Motion along Nares Strait recorded in the Lincoln Sea: aeromagnetic evidence

LOUIS C. KOVACS

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Detailed low-level aeromagnetic data taken over the Lincoln Sea and surrounding regions are discussed in an attempt to explain the evolution of the area and its relation to the possible movement of North America and Greenland along Nares Strait. A depth-to-source analysis of the data delineates a major northeastward extension of the Nares Strait extending to the western edge of the Morris Jesup Rise, and identified here as the Arctic Ocean portion of the Wegener Fault or Fracture Zone. Two regions of moderate amplitude, short wavelength anomalies characterized by shallow (< 2 km) magnetic basement are delineated, one to the north of Ellesmere Island and the other to the northwest of the Morris Jesup Rise, as well as a steep escarpment paralleling the Wegener Fault and forming the northwest boundary of a deep, sediment-filled basin. A plate tectonic analysis of these data suggests that the hot spot responsible for the formation of the Morris Jesup Rise–Yermak Plateau in the late Eocene and early Oligocene and the Kap Washington Group volcanics at about the Cretaceous–Tertiary boundary was also active in the late Cretaceous. During this period, prior to any strike-slip movement of Greenland along Nares Strait, a single, Iceland-like volcanic massif was formed north of Greenland and Ellesmere Island contemporaneously with postulated sea-floor spreading in the Makarov Basin. Sinistral movement of North America from Greenland along Nares Strait, and along a second "Ellesmere Fracture Zone" extending northeast through the massif from the edge of the Ellesmere Island shelf then led to the formation in early Tertiary time of a deep sediment-filled basin due to thinning and foundering of the crust northeast of Nares Strait, the emplacement of the western half of the massif between Lomonosov Ridge and Ellesmere Island, and of the eastern half of the massif just west of the Morris Jesup Rise. A shift in the hot spot to the east then led, with the initiation of spreading in the Eurasia Basin, to the later formation of the Morris Jesup Rise and Yermak Plateau. A total left-lateral displacement of about 250 km between these features is noted, similar to the amount suggested along Nares Strait by other geophysical work in Baffin Bay and the Labrador Sea.

L. C. Kovacs, Department of the Navy, Naval Research Laboratory, Washington, D.C. 20375, U.S.A.

Nares Strait, a linear channel separating northwestern Greenland from eastern Ellesmere Island, was considered by Wegener (1922) to be a great strike-slip fault formed by the separation of Greenland from Canada to form Baffin Bay. Since then numerous investigators have proposed various sequences of plate tectonic motion along Nares Strait (see for example, Pitman & Talwani 1972, Churkin 1973, Johnson & Vogt 1973, Ostenso & Wold 1973, Herron et al. 1974, Kristoffersen & Talwani 1977, Sclater et al. 1977, Srivastava 1978, Sweeney et al. 1978, Feden et al. 1979, Jackson et al. 1979). Other investigators (Riddihough et al. 1973, Kerr 1980) however have found little or no geologic evidence for significant offset across Nares Strait. A good review of the work by both mobilists and fixists concerning Nares Strait, as well as a compromise hypothesis, may be found in Kerr (1980) and Srivastava & Falconer (this volume).

Any strike-slip motion of Greenland along Nares Strait would be expected to have left traces in the area of the Lincoln Sea, the marginal Arctic sea north of Greenland and Ellesmere Island (Fig. 1). In fact, if the Nares Strait lineament is the surface expression of a transform fault sometimes called the Wegener Fault (Johnson & Vogt 1973, Ostenso & Wold 1973), plate tectonic considerations would require that the Wegener Fault extends through the Lincoln Sea to the anomaly 13 isochron on the west flank of the Nansen Ridge, the time at which spreading in the Labrador Sea (Srivastava 1978) and Baffin Bay (Jackson et al. 1979) ceased. Evidence of possible plate tectonic motion in the Lincoln Sea would also have to be considered in the light of geologic evidence of nearby igneous activity of latest Cretaceous or earliest Tertiary age (Rb/Sr age of 63 m.y.) from the Kap Washington Group volcanics and their associated metasediments (Dawes 1973, Larsen et al. 1978). This paper examines previously unpublished aeromagnetic data from a detailed 1975 investigation of the Lincoln Sea to see if evidence relating these tectonic episodes exists. I will also consider evidence relating

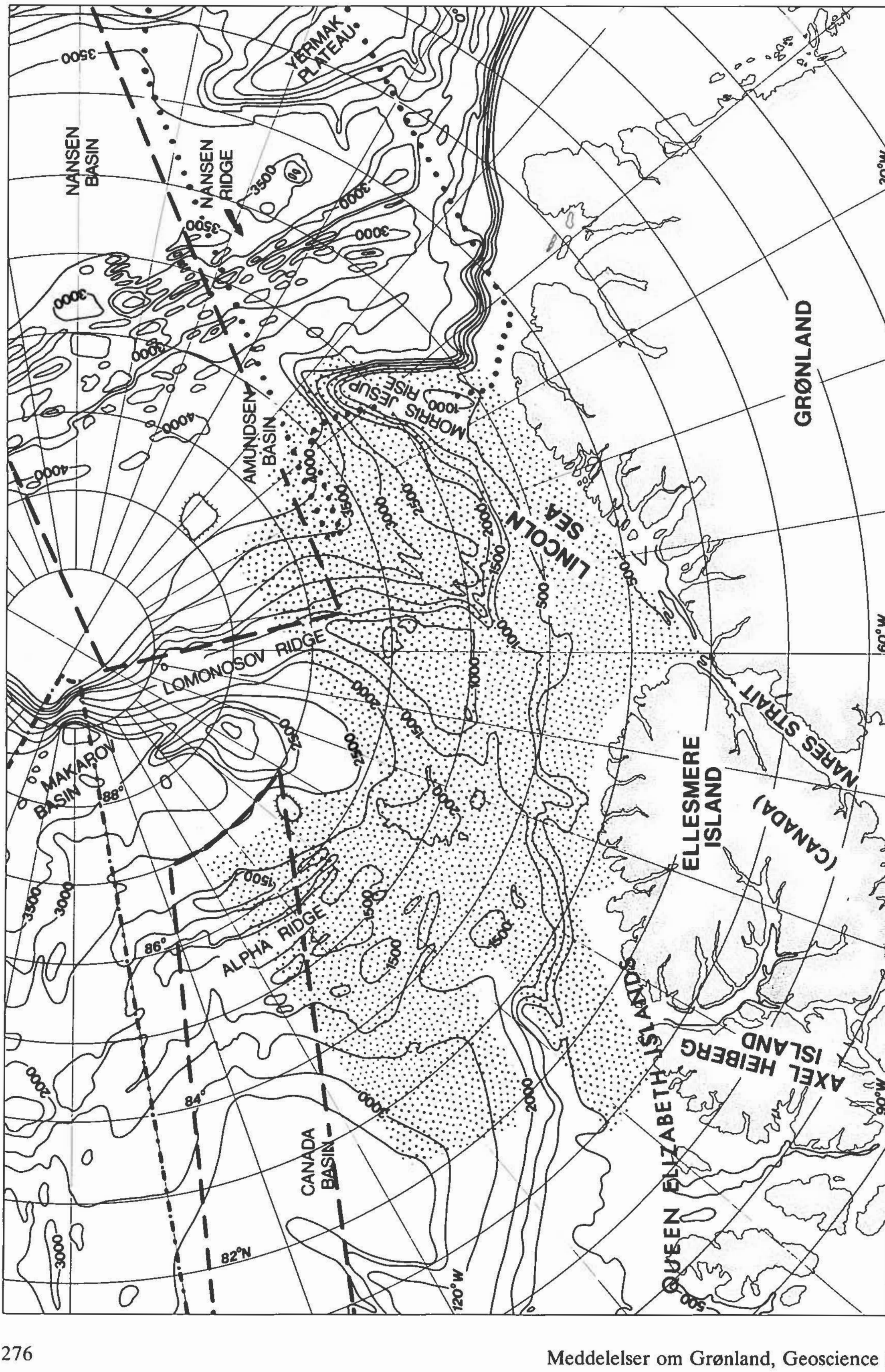

Fig. 1. Lincoln Sea and surrounding regions, showing areas of detailed aeromagnetic coverage. Stippled region denotes area discussed in this paper. Dotted outline refers to data discussed in Feden et al. (1979); dashed outlines refer to data discussed by Vogt et al. (1979a); dot-dash line outlines the region discussed in Taylor et al. (1981). Bathymetry is in metres, from Johnson et al. (1979).

Nares Strait to a RFF (ridge-transform fault-transform fault) triple junction involving the contemporaneous spreading of the Eurasia Basin, Norwegian–Greenland Sea and Baffin Bay/Labrador Sea from late Paleocene (anomaly 24) to early Oligocene (anomaly 13) and the formation of the Morris Jesup Rise–Yermak Plateau by the postulated "Yermak hot spot" (Herron et al. 1974, Vogt et al. 1978, 1979a, b, Feden et al. 1979), as well as recent evidence of sea-floor spreading in the Makarov Basin–Fletcher Abyssal Plain from the Campanian to the late Paleocene (Taylor 1978, Taylor et al. 1981).

Data collection and display

The over 30 000 line kilometres of aeromagnetic data discussed were collected by the U.S. Naval Research Laboratory in April and May of 1975. The area investigated (Fig. 1) includes the Alpha Ridge east of the 120°W meridian, overlapping the Alpha Ridge data reported on by Vogt et al. (1979a), the continental shelves of Axel Heiberg and Ellesmere Islands and the Lincoln Sea shelf north of Greenland to Kap Morris Jesup, the Morris Jesup Rise, (overlapping the Eurasia Basin data reported on by Feden et al. 1979 and Vogt et al. 1979a), the Greenland–Lomonosov Ridge slopes of the Amundsen Basin to the 4000 metre isobath, the Lomonosov Ridge south of 87°30'N and the slope of the Makarov Basin above the 2500 metre isobath. The data tracks were flown perpendicular to the major trend of the Alpha Ridge, an orientation that put the tracks approximately 30° clockwise to the strike of Nares Strait (Fig. 2). Data-track spacing was approximately 12 km over the Lincoln Sea and 22 km over the Alpha Ridge.

The data were collected aboard a modified Lockheed P3–A Orion aircraft equipped with a proton precession magnetometer. Flight altitude and speed were nominally 300 m and 450 km/hr, respectively. Navigational control was maintained using a Litton 51 dual inertial navigation system. This system generally provides positional accuracy with a drift error of .8 km/flight hour or less, so that a typical flight of 10 hours would experience a round trip error of 8 km at the end of the flight. On very long flights (12 hours) the accuracy is occasionally less due to the additional effect of the exponentially increasing amplitude of the Schuler cycle of the gyros. Fortunately, for very long flights the last few hours were usually spent in transiting back to base at high altitude so that no magnetic data were collected. Round-trip errors did not exceed 10 km for a 10 hour flight. Use of the same aircraft and navigation system in the Norwegian–Greenland Sea in 1972, 1973 and 1974, where post-flight correction of the aircraft tracks from Loran–C and satellite fixes was possible, showed overall errors of 3 to 6 km. The magnetic field total intensity, aircraft position and altitude were collected every three seconds, the IGRF–65 anomaly calculated in real-time using an onboard mini-computer, and the time, position, altitude, and residual and total field intensities stored on magnetic tape and in disc file by track.

The aeromagnetic data displayed in Fig. 3 were recalculated using the IGRF–75 reference field (Anonymous, 1976). Because slight DC offsets in the data relative to the IGRF were important in preventing an adequate display of the low-amplitude anomalies over the Lincoln Sea, the data were high pass filtered to remove any long wavelength bias due to diurnal variations and inaccuracies in the IGRF. The filter cut off period was 90 minutes, corresponding to a wavelength of 600 km at the aircraft speed flown. An unfortunate by-product of this operation would be the removal of any two-dimensional anomalies which strike parallel to the tracks. This was minimized by the orientation of the flight lines perpendicular to the dominant palaeomagnetic fabric.

Magnetic field structure

When compared to the latest available bathymetry in the area (Fig. 1, Johnson et al. 1979), interpretation of the aeromagnetic data becomes a study in contrasts (Fig. 3). Anomalies over the portion of the Alpha Ridge investigated here are typical of those reported for other areas of the ridge (Riddihough et al. 1973, Coles et al. 1978, Vogt et al. 1979a, Taylor et al. 1981), having short wavelengths with peak-to-trough amplitudes attaining 1500 nT or more and being sub-linear in character. Anomalies over the Lincoln Sea shelf and on the slope of the Amundsen Basin on the other hand are very subdued, having typical amplitudes of 100 nT or less and wavelengths of 60 km or more. Major isolated high-amplitude linear anomalies are found in three regions along the continental shelf and slope of the Queen Elizabeth Islands and Greenland. The furthest west and the deepest, labelled A–A' in Fig. 4, parallels the Ellesmere Island continental shelf at 83°30'N, 90°W in the region of the 1500+ m channel between Ellesmere Island and the Alpha Ridge (Sobzcak & Sweeney 1978, Johnson et al. 1979). The second (Fig. 4, B–B') trends slightly north of west, approximately parallel to the 1000 m isobath north of Ellesmere Island at 84°N and between 65° and 80°W. The third lies in the shallowest water (Fig. 4 C–C') and trends northwest from 84°N, 30°W, and perpendicular to the Morris Jesup Rise magnetic anomaly (Fig. 4, MJA) reported by Feden et al. (1979) for approximately 100 km before turning north and continuing to 85°20'N, 35°W (Fig. 4, C–C''), where it terminates.

Riddihough et al. (1973) suggested that the Alpha Ridge magnetic trends continue onto the shelf and over the northwest coast of Ellesmere Island on the basis of

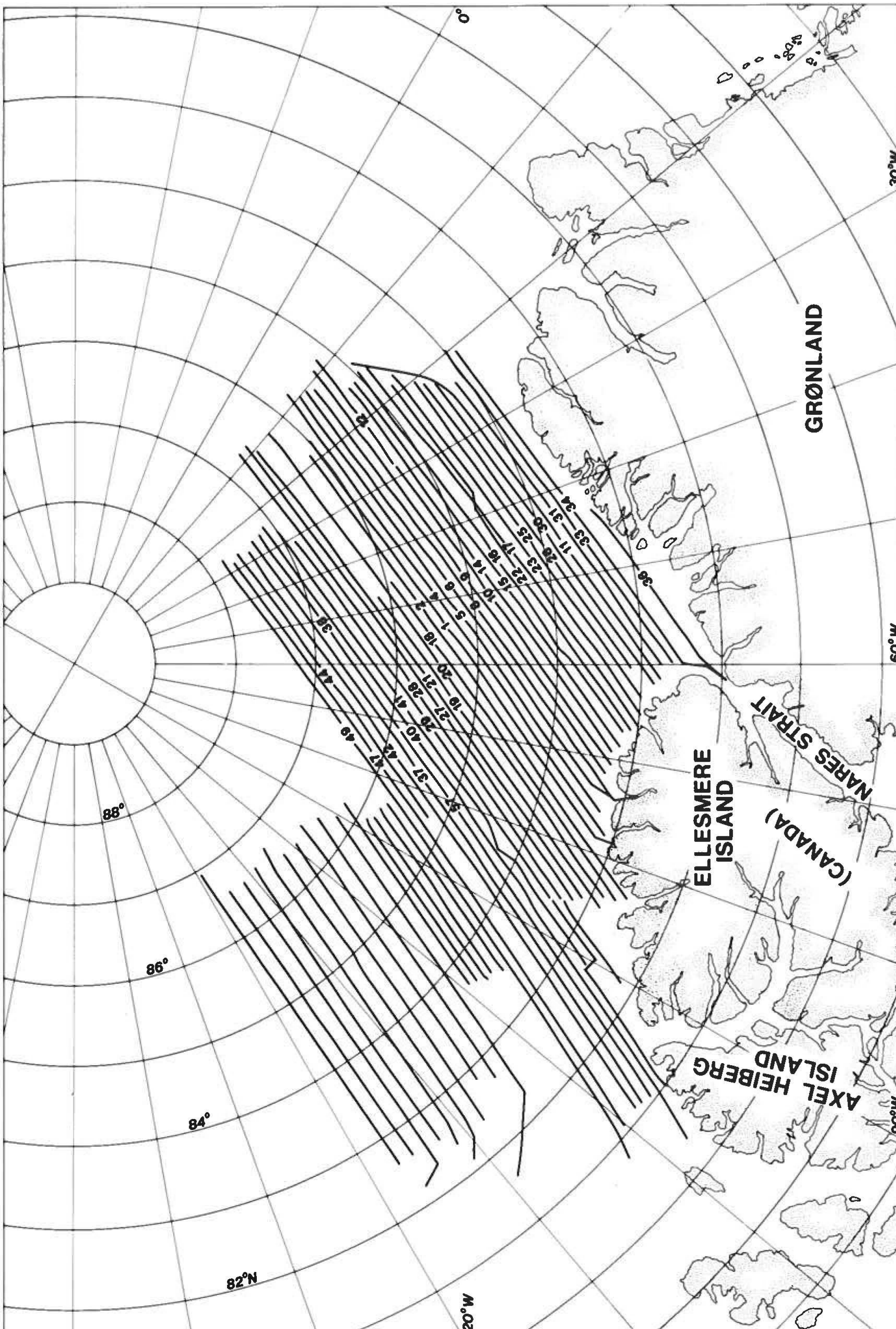

Fig. 2. Aeromagnetic data tracks flown by the Naval Research Laboratory over the Lincoln Sea in 1975. Numbered tracks correspond to numbered data referred to in Figs 7 and 8 and in the text.

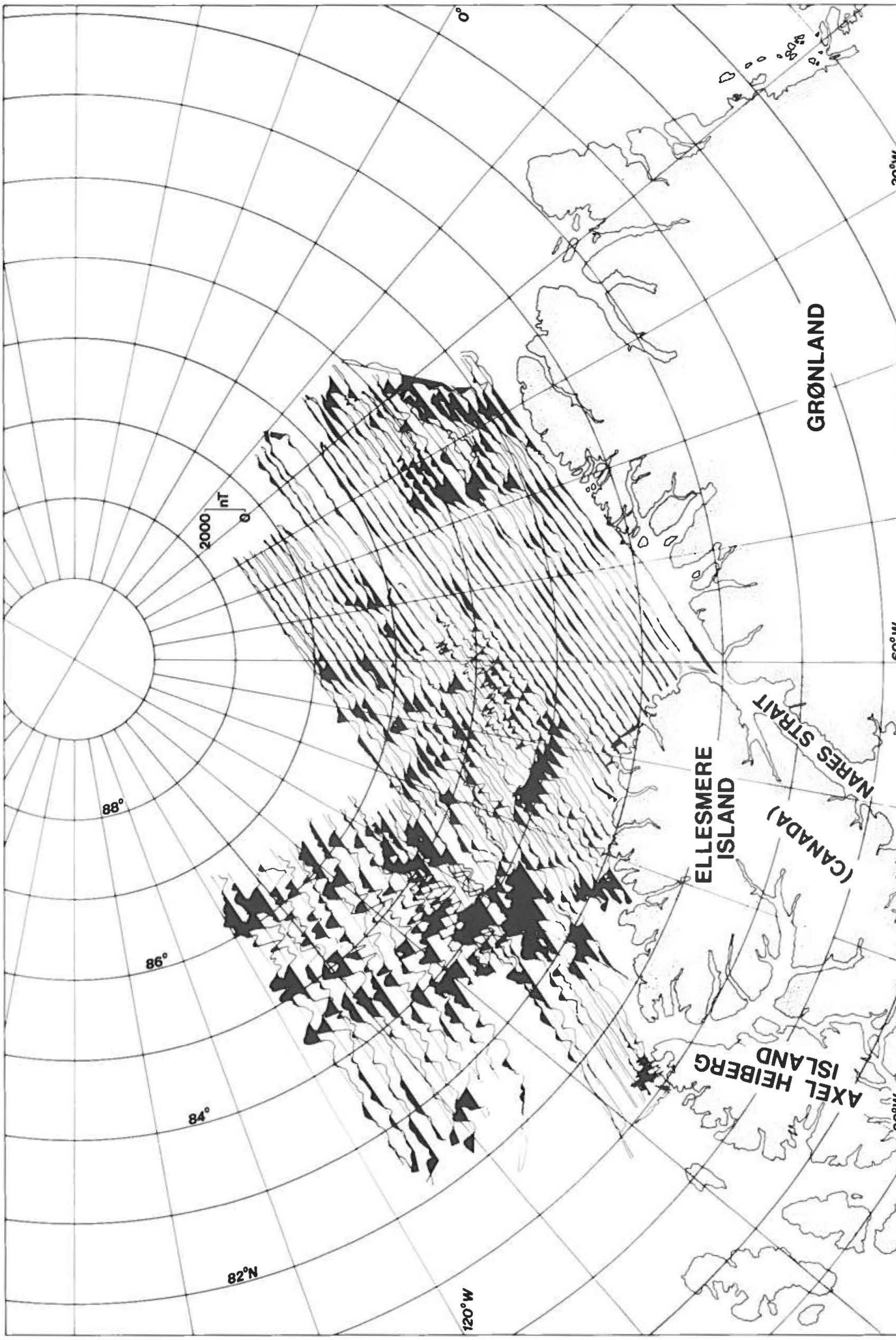

Fig. 3. IGRF–75 residual anomalies over the Lincoln Sea with diurnal variations removed. Black areas are positive anomalies, vertical exaggeration is 4000 nT per degree of latitude.

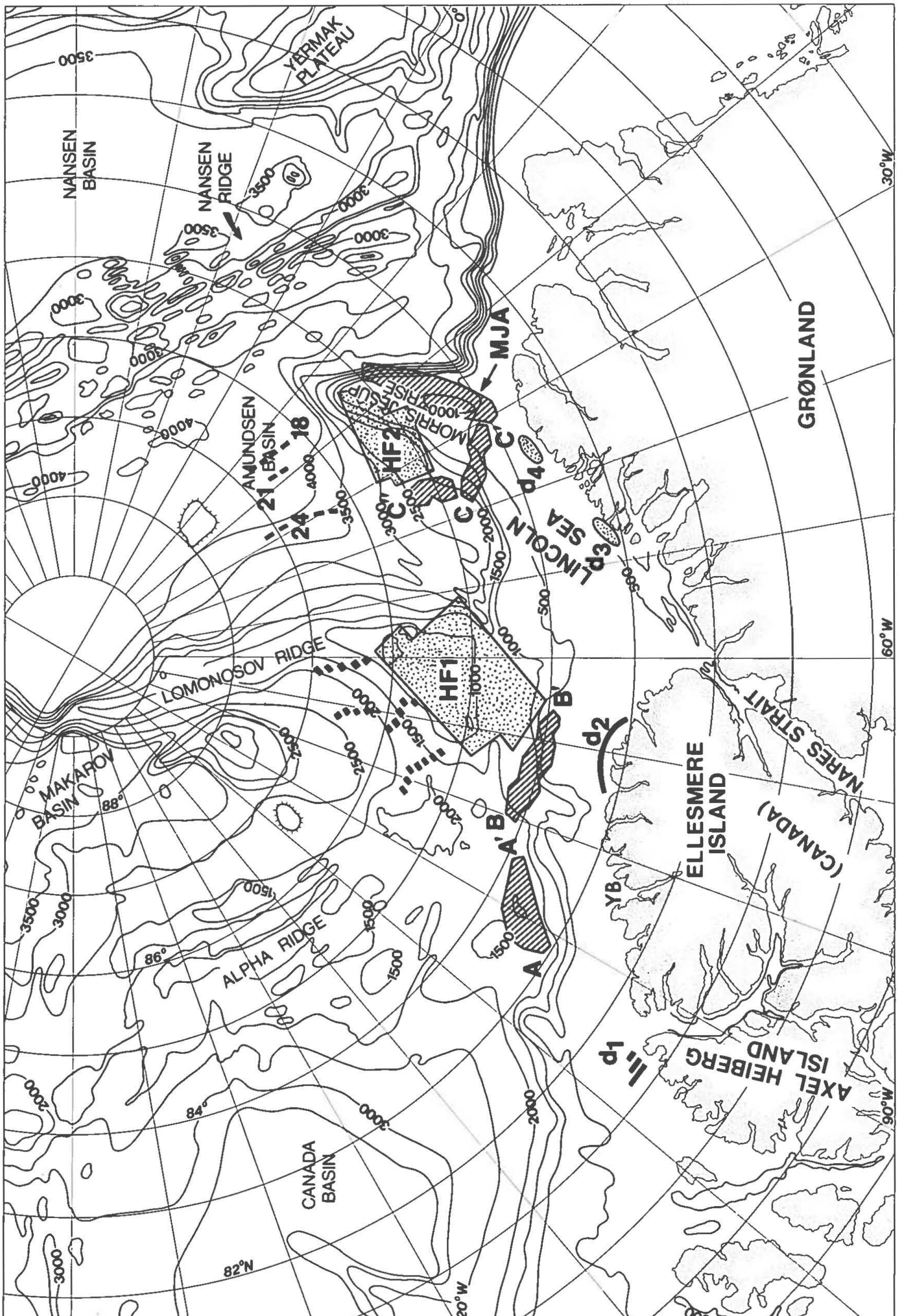

Fig. 4. Major anomaly groups discussed in the text. Stippled areas 'HF1' and 'HF2' are regions of short wavelength moderate amplitude anomalies. Shaded bar 'MJA' is the Morris Jesup Rise anomaly. Short heavy lines labelled 'd_1' and 'd_2' are due to shallow intrusive features (such as dykes). Stippled regions 'd_3' and 'd_4' lie just seaward of the Kap Washington volcanics and are probably associated with them. Unlabelled dashed lines northwest of 'HF1' are tentatively identified in the text as being due to sea-floor spreading. Numbered dashed lines are magnetic lineations identified by Feden et al. (1979) and Vogt et al. (1979a). YB = Yelverton Bay.

vertical magnetic field data collected at high altitude (3.5 km) and wide track spacing (approximately 70 km). The only such magnetic trend appearing in these data is one extending NW from Yelverton Bay at 83°N, 83°W and terminating at the 500 m isobath of the Ellesmere Island shelf. I suggest therefore that the Alpha Ridge group of anomalies is instead bordered by the broad complex high at A–A′ (Fig. 4) which lies at the southeastern end of the Alpha Ridge bathymetric structures.

Sea-floor spreading anomalies 21 to 24 (Feden et al. 1979, Vogt et al. 1979a) of the Nansen Ridge spreading centre are seen in the Amundsen Basin in the northwestern part of the investigation area. They represent the only agreed on spreading anomalies in the area. However, if the Makarov Basin was formed by sea-floor spreading processes as Taylor (1978) and Taylor et al. (1981) suggest, then similar anomalies would be expected to continue eastward toward the slope of the Makarov Basin about 87°N, 90°W and from there southeast into the area discussed in this paper. Unfortunately, this part of the Makarov Basin is the only part of the eastern Amerasia Basin still unsurveyed at low level by U.S. Navy research organizations. Unpublished data from a 1979 Canadian survey of the Lomonosov Ridge (P. J. Hood, pers. comm. 1979) suggest some of these anomalies may continue as discussed, though the situation is confused by a large bathymetric and magnetic high at 87°45′N, 88°W and these unpublished data do not extend across much of the Makarov Basin. Nevertheless, short linear anomalies do extend up the slope of the Makarov Basin parallel to the Lomonosov and Alpha Ridges and gradually blend into a region of moderate amplitude, very short wavelength (< 10 km) anomalies. These high-frequency anomalies (HF1, Fig. 4) strike parallel to B–B′ and extend NE from B–B′ in a band into the broad bathymetric high connecting the Lomonosov Ridge with the Ellesmere Island shelf. A second, similar group of high-frequency, moderate amplitude anomalies (HF2, Fig. 4) appears just east of and parallel to C–C″ and just west of the Morris Jesup Rise but these are not associated with any obvious bathymetric features in the GEBCO map Arctic bathymetry (Johnson et al. 1979).

Finally, groups of very short wavelength (< 5 km), moderate to high amplitude magnetic anomalies appear off the coasts of Axel Heiberg Island, Ellesmere Island and Greenland. The first group (d_1, Fig. 4), near the northwestern end of Axel Heiberg Island at 81°N, is near coastal Devonian dioritic intrusions (Trettin 1973) and probably associated with them. The second (d_2, Fig. 4) extends parallel to the coast of Ellesmere Island between 65°W and 75°W and is probably due to dykes of indeterminate age. The third and fourth (d_3, d_4, Fig. 4) are of lesser amplitude, lie just west and east, respectively, of the Kap Washington Group volcanics and are probably associated with them (Feden et al. 1979).

Depth-to-source analysis

The tracks labelled in Fig. 2 were analysed for depth to magnetic source using the maximum entropy autocorrelation analysis algorithm of Phillips (1975, 1978). This method assumes that the sources are dykes of semi-infinite extent lying approximately perpendicular to the tracks and having been created by a process such that the magnetization function along the track can be represented as an uncorrelated white noise sequence. Using Burg's maximum entropy spectral analysis techniques (Burg 1975), autocorrelation coefficients for a series of short data sets abstracted from the data are calculated; then, using the well-known relationship between the source depth and the autocorrelation function of a magnetic profile (see, for example, Serson & Hannaford 1957), the source depth is calculated. A complete description of the method can be found in Phillips (1975).

The analysis method is sensitive to two variables: the data point spacing and the number of data points used to calculate the autocorrelation coefficents. The minimum source depth to which the method is sensitive is proportional to the data point spacing; the point spacing should be no more than half the expected minimum source depth. The running window which determines the number of data points used to calculate the autocorrelation coefficients then determines the deepest sources that the method will accurately sense and these should be around 2Z(max)/DELX where DELX is the data point spacing and Z(max) is the maximum depth of interest. The method then calculates multiple depth estimates centred on multiples of this window; inaccurate estimates are rejected on the basis of their lack of close convergence. In the analysis presented here, two separate depth-to-source analyses were made due to the large range in expected source depths: the first at a point spacing and window of 1 and 30 kilometres, respectively (sensitive to source depths ranging from 2 to 15 km), and the second at a point spacing and window of .25 and 7.5 km, respectively (sensitive to depths from .5 to 3.75 km). Though the method would be expected to be sensitive to the strike of magnetic features in relation to the data tracks, in practice most real anomaly data contain three dimensional source information which tends to counteract this. Depth-to-source data calculated from aeromagnetic investigations over the Mohns and Knipovich Ridges (Kovacs & Vogt 1979) have shown excellent agreement with bathymetric and seismic data when the data track was as much as 30 to 45 degrees non-perpendicular to the magnetic fabric. Uncertainties in the calculated source depths are typically one third the data point spacing or less, or 80 m and 300 m respectively for the two analyses made. The results from these analyses were then combined and contoured and are presented in raw (Fig. 5) and generalized forms (Fig. 6).

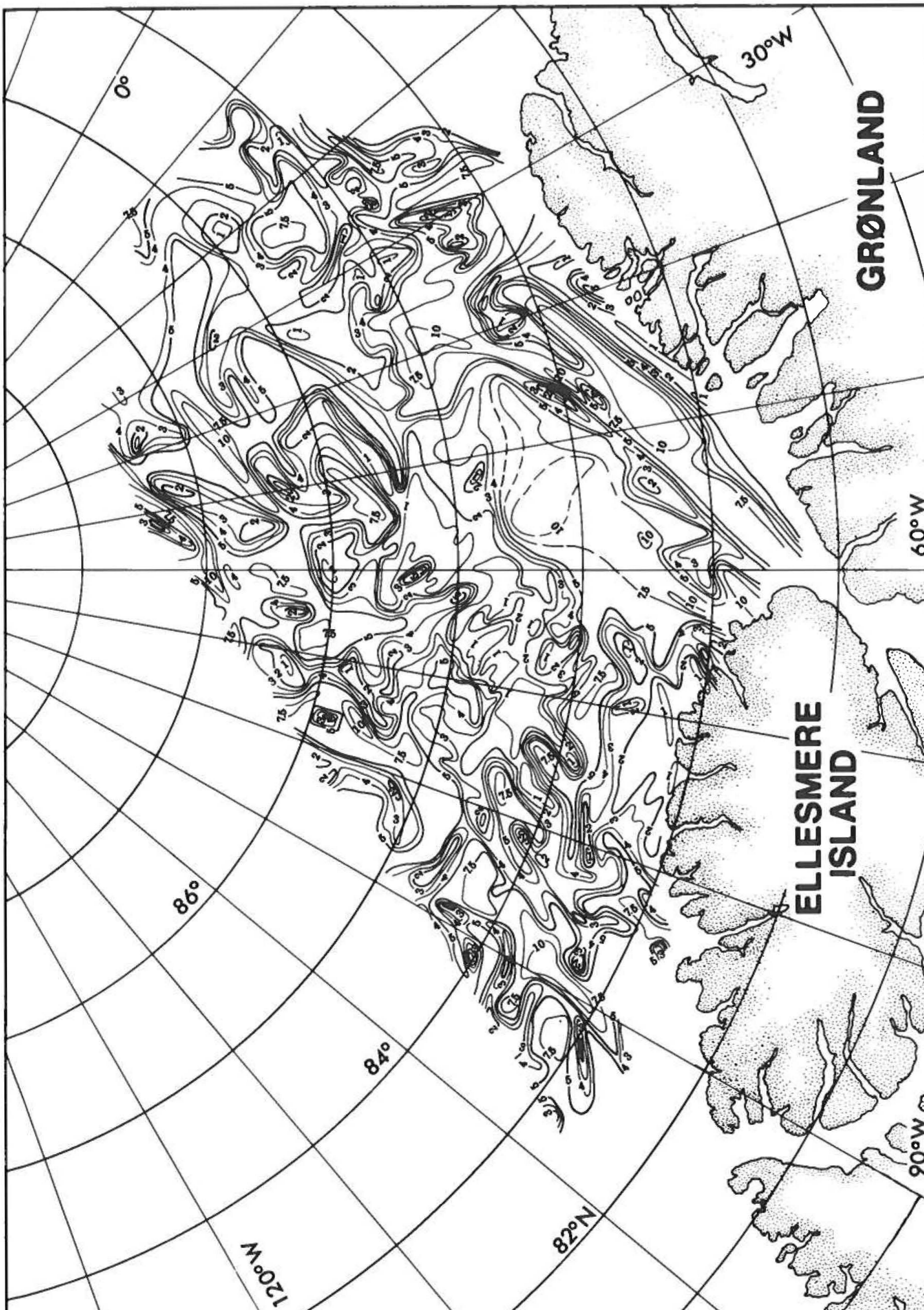

Fig. 5. Contoured depth-to-source magnetic data calculated from the numbered tracks in Fig. 1. Depths used are a combination of results calculated from data sampled every 0.25 km (depths <4 km) and data sampled every 1.0 km (depths >2 km). Contour interval is 1 km from 0 to 5 km, 2.5 km from 5 to 10 km.

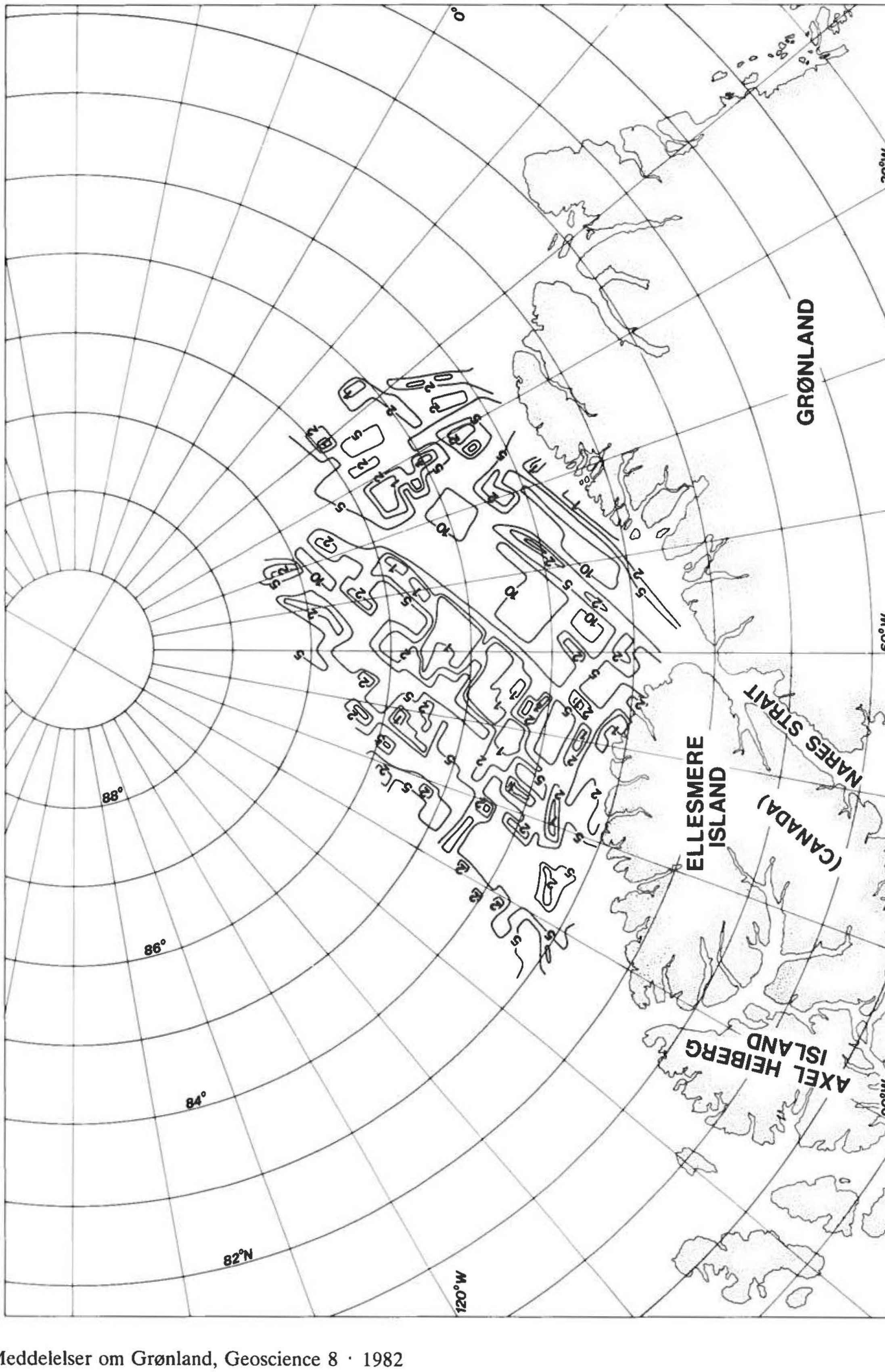

Fig. 6. Generalized depth-to-source data from Fig. 5. 1 km, 2 km, 5 km and 10 km contours.

Discussion and interpretation

In Figs 5 and 6, two major source-depth structures are immediately apparent: a linear region of deep (> 10 km) sources extending some 300 km from Nares Strait toward the Morris Jesup Rise, and a large source-depth high (< 2 km deep) under the short wavelength linear anomalies (HF1) found to the northeast of B–B′ (Fig. 4), and sub-parallel to the previously mentioned source depth low. Source depth highs also exist under the Morris Jesup Rise and along the coasts of Greenland and Ellesmere Island. Additionally, a group of highs are found northwest of the Morris Jesup Rise and northeast of and parallel to C–C″, under HF2 (Fig. 4). Linear regions of deep sources are found northwest of this region and northwest of and parallel to the large magnetic source high northeast of B–B′. A basin of deep sources may be found centred at 84°N, 55°W between the deep source extension of Nares Strait and the source high northeast of B–B′. Finally, isolated source highs such as the dykes mentioned previously (Fig. 4) are found along the continental shelf of Ellesmere Island and in scattered highs along the Alpha Ridge.

On the basis of their close association with the slope or break in the shelves of Ellesmere Island and Greenland the linear anomaly B–B′ (Figs 4 and 7) is postulated to mark the continent–ocean boundary, similar to the East Coast Magnetic Anomaly discussed by Taylor et al. (1968). C–C′ (Figs 4 and 7) is similarly taken to be associated with the edge of Greenland's continental shelf, rather than with the Morris Jesup Rise anomaly because of its difference in strike and close association with the short wavelength magnetic features similar to HF1 that lie west of the Morris Jesup Rise. If, as postulated by Srivastava (1978) and Jackson et al. (1979), 250 km of left-lateral motion occurred along Nares Strait during the opening of Baffin Bay, then rotating Greenland back to close Baffin Bay brings the isolated magnetic highs B–B′ and C″–C′ into alignment (Fig. 7B). This similarly brings the two regions (HF1 and HF2, Fig. 4) of moderate amplitude, short wavelength anomalies that lie northeast of B–B′ and C–C′ into alignment. The linear magnetic source deep, found in the depth-to-source analysis (Figs 5 and 6) to extend from and in line with Nares Strait, is therefore taken to be additional evidence of a major transform fault along Nares Strait that extends into the Lincoln Sea to the Morris Jesup Rise. This is labelled the Wegener Fracture Zone in Fig. 9, following Johnson & Vogt (1973) and Ostenso & Wold (1973).

Similarly, a second fracture zone is taken to lie along the boundary between the magnetic basement high under HF1 (Fig. 4) and the magnetic basement low southeast of HF1 and southwest of C–C″, and coincident with the channel-like bights in the 2000, 2500, 3000 and 3500 m GEBCO map sheet 5.17 isobaths of the Lomonosov Ridge – Amundsen Basin slope (Johnson et al. 1979). This fracture zone, which I call here the Ellesmere Fracture Zone (Fig. 9) extends from its southwestern terminus in the magnetic basement at the 500 m isobath to its northeastern end just seaward of the 3500 m isobath of the Amundsen Basin near the anomaly 24 isochron (Fig. 4). The region of subdued, long wavelength anomalies bordered by the Ellesmere Island shelf, the Ellesmere and Wegener Fracture Zones and the magnetic basement high north and east of C″–C–C′ that is characterized in Figs 5 and 6 by moderately deep magnetic basement could then be a region of thinned and foundered continental crust, rather than oceanic crust, formed by the left-lateral motion of Arctic Canada in relation to Greenland along the Wegener and Ellesmere Fracture Zones.

A close examination of the magnetic anomalies in regions HF1 and HF2 (Fig. 8) shows some features characteristic of oceanic sea-floor spreading anomalies, including bilaterally symmetric anomalies equidistant from an occasionally visible central magnetic high. This central high also corresponds closely to a 70 km long by 20 km wide low in the middle of the depth-to-source data for region HF1 (Figs 5 and 6). An unabashed plate tectonics interpretation of the magnetic evidence in these areas then suggests that these high-frequency anomalies are sea-floor spreading anomalies with a fossil spreading centre lying under the starred region shown in Fig. 8, and that the following plate tectonic sequence took place. Spreading postulated to have begun in the Santonian or early Campanian (Taylor 1978, Taylor et al. 1981) in the Makarov Basin extended up the slope of the northeastern Ellesmere Island – northern Greenland shelf and terminated in a transition region similar to the present-day Gulf of Tadjurah (Courtillot et al. 1980) at the Kap Washington Group volcanics, beginning the formation of a shallow, possibly emergent, plateau of oceanic crust (Fig. 9A). This was followed shortly by the initiation of spreading in the Labrador Sea in the Maastrichtian at anomaly 32 (Srivastava 1978). By anomaly 25 in the mid-Paleocene (Fig. 9B) spreading had begun in Baffin Bay (Srivastava 1978, Jackson et al. 1979) and by late Paleocene prior to anomaly 24, spreading had begun in the Norwegian–Greenland Sea and Eurasia Basin (Pitman & Talwani 1972, Johnson & Vogt 1973, Herron et al. 1974, Kristoffersen & Talwani 1977, Srivastava 1978, Feden et al. 1979, Jackson et al. 1979, Vogt et al. 1979a, b). By this time, the shallow plateau over what I call here the Kap Washington hot spot was fully formed and was beginning to be split into two pieces (HF1, HF2, Fig. 4) by the formation of the Wegener–Ellesmere fault complex that formed the southwest arm of the RFF triple junction north of Greenland (Fig. 9C). This strike-slip motion between HF1 and HF2 was accompanied by thinning and foundering of the continental crust between the Ellesmere and Wegener Fracture Zones and between HF2 and Ellesmere Island, forming a deep sedimentary basin. Shortly after spreading ceased in the Makarov Basin, the Lomonosov Ridge became fixed to

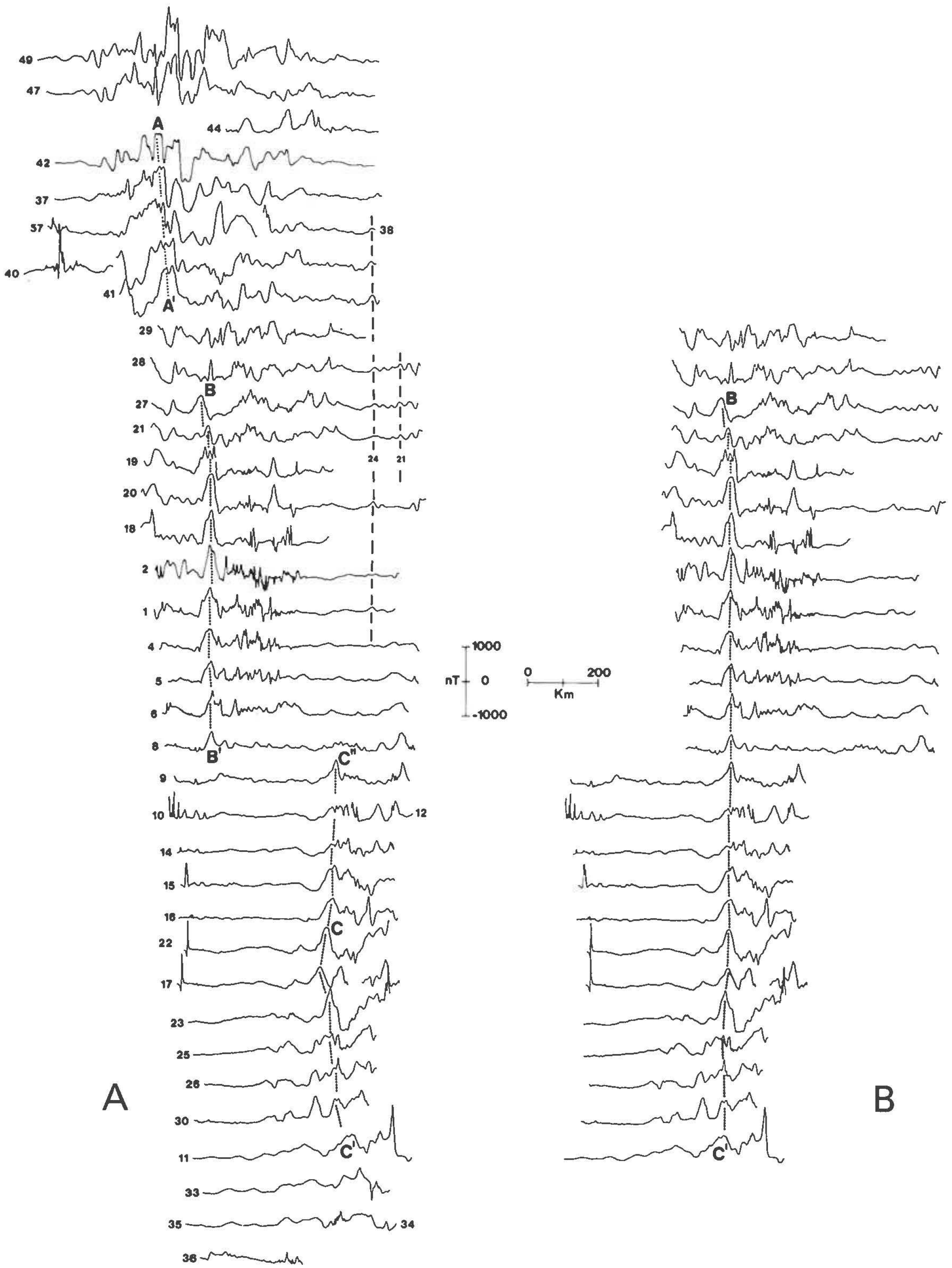

Fig. 7. A: Anomaly versus distance profiles for the tracks numbered in Fig. 2. Southern ends of all tracks are on the left. Features are aligned using a line on Fig. 2 from the intersection of track 49 and 70°W long. to the intersection of track 36 and 45°W long. Dotted lines connect continental edge anomalies A–A′, B–B′ and C″–C–C′ shown in Fig. 4. Dashed lines are anomalies 21 and 24 as identified by Feden et al. (1979) and Vogt et al. (1979a). B: Anomaly versus distance profiles for track numbers 29 through 36, with tracks 9 through 36 shifted left (south) to align C–C″ with B–B′.

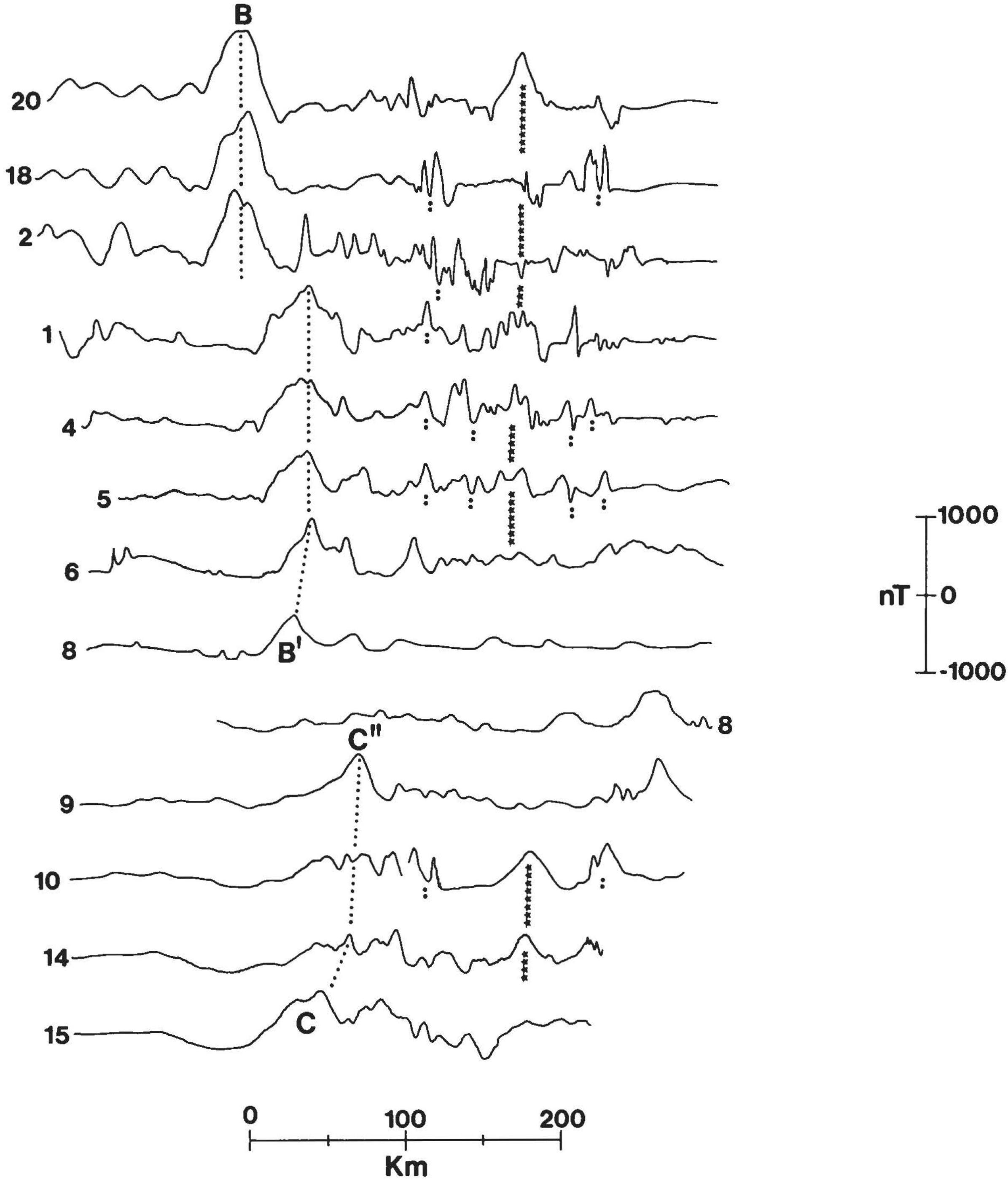

Fig. 8. Anomaly versus distance profiles for tracks 20 through 15 (location in Fig. 2), aligned as in Fig. 7B, but with track 8 cut in the middle and magnetic highs aligned. Postulated relic central anomaly is starred. representative anomalies having bilateral symmetry are dotted. Note the change in relative scale compared to Fig. 7.

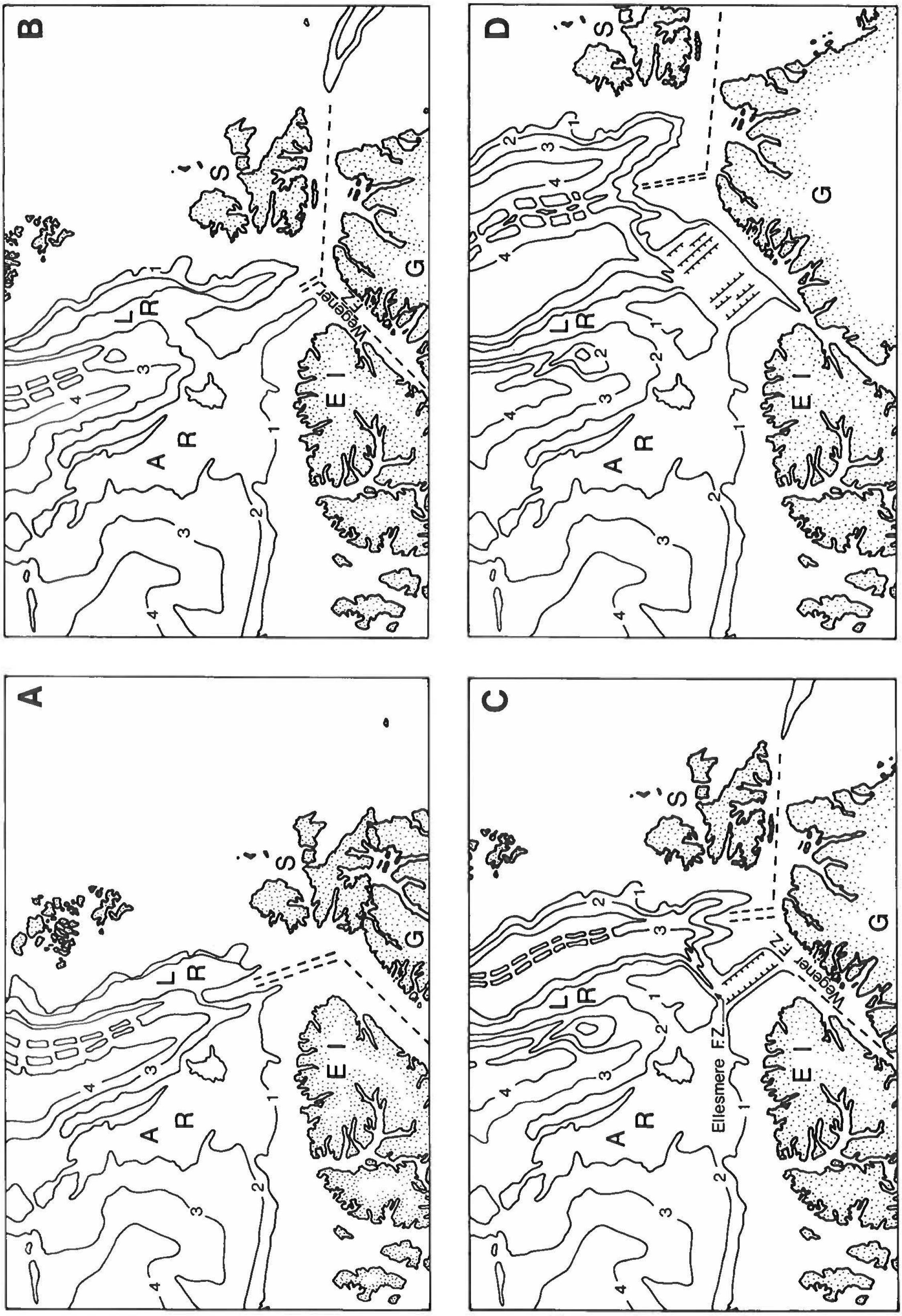

Fig. 9. Suggested plate tectonic evolution of the Lincoln Sea region. AR – Alpha Ridge; LR – Lomonosov Ridge; EI – Ellesmere Island; G – Greenland; S – Svalbard; single dashed lines denote active fracture zones; double dashed lines denote landward extensions of active spreading centres. A: Anomaly 34 time, 80 m.y. B: Anomaly 25 time, 59 m.y. C: Anomaly 24 time, 56 m.y. D: Anomaly 13 time, 35 m.y. Age of magnetic anomalies based on time scale of LaBrecque et al. (1977).

Ellesmere Island and Canada across the plateau forming HF1, and the position of the Kap Washington hot spot relative to Greenland shifted slightly eastward of HF2 beginning the formation of the Morris Jesup Rise–Yermak Plateau (Feden et al. 1979, Vogt et al. 1979b). By anomaly 13 time in the early Oligocene (Fig. 9D) spreading in Baffin Bay and the Labrador Sea (Srivastava 1978, Jackson et al. 1979) and strike-slip motion along the Wegener–Ellesmere Faults ceased, the anomalous production of basalt forming the Morris Jesup Rise and Yermak Plateau abruptly ended (Feden et al. 1979) and the basement morphology of the Makarov Basin, Lomonosov Ridge, Lincoln Sea and Morris Jesup Rise became essentially fixed. Continued spreading along the North Atlantic and Arctic spreading ridges (Karasik et al. 1972, Pitman & Talwani 1972, Ostenso & Wold 1973, Herron et al. 1974, Pitman & Herron 1974, Talwani & Eldholm 1977, Srivastava 1978, Sweeney et al. 1978, Feden et al. 1979, Vogt et al. 1979a, b) then led to the formation of the present-day structures.

As in any preliminary hypothesis derived primarily from aeromagnetics and unconstrained by seismic or drill hole data, several problems exist in this interpretation. Srivastava (1978) postulated a northwest component to the motion of Greenland, towards Ellesmere Island in the late Cretaceous and early Tertiary to form the Innuitian fold belt during the Eurekan orogeny; this movement of Greenland is further discussed by Srivastava & Falconer (this volume). If such a compressive motion took place there is no record of it in this author's interpretation of the Lincoln Sea aeromagnetics. In fact, depending on the particular sequence of motions used to rotate Greenland back against Arctic Canada, and the choice of the strike of the anomalies in the area HF2 (Fig. 4), a gap of as much as 50 to 80 km between the supposedly once contiguous blocks HF1 and HF2 appears! This would tend to imply a separation of Greenland from Ellesmere Island by this amount, rather than compressive motion.

Another problem is whether the basement under HF1 and HF2 is totally oceanic, and formed by plate tectonic and hot spot/plume processes. The anomaly record, though appearing very similar to the partially lineated high-frequency anomalies just north of Iceland (Vogt et al. 1980), is too spotty for any reasonable anomaly identifications to be made. In fact, the above interpretation may be overly enthusiastic, a possible alternative being the generation of numerous dykes in the regions HF1 and HF2 which coincidentally formed structures having occasional bilateral symmetry. There is also no bathymetric feature clearly associated with HF2, though the detailed magnetics and the close correspondence of magnetic features suggest this is more likely due to the lack of detailed bathymetric data in the area. A reinterpretation of the bathymetry incorporating the magnetics and depth-to-source data is given in Fig. 10.

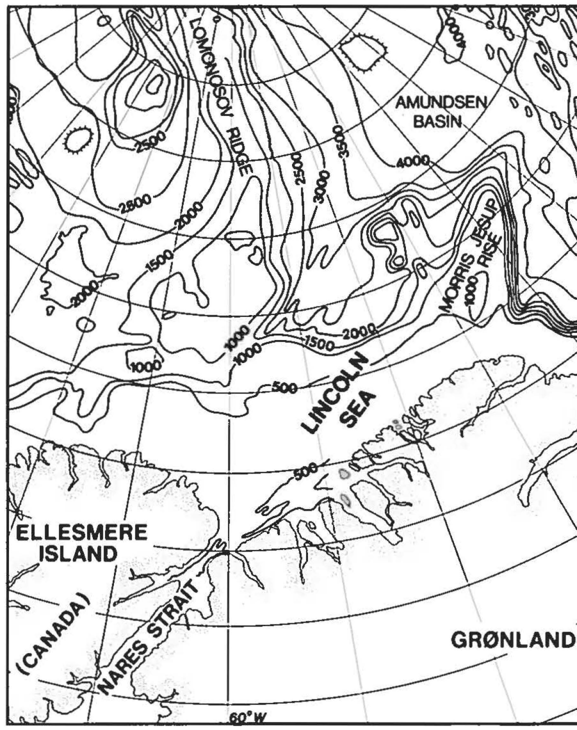

Fig. 10. Revised Lincoln Sea bathymetry (cf. Fig. 1), using discussed depth-to-source and magnetic data, and GEBCO sheet 5.17 (Johnson et al. 1979). Bathymetry in metres.

Another problem with a spreading history in the region northeast of B–B′ (Fig. 4) is its lack of subsidence and the fact that it forms the transition between the Ellesmere Island continental shelf and the generally acknowledged continental structures of the Lomonosov Ridge. Oceanic crust between the Lomonosov Ridge and the Greenland/Ellesmere Island shelf cértainly cannot be ruled out, given the complex history of the area, but if it exists at the source depths calculated a large free air gravity anomaly would be expected. Such an anomaly does not appear in the available regional data (Sobczak 1978). This, however may be due to the low pass filtering implicit in its method of presentation (Sobczak 1978), since a free air high of about 60 mgal is shown on one line of a detailed gravity survey of the Lincoln Sea (Sobczak & Stephens 1974). All the processes postulated would be characterized by very low spreading rates and fluctuating rates of basalt production as discussed by Feden et al. (1979) and Jackson et al. (1979), which could be responsible for the relatively shallow and equivocal character of the anomalies. Certainly, other interpretations are possible and theories on the origin of the area will continue to be revised as more geophysical data become available. Hopefully, the interpretation offered here can at least serve as a guide to future work in the Lincoln Sea and its geotectonic connections to the surrounding Arctic regions.

Conclusions

On the basis of a depth-to-source analysis of previously unpublished aeromagnetic data in the Lincoln Sea, a major deep magnetic basement extension of the Nares Strait is delineated and identified as the Wegener Fracture Zone. Shelf edge anomalies and two anomalously shallow blocks of possible oceanic anomalies lying perpendicular to the fracture zone are identified; an approximately 250 km displacement along the fracture zone is postulated to explain the offset in these magnetic features. Another fracture zone is delineated, along with a major sediment filled basin whose deep magnetic basement structure is due to thinning and foundering of the underlying continental crust.

The anomalously shallow oceanic anomalies found northeast of the shelf edge anomalies are postulated to be due to an Iceland-like hot spot and to the very slow spreading rates and complex history of the area, though the magnetic record is not unequivocal enough to rule out a swarm of dykes in an otherwise continental structure.

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