles and distances are labelled in figure 6. The magnetization constants are:

$I_x = I \cos i_o \cos C_o$ and $I_z = I \sin i_o$

where $I = T_o k$ and i_o = the magnetic dip angle, C_o = the strike of the ridge, T_o = the total magnetic intensity and k = the susceptibility.

The contributions of all blocks in the strip model are added to obtain the magnetic intensity at the origin. For other points on the profile the pattern is displaced and then the sums are recalculated (Vacquier, 1972).

DAVIS STRAIT MODELS

Based on the identification of anomalies and spreading rates given by Wu (1984), models were developed and magnetic anomaly profiles were calculated for each model. The models use normally and reversely magnetized blocks to represent the geomagnetic reversal time scale as given by Harland et al (1982). The blocks were assumed to be two kilometers thick at a depth of one kilometer below the ocean bottom, as given by the bathymetry. Values for magnetic field intensity, declination, and inclination were obtained from charts of the earth's magnetic field e.g. Parkinson (1983).

Figure 7 shows the results of the Davis Strait models. Profile (a) shows the magnetic anomaly profile produced from Wu's (1984) interpretation, as shown in figure 5. A constant spreading rate of 10.2 mm/yr was used. This is greater than the rate of 8.4 mm/yr reported by Wu (1984). Superimposed over the calculated anomaly is an observed profile. Other observed profiles are shown in figure 5. There is poor agreement between the observed and calculated anomalies. Profile 7(b) is the calculated anomaly for a modified version of Wu's (1984) interpretation. The modification is based on reidentification of anomalies in the Labrador Sea by Srivastava and Tapscott (1985). Anomaly 24 has been reidentified as anomaly 25. A constant spreading rate of 8.6 mm/yr was used. An observed profile

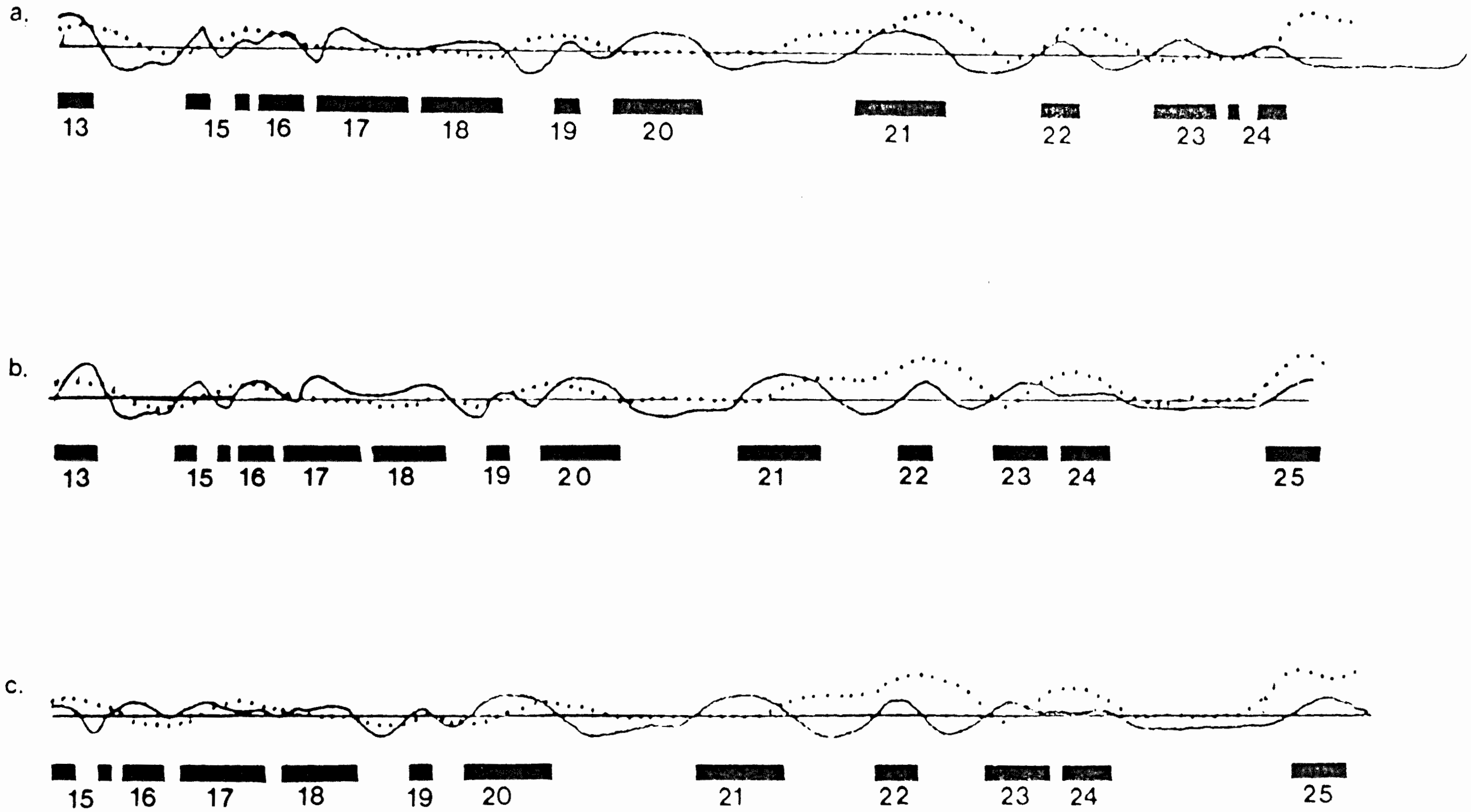

Figure 7. Davis Strait magnetic models. Shown are calculated profiles with polarity chrons number shown below profile. Observed profile (dotted) shown superimposed. Horizontal scale 1:1,000,000. Vertical scale 600nT/cm.

(a) Model of Wu's (1984) interpretation. Block model with polarity chrons number shown below profile. Observed profile (dotted) shown superimposed.

(b) Model for reidentification of anomaly 24 as anomaly 25.

(c) Model for the reidentification of youngest peak as anomaly 15.

is superimposed over the calculated anomaly. The agreement between the observed and calculated profile is better than in the first model but the fit is still poor.

Some workers (Srivastava, personal communication) believe that spreading in the Davis Strait ceased before anomaly 13 time and therefore magnetic anomaly 13 is not present in the Davis Strait. Based on this interpretation, a model was developed assuming that the peak that Wu (1984) believes is due to anomaly 13, is actually due to anomaly 15. A constant spreading rate of 9.8 mm/yr was used. The model for this interpretation is shown in figure 7(c). The observed profile is superimposed over the calculated profile. The agreement between the observed and calculated profiles is poor. As seen in figure 5, a large negative trough occurs east of the central peak on many profiles. If the central peak is due to anomaly 15, then, as can be seen from the pattern of magnetic reversals, there is no explanation for the large negative troughs. The periods of reversed polarity occurring between anomalies 15 and 16 are not large enough to produce the large trough seen in the observed profiles. However, Wu's (1984) identification of the central peak as anomaly 13 does produce the required trough. On this basis I believe that the interpretation shown in figure 7(b) is most nearly correct.

LABRADOR SEA MODELS

Modelling was also done in the northern Labrador Sea where there are more data and the anomalies have been better identified. Figure 8 shows the location of the areas which were modelled. Observed profiles from an area in northeastern Labrador Sea are shown in figure 9(a). A model was developed using the identifications of anomalies as given by Srivastava and Tapscott (1985), shown in figure 9(a). As suggested by Srivastava (personal communication) the model used spreading rates of 9.0 mm/yr between anomalies 24 and 26 and 5.1 mm/yr between anomalies 27 and 31. The calculated profile is shown in figure 9(b). Superimposed over the calculated anomaly is the observed profile which fits the model best. There is a reasonable agreement between the observed and calculated anomalies.

Modelling was also done on the equivalent area to the west of the spreading center in the northern Labrador Sea. Some observed profiles from this area are shown in figure 10(a). The identifications for anomalies, as given by Srivastava and Tapscott (1985), is shown in figure 10(a). The model developed for the area to the east of the spreading center is reversed and shown in figure 10(b). Shown superimposed over the calculated profile is an observed profile from the area. The agreement between the observed and calculated profiles is poor.

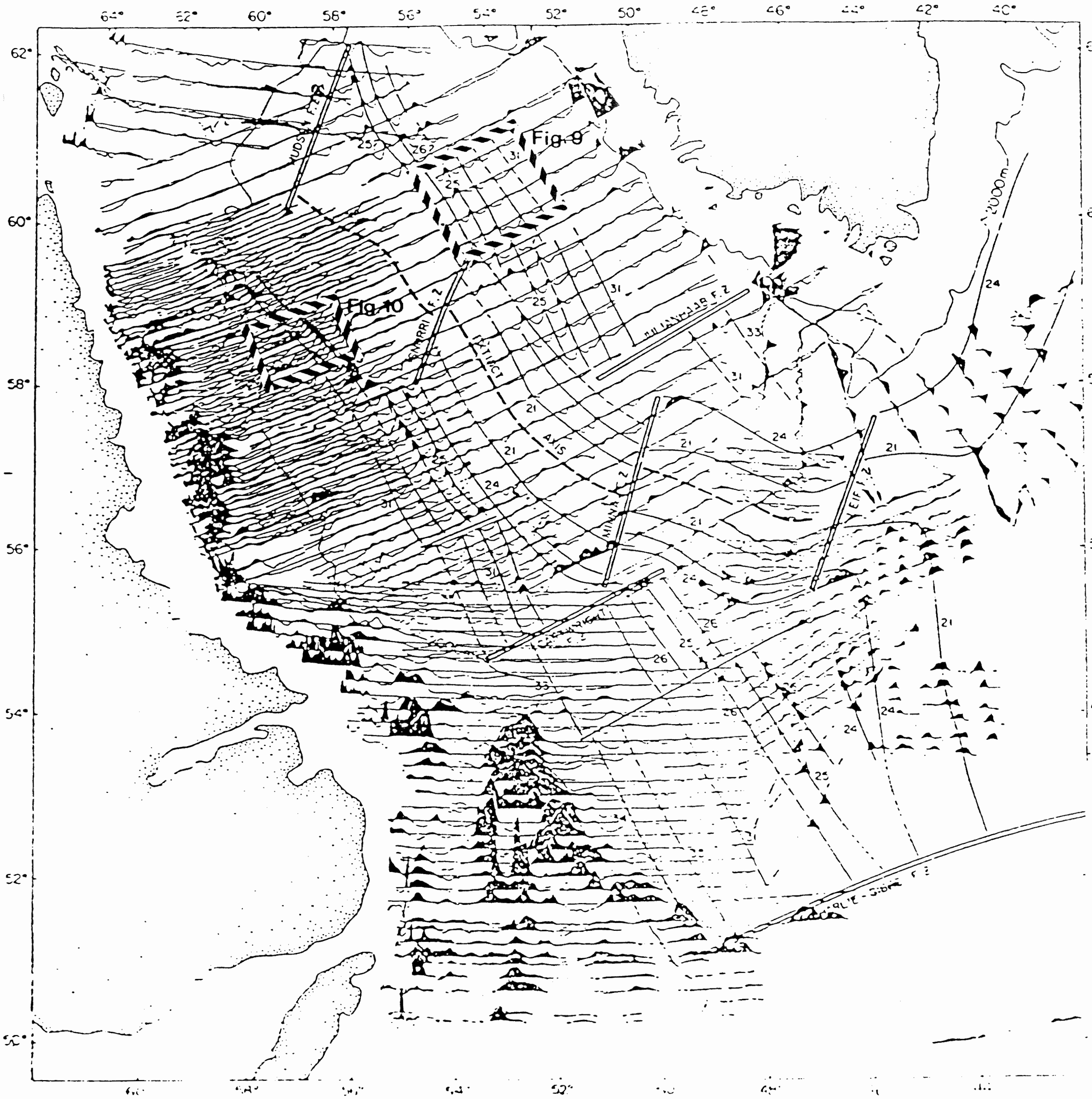

Figure 8. Magnetic lineations in the Labrador Sea as obtained from correlations of the magnetic anomalies. Also shown are the fracture zones and the extinct ridge axis. Locations of the observed profiles shown in figures 9 and 10 are indicated. (Srivastava and Tapscott, 1985).

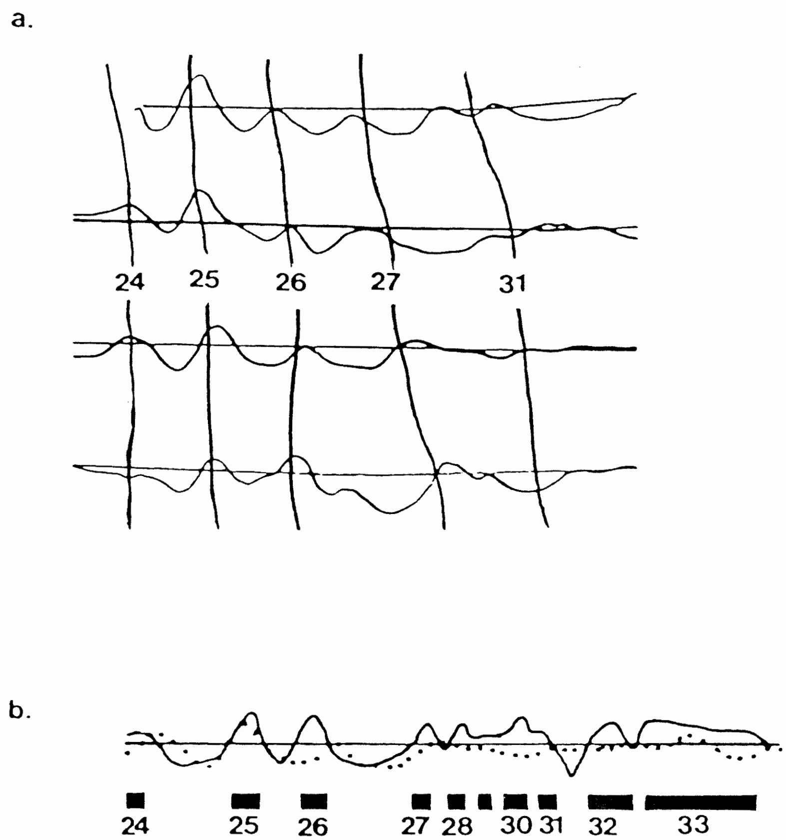

Figure 9. Northeastern Labrador Sea models. Horizontal scale 1:2,000,000. Vertical scale 600γ/cm.

(a) Observed profiles with interpretion of Srivastava and Tapscott (1985).

(b) Calculated profile with block model and polarity chron numbers shown below. Best fitting observed profile (dotted) superimposed.

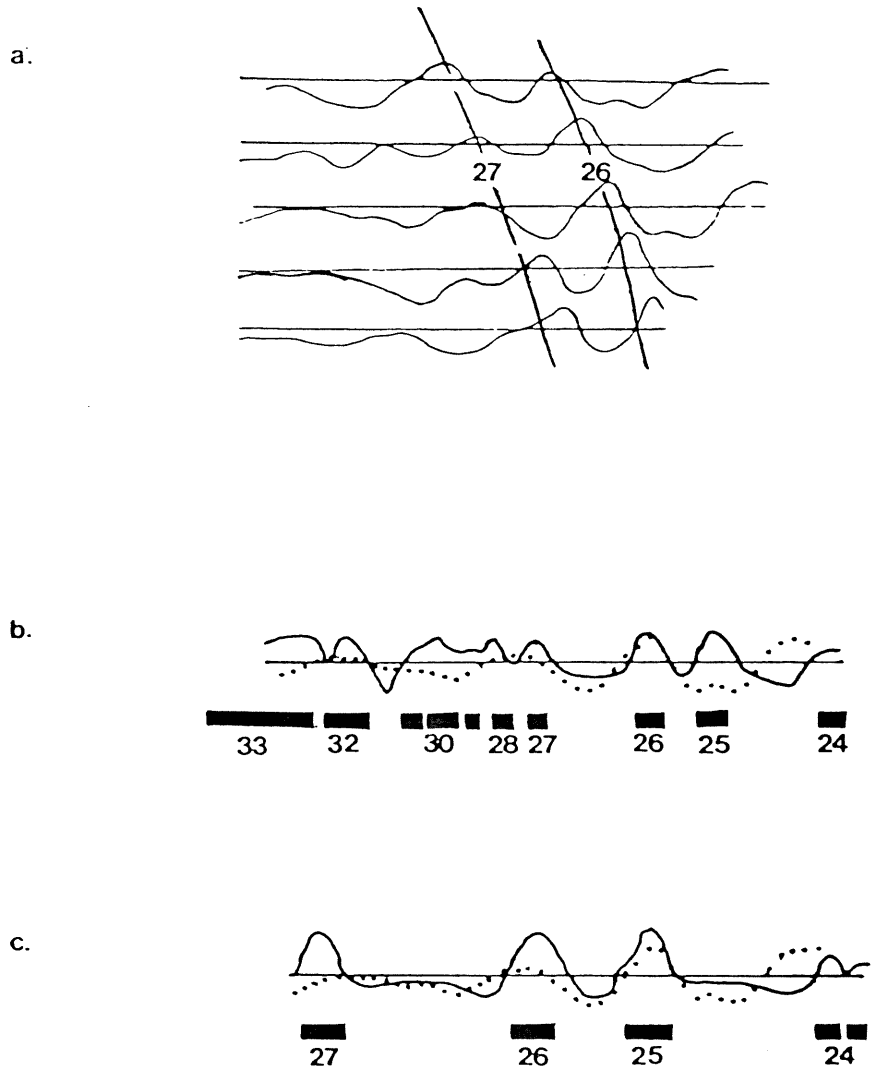

Figure 10. Northwest Labrador Sea Models. Horizontal scale 1:2,000,000. Vertical scale 600γ/cm.

(a) Observed profiles with interpretation of Srivastava and Tapscott (1985).

(b)and (c) Calculated profiles with block model and polarity chrons number shown below profile. Observed profile (dotted) shown superimposed.

(b) Model from eastern counterpart, according to interpretation shown.

(c) Model for reidentification of anomaly 26 as 25.

Strong positive peaks, thought to be due to anomalies 24 and 25, are shown in the area east of the spreading center. In the interpretation given in Srivastava and Tapscott (1985), no anomaly 25 is shown west of the spreading center. A model was developed based on the reidentification of the anomaly labelled 26 in Srivastava and Tapscott (1985), to anomaly 25. A constant spreading rate of 16.0 mm/yr was assumed for anomalies 24-27. The model based on this interpretation is shown in figure 10(c). The observed profile is superimposed on the calculated profile. There is a fairly good agreement between the observed and calculated profiles.

SUMMARY

The Labrador Sea models seem to suggest that a reasonable agreement between the observed and calculated profiles can be expected. The slow spreading rates, and hence, increased likelihood of crust with mixed polarity in this area, may contribute to the discrepancies in the agreement between the observed and calculated profiles (Schouten and Denham, 1979).

In the Davis Strait, the calculated profile of figure 7(b), based on the interpretation of Wu (1984), with anomaly 24 reidentified as 25, (after Srivastava and Tapscott (1985)),appears to fit the observed profile slightly better than the calculated profiles produced by other models. However, the fit is still poor.

CONCLUSIONS

There have been disagreements as to the nature of the crust in the Davis Strait region. Detailed marine magnetic data were collected on geophysical surveys carried out by the Bedford Institute of Oceanography during 1980-81. Magnetic models were developed based on Wu's (1984) interpretation of this data. The model which produces a calculated magnetic profile that fits the observed magnetic data best, is a model based on the interpretation of Wu (1984) with a reidentification of an anomaly as given by Srivastava and Tapscott (1985). However, the fit between the observed and calculated profiles is poor.

Models were also developed for the northern Labrador Sea, where more data are available and the anomalies are better identified. These models produce calculated profiles which agree fairly well with the observed profiles in the east, but suggest that Srivastava and Tapscott's (1985) identifications in the west may need to be re-examined.

The models developed in the Davis Strait seem to indicate that the observed magnetic profiles, while likely to be produced by seafloor spreading, could not be produced from the simple sea-floor spreading crustal configuration suggested by Wu (1984). Hence, the process of spreading in the Davis Strait must be more complicated than Wu's (1984) simple model.

ACKNOWLEDGEMENTS

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      PROGRAM MAGNOM
C     ***********************************************************
C     PROGRAMME TO COMPUTE MAGNETIC ANOMALY DUE TO TWO DIMENSION
C     DETAILS SEE REF. TALWANI IN COMPUTERS IN THE MINERAL INDUS
C .   A=ANGLE TO MAGNETIZATION VECTOR, MEASURED IN DEGREES DOWNW
C     HORIZONTAL PLANE EQUALS I FOR INDUCED MAGNETIZATION.
C     B= ANGLE BETWEEN HORIZONTAL PROJECTION OF THE MAGNETIZATIO
C     GEOGRAPHIC NORTH, MEASURED CLOCKWISE FROM GEOGRAPHIC NORTH
C     D FOR INDUCED MAGNETIZATION
C     C= ANGLE BETWEEN POSITIVE X AXIS AND GEOGRAPHIC NORTH, MEA
C     FROM GEOGRAPHIC NORTH, IN DEGREES
C     D = MAGNETIC DECLINATION IN DEGREES, POSITIVE WEST
C     DIP = INCLINATION OR DIP IN DEGREES, POSITIVE IN NORTHERN
C     F = TOTAL MAGNETIC FIELD INTENSITY IN GAMMAS.
C     DELX = INCREMENT IN X FOR FIELD POINTS
C     AM = MAGNETIZATION, J, IN E.M.U. MULTIPLIED BY 100000.
C     CONS = CONST. VALUE OF Z AT WHICH MEASUREMENTS ARE MADE, Z
C     EXX,ZEE= COORDINATES OF THE BODY, CLOCKWISE SEQUENCE,INCLU
C     JTOT = TOTAL NUMBER OF BODY POINTS.
C     FO = X VALUE OF FIRST FIELD POINT.
C     KTOT = TOTAL NUMBER OF FIELD POINTS TO BE CALCULATED.
C     MTOT = NUMBER OF BODIES
C     INDC = ZERO FOR ADDING PRESENT ANOMALIES TO THE NEXT ONES
C     RESETTING THE PROGRAMME.
C     IND = INDICATES WHETHER REMANENT OR INDUCED. 0 FOR INDUCED
C     REMANENT
C     NN = 1 IF OBSERVED VALUES ARE READ (
C     SUS = MAGNETIC SUSCEPTIBILITY, K, IN E.M.U.
C     ***********************************************************
      DIMENSION FX(500),EXX(200),ZEE(200),PSUM(500),QSUM(500)
      DIMENSION TSUM(500),GTOT(500),TOBS(500)
      CHARACTER*80 IDENT
      OPEN (UNIT=60, FILE='LAB2')
      OPEN (UNIT=61, FILE='OUT')
      CALL ERRSET(KOUNT,1000)
  801 FORMAT(3F10.0)
  802 FORMAT(10F8.0)
  803 FORMAT(1X,2F10.2)
  804 FORMAT(I4)
  805 FORMAT(2I4)
  806 FORMAT(///'MAGNETIZATION IS INDUCED ONLY SUS=',F7.4,' F',
     1F10.2,' D',F8.2,' DIP= ',F8.2)
  807 FORMAT('     K        FX(K)           T')
  808 FORMAT(' TOTAL FIELD ')
  809 FORMAT(///'MAGNETIZATION IS REM INT. OF MAG= ',F9.2,'B=',F
     1'A=',F8.2)
  810 FORMAT(A80)
```

```
C        ************************************************************
      WRITE (61,809) AM,B,A
      WRITE (61,807)
      CDIP=COS(0.0174533*A)
      SDIP=SIN(0.0174533*A)
      SD=COS(0.0174533*(C-B))
  432 DO 4321 K=1,KTOT
      H=2.*AM*((CDIP*SD*PSUM(K))+(SDIP*QSUM(K)))
      V=2.*AM*((CDIP*SD*QSUM(K))-(SDIP*PSUM(K)))
      T=H*CDIPD*SDD+V*SDIPD
 4321 TSUM(K)=T+TSUM(K)
C4321 WRITE (61,1100) K,FX(K),TSUM(K)
  605 CONTINUE
C     IF(INDC.GT.0) PRINT 808
C     DO 1002 K=1,KTOT
C     GTOT(K)=TSUM(K)+GTOT(K)
C     IF(INDC.LT.1) GO TO 1002
C     WRITE (61,1100) K,FX(K),GTOT(K)
 1002 CONTINUE
      DO 1003 K = 1,KTOT
 1003 WRITE (61,1100) K,FX(K),TSUM(K)
C     CALL PLOTB(1,TSUM,500,3,KTOT,-500.0,500.0)
C     IF(INDC) 1001,1001,1051
      END
```

```
  280 THETB=ATAN(Z2/X2)
  300 IF(Z1-Z2)320,31,320
   31 P=0
      Q=0
      GO TO 34
  320 OMEGA=THETA-THETB
      IF(OMEGA)3201,3202,3202
 3202 IF(OMEGA-3.1415927)330,330,340
 3201 IF(OMEGA+3.1415927)340,330,330
  330 THETD=OMEGA
      GO TO 370
  340 IF(OMEGA)350,360,360
  350 THETD=OMEGA+6.2831853
      GO TO 370
  360 THETD=OMEGA-6.2831853
  370 X12=X1-X2
      Z21=Z2-Z1
      XSQ=X12**2
      ZSQ=Z21**2
      XZ=Z21*X12
      GL=0.5*ALOG(RSQ2/RSQ1)
      P=((ZSQ/(XSQ+ZSQ))*THETD)+((XZ/(XSQ+ZSQ))*GL)
      Q=(THETD*(XZ/(XSQ+ZSQ)))-(GL*(ZSQ/(XSQ+ZSQ)))
   34 PSUM(K)=PSUM(K)+P
      QSUM(K)=QSUM(K)+Q
      X1=X2
      Z1=Z2
      RSQ1=RSQ2
      THETA=THETB
      J=J+1
      JR=J-1
      IF(JR-LO)201,36,36
   36 CONTINUE
  437 IF(IND)430,430,431
C      *************************************************************
  430 READ ( 60,801 )SUS
C 430 SUS=5.
C     *************************************************************
      WRITE (61,806) SUS,F,D,DIP
      WRITE (61,807)
      AM=SUS*F
      CDIP=CDIPD
      SDIP=SDIPD
      SD=SDD
      GO TO 432
C      *************************************************************
  431 READ ( 60,801 ) AM,B,A
```

```
      LLL = JTOT + 1 - L1
      LO = 2*JTOT + 1
      EXX(LL) = EXX(LLL)
      EXX(LO) = EXX(1)
      ZEE(LL) = ZEE(LLL) + THICK
   90 ZEE(LO)= ZEE(1)
      WRITE (61,803)  (EXX(J), ZEE(J), J=1,LO)
       GO TO 100
   95 WRITE (61,803)  (EXX(J), ZEE(J), J=1,JTOT)
      LO = JTOT
  100 DO 36 K=1,KTOT
      PSUM(K) = 0
      QSUM(K) = 0
      X1 = EXX(1) - FX(K)
      Z1 = ZEE(1) - FZ
      RSQ1 = X1**2+Z1**2
      IF (X1) 110,140,180
  110 IF(Z1) 120,130,130
  120 THETA = ATAN(Z1/X1) - 3.1415927
      GO TO 200
  130 THETA = ATAN(Z1/X1) + 3.1415927
      GO TO 200
  140 IF(Z1) 150,160,170
  150 THETA = -1.5707963
      GO TO 200
  160 THETA = 0.0
      GO TO 200
  170 THETA=1.5707963
      GO TO 200
  180 THETA=ATAN(Z1/X1)
  200 J=2
  201 X2=EXX(J)-FX(K)
      Z2=ZEE(J)-FZ
      RSQ2=X2**2+Z2**2
      IF(X2)210,240,280
  210 IF(Z2)220,230,230
  220 THETB=ATAN(Z2/X2)-3.1415927
      GO TO 300
  230 THETB=ATAN(Z2/X2)+3.1415927
      GO TO 300
  240 IF(Z2)250,260,270
  250 THETB=-1.5707963
      GO TO 300
  260 THETB=0.0
      GO TO 300
  270 THETB=1.5707963
      GO TO 300
```

```
 1100 FORMAT(1X,I4,2F15.2)
 1051 CONTINUE
      DO 1005 I=1,500
      TOBS(I) = 0.0
 1005 GTOT(I) = 0.0
C     ***********************************************************
      READ ( 60,810) IDENT
C     ***********************************************************
      WRITE (61,810)  IDENT
C     ***********************************************************
      READ ( 60,801)  D,DIP,F
      READ ( 60,801)  C
      READ ( 60,801)  CONS
      READ ( 60,801)  FO, DELEX, THICK
      READ (60,805)  KTOT,NN
      IF(NN.EQ.0) GO TO 30
      READ (60,802)  (TOBS(I), I=1,KTOT)
C     ***********************************************************
   30 DO 604 K = 1,KTOT
      RK = K
      FX(K) = (FO - DELEX) + DELEX*RK
  604 FZ = CONS
      CDIPD = COS(0.0174533*DIP)
      SDIPD = SIN(0.0174533*DIP)
      SDD = COS(0.0174533*(C-D))
 1001 CONTINUE
C     ***********************************************************
      READ (60,804)  INDC
C     ***********************************************************
C     IF(EOFCKF(60).EQ.1)STOP
      DO 1008 I=1,500
 1008 TSUM(I)=0
C     ***********************************************************
      READ (60,804) IND
      READ (60,804) MTOT
C     ***********************************************************
      DO 605 L=1,MTOT
C     ***********************************************************
C     READ (60,804) JTOT
      JTOT=5
      DO 600 J=1,JTOT
      READ (60,802)  EXX(J),ZEE(J)
600   CONTINUE
C      **********************************************************
      IF (THICK .EQ. 0.0) GO TO 95
      DO 90 L1 = 1,JTOT
      LL = JTOT + L1
```