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Volcanogenic Sandstones as Aeromagnetic Markers on Judge Daly Promontory and in Robeson Channel, Northern Nares Strait

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Abstract: Aeromagnetic data were collected over the Hall Basin and adjacent coastal land areas of northern Nares Strait during the 2001 Canadian-German Nares Strait Expedition to provide an improved onshore-offshore linkage of geological structures related to the Late Cretaceous – Early Paleogene Eurekan Orogeny. The total field magnetic anomaly data are characterized by broad long-wavelength anomalies compatible with thick sequences of non-magnetic Silurian and Devonian carbonate facies. On the Greenland side of the survey block, the magnetic anomalies are generally positive, possibly reflecting the magnetic characteristics of deeply buried crystalline rocks of the Paleozoic platform. Over Ellesmere Island, the magnetic anomalies are low in amplitude, suggesting a different basement composition from Greenland. Two linear northeast oriented positive magnetic anomalies are observed on Judge Daly Promontory. One extends along the south coast between Carl Ritter Bay and the mouth of Daly River. The second occurs over the northern end of the peninsula and extends offshore from Cape Baird to Robeson Channel. From field samples, this anomaly has been correlated with thrust fault-bounded Tertiary sedimentary basins, which have increased susceptibility values caused by the content of basalt clasts. The thrust fault, bounding the southern edge of these basins has been mapped as a continuous feature across Judge Daly Promontory, however, the absence of a continuous magnetic anomaly is likely the result of complete erosion of the sedimentary wedge. The amplitude of this anomaly decreases south of Carl Ritter Bay, as a result of decreased content of basalt clasts. A small magnetic anomaly at 81.3 °N, 66.8 °W also coincides with an isolated outcrop of Tertiary rocks, associated with a different fault. The offshore extension of these anomalies indicates a continuity of the Tertiary basins northeast–ward to Robeson Channel and to the Lincoln Sea. It does not follow a simple continuous line, but appears to be broken in subsections of slightly differing directions. Similar offsets are observed in a parallel magnetic anomaly in Hall Basin suggesting crosscutting NW–SE trending faults. The magnetic anomalies and onshore geological observations suggest that the Wegener Fault is not a simple strike-slip fault, but a complex system of faults and a chain of blocks and basins.

Zusammenfassung: Während der deutsch-kanadischen Nares Strait-Expedition 2001 wurde ein aeromagnetisches Messprogramm über dem Hall Basin der nördlichen Nares Strait und anliegenden Küstengebieten durchgeführt um eine bessere Korrelierung geologischer Strukturen des spätkretazisch –frühtertiären Eureka-Orogens an Land und unter dem Meer zu erreichen. Die Daten des magnetischen Totalfelds sind durch breite langwellige Anomalien gekennzeichnet, die mit mächtigen nicht-magnetischen Abfolgen der silurisch-devonischen Karbonatfazies korreliert werden. Auf der grönländischen Seite des Untersuchungsgebiets sind diese Anomalien generell positiv. Vermutlich spiegeln sie die magnetischen Eigenschaften des die Karbonatplattform in der Tiefe unterlagernden kristallinen Grundgebirges wider. Über Ellesmere Island weisen magnetische Anomalien geringer Amplitude auf einen anderen Charakter des Grundgebirges hin. Über der Judge Daly Promontery wurden zwei NE–SW-streichende lineare positive Anomalienzüge registriert. Der eine von ihnen erstreckt sich küstenparallel zwischen Carl Ritter Bay und der Mündung des Daly Rivers, der andere setzt sich von der Nordspitze der Halbinsel unter den Meeresarm des Robeson Channels fort. Diese Anomalien konnten mit störungsbegrenzten tertiären Sedimentbecken korreliert werden, die nach Beprobungen eine durch vulkanische Komponenten bedingte hohe Suszeptibilität aufweisen. Die Störung, die diese Becken im Süden begrenzt, kann durch die gesamte Judge Daly Promontery verfolgt werden. Wo die tertiären Sedimente jedoch erodiert sind (nördlich der Mündung des Daly River), setzt auch die Anomalie aus. Die Anomalie endet südlich von Carl Ritter Bay als Folge des Fazieswechsels von Sandsteinen zu Konglomeraten. Eine separate kleine Anomalie bei 81,3 °N und 66,8 °W korreliert mit einem isolierten Tertiär-Aufschluss, der an eine andere Störung gebunden ist. Der nördliche Anomalienzug deutet auf eine Fortsetzung der tertiären Becken unter dem Meer des Robeson Channels und der Lincoln Sea hin. Diese Anomalien folgen nicht einer einfachen Linie, sondern sind in Einzelsegmente mit leicht veränderter Richtung unterteilt. Vergleichbare leichte Verschiebungen an SE–NW streichenden Querstrukturen sind in einem parallelen Anomalienzug im Hall Basin zu beobachten. Die magnetischen Anomalien kombiniert mit geologischen Beobachtungen am Boden legen die Vermutung nahe, dass die Wegener-Störung in diesem Raum keine einfache Blattverschiebung ist, sondern ein komplexes System von tektonischen Blöcken und Becken umfasst.

INTRODUCTION

During the tectonic development of the North Atlantic and the northern polar oceans the relative movements of the Greenland Plate and the North American Plate played an important role. Within the Nares Strait waterway (Fig. 1), between northern Greenland and Ellesmere Island, the existence of a significant plate boundary (Wegener Fault) has been discussed since the early 1900s (WEGENER 1915) and plate kinematic models have suggested that up to 300 km of sinistral strike-slip motion occurred (SRIVASTAVA & TAPSCOTT 1986). ROEST & SRIVASTAVA (1989) presented a new kinematic model which identified two phases of motion for the Greenland Plate relative to North America. In the Nares Strait region (along the Wegener Fault), this model defines a phase of Paleocene sinistral strike-slip motion followed by Eocene convergence. OAKEY (1994) demonstrated that this Eocene convergence is consistent with the compressive deformation within the Eurekan Orogeny; however, the kinematic model presented by OAKEY & CHALMERS (2001) suggests that the Eocene convergence would accommodate a continued component of (minor) sinistral strike-slip motion.

Geological investigations onshore of Judge Daly Promontory have identified Paleogene basin systems (MAYR & DE VRIES 1982; PIEPJOHN et al. 2001) bounded by a complex pattern of strike-slip and thrust faults. The Judge Daly Fault Zone has been interpreted to be the onshore equivalent of the Wegener Fault (HARRISON 2006). SAALMANN et al. (in press) refer to these basins as the Pavy River Basin in the northern part of Judge Daly Promontory, Cape Back Basin in the coastal section northeast of Carl Ritter Bay and a small basin in north central Judge Daly Promontory as the Triangle Basin. The faults bounding these basins are predominantly compressive, however, there is a component of strike-slip motion which is consistent with OAKEY & CHALMERS (2001) model of Eocene motion.

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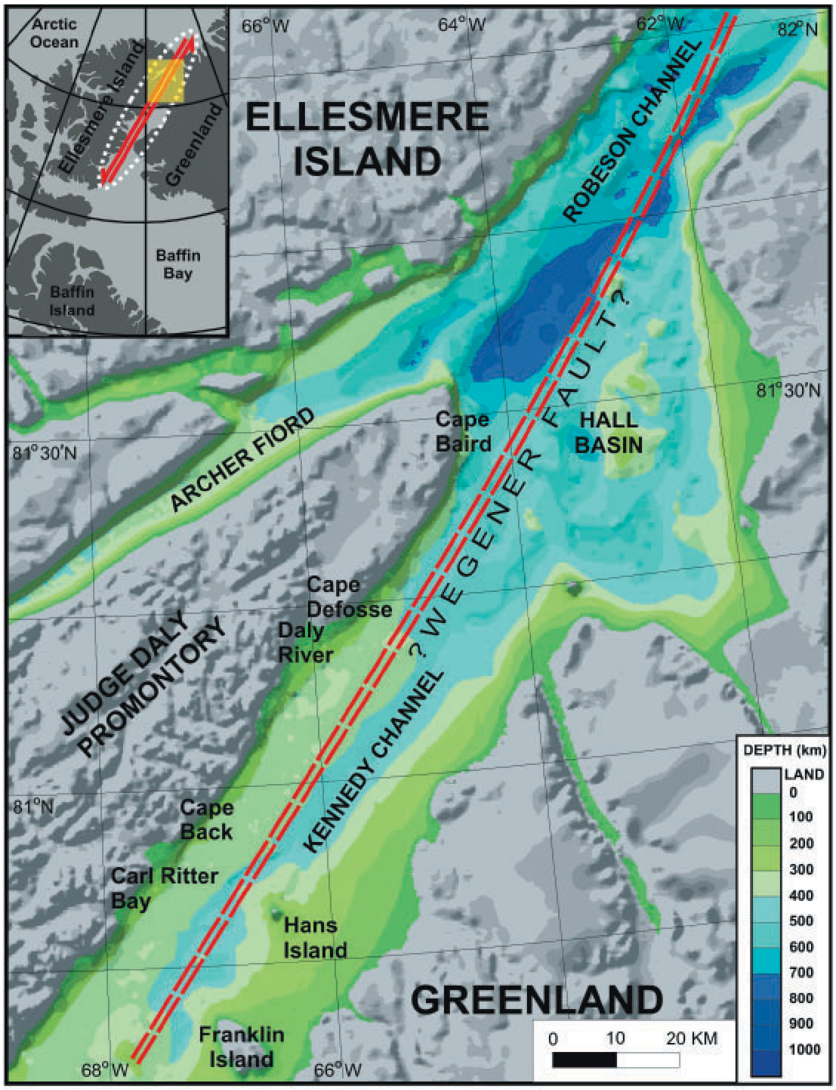

Fig. 1: Physiography of northern Nares Strait. The position of the presumed Wegener Fault is modified after OKULITCH (1991) (double dashed red line). The insert map shows the location of the Nares Strait (dotted ellipse) with respect to northern Greenland, Ellesmere Island and Baffin Bay; the survey area (yellow box); and the assumed sinistral offset along the Wegener Fault (red arrows).

During 1982 and 1983, low elevation (305 m) reconnaissance aeromagnetic surveys were carried out over Nares Strait covering Robeson Channel, Hall Basin, Kennedy Channel and Judge Daly Promontory (HOOD et al. 1985) (Fig. 2). Survey lines were spaced somewhat irregular at about 10 km intervals and navigation was done using the VLF Global Navigation System. Line-by-line interpretation showed a sequence of magnetic anomalies, that were interpreted by HOOD et al. (1985) as a SE–dipping dyke system aligned with the strike of Nares Strait, and seemed to confirm the hypothesis of sinistral displacement along the Wegener Fault. However, subsequent geological mapping onshore Judge Daly Promontory were unsuccessful in identifying a source rock for these anomalies.

As part of the 2001 Nares Strait Cruise aeromagnetic data were collected over Judge Daly Promontory and the waters of southern Robeson Channel, Hall Basin, and northern Kennedy Channel (Fig. 3). Systematic survey line spacing with modern GPS navigation provides a substantially improved mapping tool to correlate magnetic anomalies with geological structures. Covering both on- and offshore areas ensures that structures identified on land can be “extrapolated” to the Nares Strait channels and the Hall Basin and provide a regional continuity of the Eurekan (Wegener) fault system.

PHYSIOGRAPHY OF NORTHERN NARES STRAIT

In northern Nares Strait, the main seaway consists of the Kennedy Channel, Hall Basin, and Robeson Channel (Fig. 1). In Kennedy Channel the water depths along the Greenland coast shallow gradually, with depths of less than 300 m. Within this coastal platform are Franklin Island and Hans Island. Along the southern coast of Judge Daly Promontory, the water depth drops off very abruptly, to over 300 m within 1 km of the shoreline. The central trough within Kennedy Channel is slightly deeper than 400 m. The Hall Basin is a rugged platform, with bathymetric depths generally below 400 m and a complex pattern of seafloor relief. There is a central high where bathymetry shallows to 200 m. Within Robeson Channel there is a narrow trough over 700 m deep extending from Cape Baird toward the northeast, close to the Greenland coast. Along the northern edge of the trough is a bathymetric ridge with depths less than 500 m. Between this central ridge and the Ellesmere coast is a complex platform with water depths between 400 m and 700 m. Bathymetry of Archer Fiord is generally 200 m to 300 m, and deepens to the northeast to over 600 m.

The surrounding topography is extremely rugged and coastal cliffs are commonly over 600 m. Greenland is characterized by

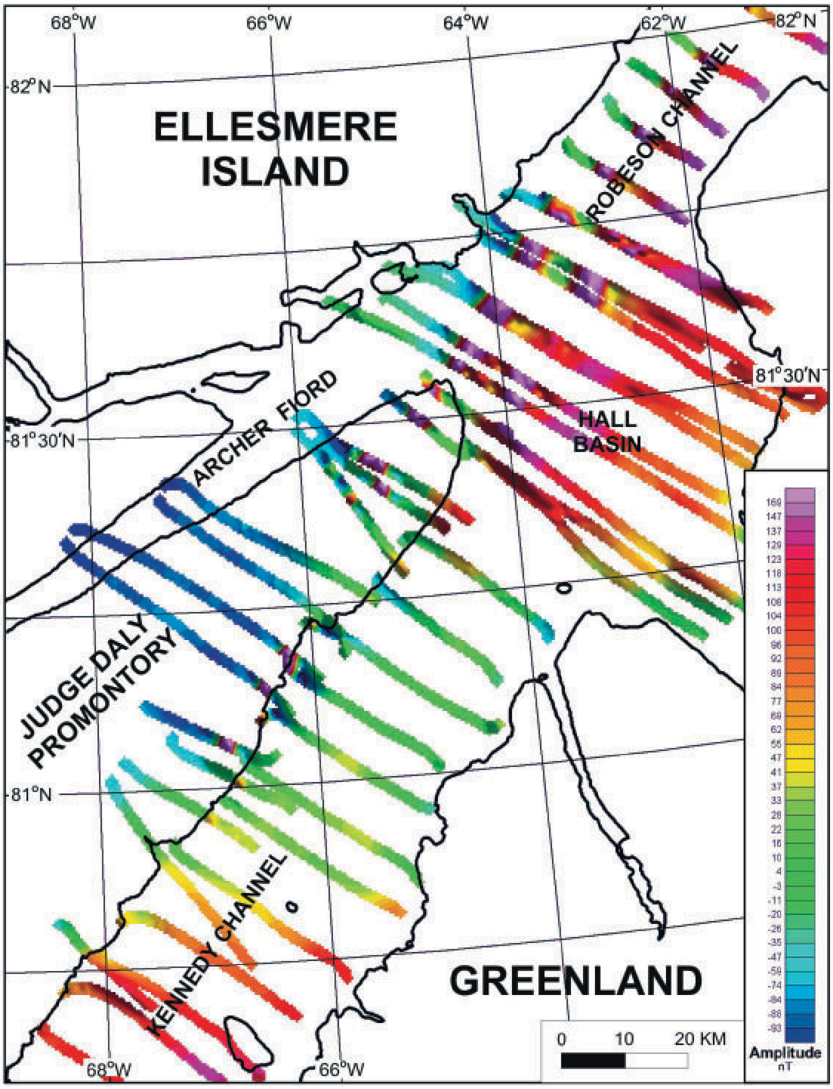

Fig. 2: Aeromagnetic survey lines collected during the 1982-1983 surveys over Robeson Channel, Hall Basin, Kennedy Channel (Hood et al. 1985). Magnetic anomalies are presented along the lines with an equal-area colour scale.

broad flat areas with elevations between 500 m and 600 m, incised with long glacial fjords and covered by large ice-fields. Judge Daly Promontory has extremely rugged topography with several rivers such as the Daly River and little permanent ice. Coastal cliffs are generally 700-800 m in height and central peaks exceed 1200 m. North of Archer Fjord, Ellesmere Island has a complex shoreline with many islands and elevations of 400- 500 m. Further north, adjacent to Robeson Channel, shear coastal cliffs exceed 1200 m.

THE SURVEY: LAY-OUT, DATA ACQUISITION, PROCESSING, AND MAP PRODUCTION

The aeromagnetic survey was part of the joint Canadian-German cruise Nares Strait 2001, operated from board of the Canadian Coast Guard ice-breaker "Louis S. St. Laurent". The measuring platform was one of the Coast Guard twin-engined helicopters of the type Bo105. A Cs-magnetometer was towed in bird configuration 25 m below the helicopter. Flight navigation was done by using the helicopter's GPS-system, altitude was controlled by barometric and radar altimeters. For detailed positioning a separate GPS-antenna was mounted on the tail-boom, feeding the data directly to the data acquisition system inside the cabin.

Ideally, the distance to the magnetic source and the spacing of profile-lines should be approximately the same so that magnetic anomalies can be recognized in all directions to yield an unambiguous picture (Bosum 1981). However, even ratios of 1:2 to 1:4 between distance to source and separation of survey lines can provide good information on the source body (Bosum 1981). With water depths in the northern Nares Strait reaching 400-800 m, and a constant barometric survey level of 2000 ft (610 m), a profile spacing of 2 km was considered sufficient, as a compromise between optimal spacing and the area to be covered. Over the mountains of Judge Daly Promontory survey lines were flown draped at a mean terrain clearance of 1000 ft (305 m).

In total, 5470 km of survey lines were completed over the northern Judge Daly Promontory, the Kennedy Channel including a coastal strip over Greenland, the western Hall Basin and parts of the Robeson Channel (Fig. 3). Profile-lines are orientated approximately north–south, with tie-lines every 10 km (i.e. at a ratio of 1:5 to account for the special problem of conducting aeromagnetic surveys at high magnetic latitudes, where considerable magnetic time variations are known) running east–west. Neither orientation is at a perpendicular angle to the strike of the expected structures as often thought to be optimal for potential field surveys. Since our objective was to obtain a planar coverage describing the magnetic anomalies completely, an orientation at right angle to the strike is not necessary: In data processing it is easier to distinguish the real geological trends from any other trends (such as insufficiently removed diurnal variations) along lines if they do not have the same orientation.

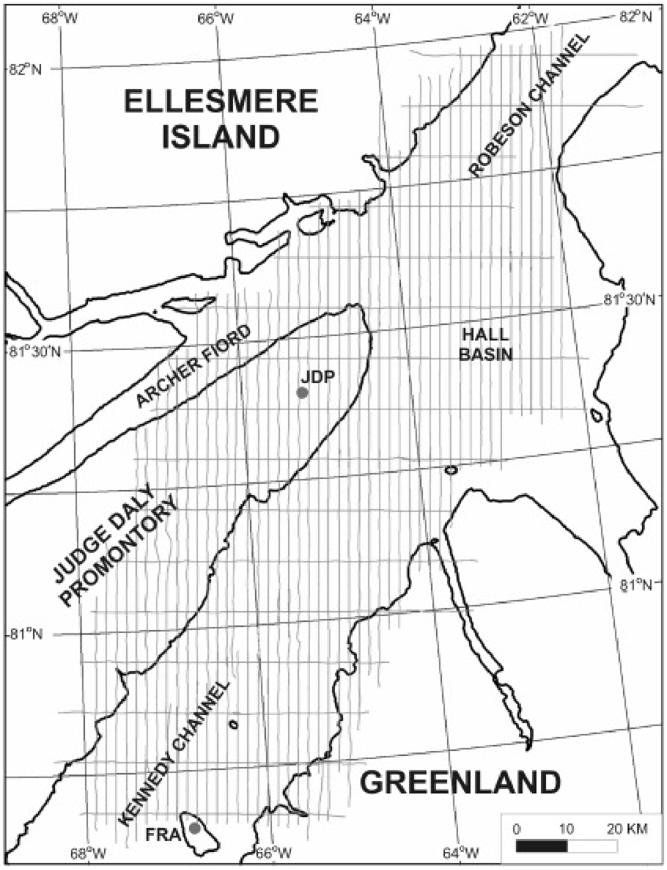

Fig. 3: Aeromagnetic survey lines and tie lines collected during the Nares Strait 2001 cruise. Base stations (grey dots) were installed on Franklin Island (FRA) and Judge Daly Promontory (JDP) to monitor diurnal variations of the magnetic field.

Geomagnetic activity was monitored by two base stations set up within the survey area on Franklin Island (FRA) and in the northern part of Judge Daly Promontory (JDP) (Fig. 3). The total magnetic field was recorded at one-minute intervals. The daily pattern of the diurnal variations is similar at both stations (Fig. 4), though amplitudes are slightly different. However, the largest differences occur during times of a day when no survey flights took place (survey flying deliberately was done during the local night hours when geomagnetic activity was reduced based on pre-survey studies of the closest permanent magnetic stations at Alert, Resolute Bay, and Thule). Thus it is justified to use data from only the station FRA on Franklin Island for diurnal correction for all parts of the survey area. Also, data were smoothed with a 30-minute low-pass filter to exclude short-period variations, thus avoiding introduction of "artificial" anomalies in the more distant parts of the survey area. The filtered base-station data were then interpolated to one-second intervals and subsequently subtracted from the survey's magnetic field values.

The internal (main-field) component was removed by calculating for each survey point the IGRF (International Geomagnetic Reference Field) for 22 August 2001 (as the central date for the survey) using the IGRF model 2000 International Association of Geomagnetism and Aeronomy (IAGA) Division V, Working Group 8, 2000) and subtracting it from the magnetic field values.

After base station correction and IGRF removal, some discrepancies between the magnetic field values at the intersections of profile-lines and tie-lines remained. The calculated deviations were minimized using an iterative levelling approach (Damaske et al. 2005). In this way not only the higher frequency parts of the diurnal variation were accounted for, but also discrepancies due to differences in elevation or from

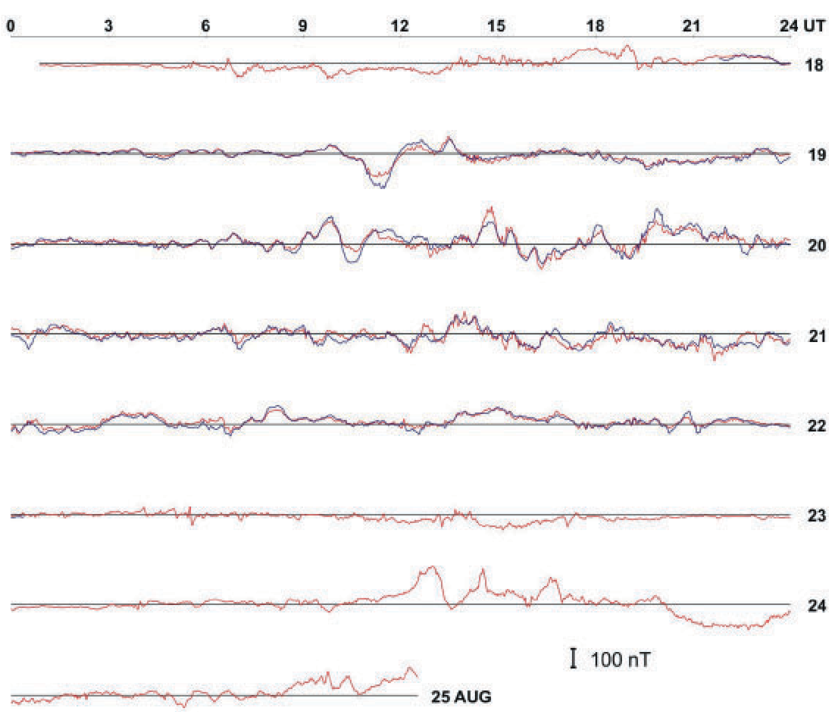

Fig. 4: Diurnal variations recorded at the base stations on Franklin Island (FRA) (shown in red) from 18-26 August 2001 and on Judge Daly Promontory (JDP) (shown in blue) from 18-24 August 2001. The mean value of 56220 nT was used as a baseline value for (FRA), and the mean value of 56075 nT used as baseline for (JDP). Shown are intervals from 0h to 24h Universal Time (UT).

any other effect were reduced. Final grids were produced from the levelled data incorporating all profile- and tie-lines using a cell size of 400 m and interpolated with a minimum curvature algorithm. All data processing was done using the programme package of GEOSOFT-OASISmontaj.

DISCUSSION OF ANOMALIES

The final map of the anomalies of the total magnetic field of the Hall Basin survey (Fig. 5) shows a distinct pattern of elongated anomalies or anomaly chains running southwest-northeast through the survey area. These anomaly chains divide the survey area into a block to the north and west of relatively little internal structure and of distinctively lower amplitudes than the rest of the survey area. To the south and east of the anomaly chains large positive anomalies dominate.

The block of large positive anomalies is apparently a continuation of the same type of anomalies known to dominate the northern and north-eastern margin of the Greenland craton (VERHOEF et al. 1996, SCHLINDWEIN & MEYER 1999) reflecting deeply buried crystalline rocks. The northwestern magnetic low extends (see Fig. 13) over large parts of north-eastern Ellesmere Island (Hazen and Clements Markham foldbelts) which consists of a thick sequence of Paleozoic fine grained basin deposits (TRETTIN et al. 1991).

The high amplitude, short wavelength anomalies, aligned partially in chains, are of critical significance for the interpretation of the tectonic development in the area. These anomalies can been seen in part in the survey described by HOOD et al. (1985) and were originally interpreted as arising from dykes. However, positioning at that time was insufficient to correlate the anomalies with smaller scale geological features.

Anomalies over Judge Daly Promontory

The southernmost portion of the anomaly chain corresponds with a fault bounded onshore Tertiary basin in the Cape Back area of eastern Judge Daly Promontory (Cape Back Basin) (Fig. 6). The anomaly is most prominent over the northeastern portion of the basin, extends offshore to the northeast, and

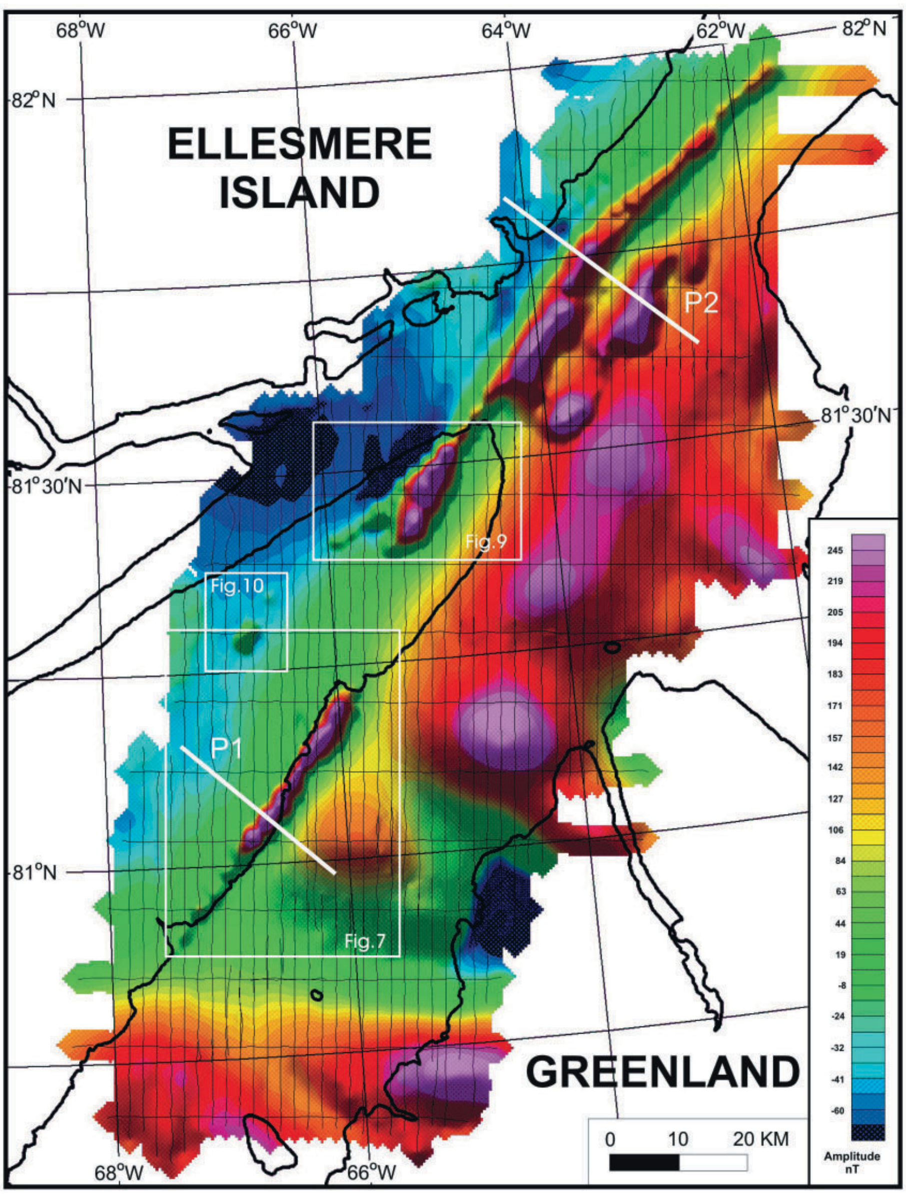

Fig. 5: Anomalies of the Total Magnetic Field over Hall Basin, Judge Daly Promontory, and Kennedy Channel. Colour scale is equal-area and shadowing direction is from 345°. Survey lines (in black) are displayed. P1 and P2 indicate the positions of the two synthetic profile lines extracted from the grid and modelled in Figure 8 (P1) and Figure 12 (P2). Locations of Figures 7, 9 and 10 are indicated (white boxes).

Sample	Type	SI (10^{-3})
SE 106/99	basalt	25+
SE 160/00	basalt	101
SE 148/00	basaltic trachyandesite	30
SE 115/99	basaltic trachyandesite	65
SE 137/00	trachybasalt	70
SE 161/00	trachyt	55+
SE 147/00a	tephrite	88
SE 147/00b	tephrite	98
SE 155/00	tephrite	87
SE 114/99	tephrite	32
SE 139/00	mugearite	54
SE 158/00	phonolite	14+
SE 149/00	ignimbrite	4.5
SE 140/00	benmoreite	0.7

Tab. 1: Volcanic pebbles of the "Cape Back Tertiary" sediments collected during CASE 5 (1999) and CASE 6 (2000) by S. Estrada. The samples are described in ESTRADA et al. (in press). All measurements using a kappameter type K5 were taken at clear and even cuts of the samples. For samples of smaller size than the standard diameter the given value has been corrected according to the instruments correction table. The size of a few samples was smaller than the correction table was layed out for: measurements of these samples were corrected with the maximum factor of 1.2 given in the correction table and are marked by "+", indicating that the susceptibility is higher than the value given in this table.

terminates at Cape Defosse. To the southwest, the anomaly reduces in amplitude and width and terminates at Carl Ritter Bay. The magnetic anomaly is attributed to the presence of volcanic sediments within the basin fill having high magnetic susceptibility values. The presence of these volcanogenic clasts was first noted by MIALL (1982), and ESTRADA et al. (in press) documented the high susceptibility values (Tab. 1). Volcanic pebbles collected in the Cape Back area (at about 81 °S, 67 °W) during the CASE 5 (in 1999) and CASE 6 (in 2000) projects (ESTRADA et al. in press) reveal susceptibilities values of up to 100 x 10^{-3} SI units. Highest values occur in the SiO_2-poor volcanic pebbles, i.e. basalts and tephrites. In situ field measurements made by ZENTILLI & GRIST (2001) during the 2001 Nares Strait cruise identified that the highest magnetic susceptibilities values are found in Tertiary clastic units at the northern end of the basin. The reduction in amplitude of the southern end of the magnetic anomaly suggests a decrease in the volume magnetic material either by thinning of the formation containing the volcanic clasts, burial and covering by overlying non-magnetic sediments, a systematic change of original sediment source, or a combination of all three. Submersion of the formation containing the volcanic material is in agreement with observations that in the southern portion of the Tertiary basin no volcanic clasts are present at the surface (MIALL 1982).

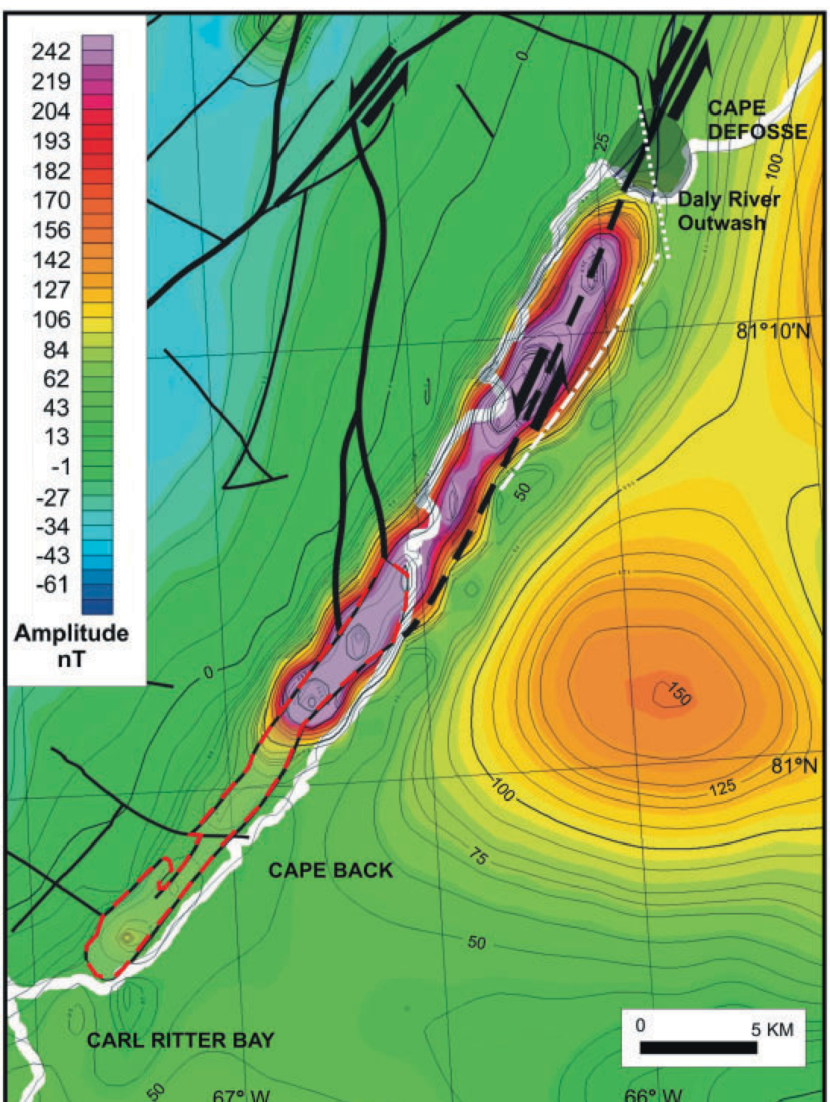

Fig. 6: Magnetic anomalies and position of Tertiary basin northeast of Carl Ritter Bay. Outline of the Cape Back Tertiary basin (in red) taken from Tessensohn et al. (in press). Fault structures (black lines) simplified after von Gosen et al. (in press). Also shown is a new interpretation of the offshore location of the bounding strike-slip fault (dashed white line) with an offsetting fault (dotted white line) beneath the Daly River outwash (grey polygon).

The overlay fault structures (simplified after VON GOSEN et al. in press) shows the offshore extension of the southern strike-slip bounding fault (black dashed line) crossing the northern end of the magnetic anomaly near Cape Defosse (Fig. 6). In this area, the outwash plain from the Daly River (grey polygon) limits direct mapping. From the geometry of the magnetic anomaly, it is reasonable to extend the offshore strike-slip fault to the eastern edge of the magnetic anomaly (dashed white line) where it is offset by a north-oriented fault (white dotted line). As such, the NE–oriented strike-slip fault is a primary feature and overprinted by a later period of faulting, consistent with the two phases of plate motion defined by OAKEY & CHALMERS (2001) kinematic model.

A comparison of the new survey results over the Cape Back Basin are shown in Figure 7 with the single lines collected in 1982 and 1983 (grey overlay) (HOOD et al. 1985). Although the anomalies are identified in the older survey, their locations are displaced by a few kilometres to the northwest, explaining the inability to correlate the anomalies with mapped geological features.

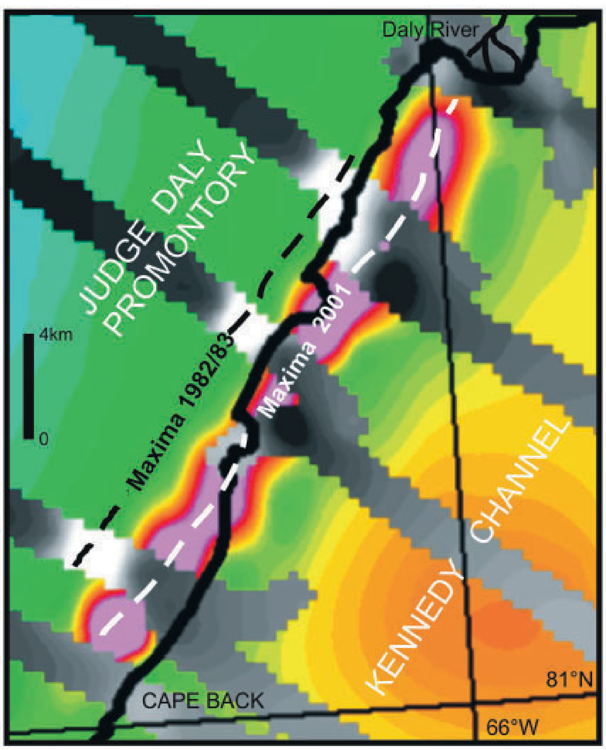

Fig. 7: Comparison of the positions of anomalies derived from the aeromagnetic survey Nares Strait 2001 (section taken from Fig. 5, without flight lines) with those of the 1982-1983 survey (taken from Fig. 1, but in grey scale: lighter grey refers to higher values of the magnetic anomaly field). The area shown here is the coastal strip between Cape Back and the mouth of the Daly River.

Modelling of the Cape Back magnetic anomaly was done after removing the regional trend of the magnetic field by subtracting wave-lengths longer than 20 km. Since the anomaly (chain) is coincident with the steep gradient between the Greenland magnetic high and the Ellesmere magnetic low this gradient needs to be removed. With the given survey parameters it is not possible to calculate a gradient of sufficient accuracy needed for determining the detailed geometry of the source body. Keeping the geometry of the model body simple, the model results agreed with geological observations on the width, thickness and possible inclinations of the faults at the boundaries of the basin (MIALL 1982, SAALMANN et al. in press). As an example, Figure 8 shows a synthetic profile P1 of the magnetic anomaly extracted from the grid (see Fig. 5 for location) perpendicular to the strike of the basin and the corresponding modelled 2D body approximating the basin. The slight "skew" in the magnetic profile could only be fit (with a simple mode) by a NE–dipping wedge, consistent with the dip direction of the mapped thrust faults.

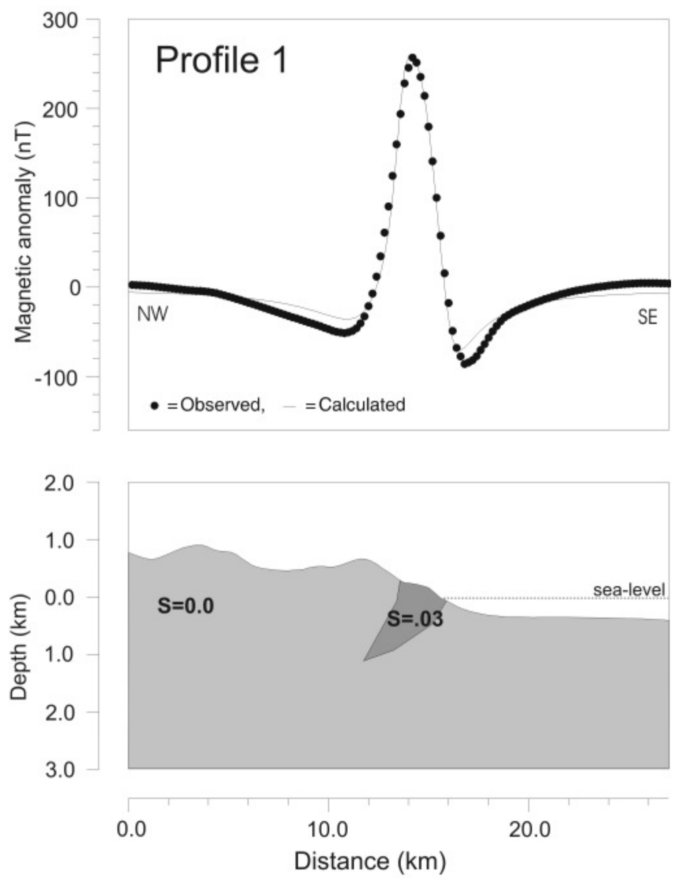

Fig. 8: Modelling a typical profile (P1) across the Tertiary basin along Kennedy Channel northeast of Carl Ritter Bay (position of profile, see Fig. 5). Susceptibility S is given in SI-units.

The magnetic anomalies previously attributed to dykes (HOOD et al. 1985) can now be easily explained by an elongated NE–dipping wedge of highly magnetic sediments within the Cape Back Basin. Additionally, the full outline of the basin (TESSENSOHN et al. in press) can now be inferred from the extent of this anomaly (-chain): from Carl Ritter Bay it covers a strip over the coast (Cape Back) along Kennedy Channel and extends further northeast-ward under water, terminating just before reaching the coast again at the mouth of the Daly River close to Cape Defosse.

Over northern Judge Daly Promontory, the Pavy River Tertiary basin (TESSENSOHN et al. in press) also has a corresponding magnetic anomaly (Fig. 9). Strike-slip faults bounding the basin to the southeast (Kennedy Channel side) and to northwest (Archer Fiord side) are located along the position of the steep gradient of the magnetic anomaly. Along the Archer Fiord fault (TESSENSOHN et al. in press) to the southwest the lower amplitudes of the magnetic anomalies suggest less

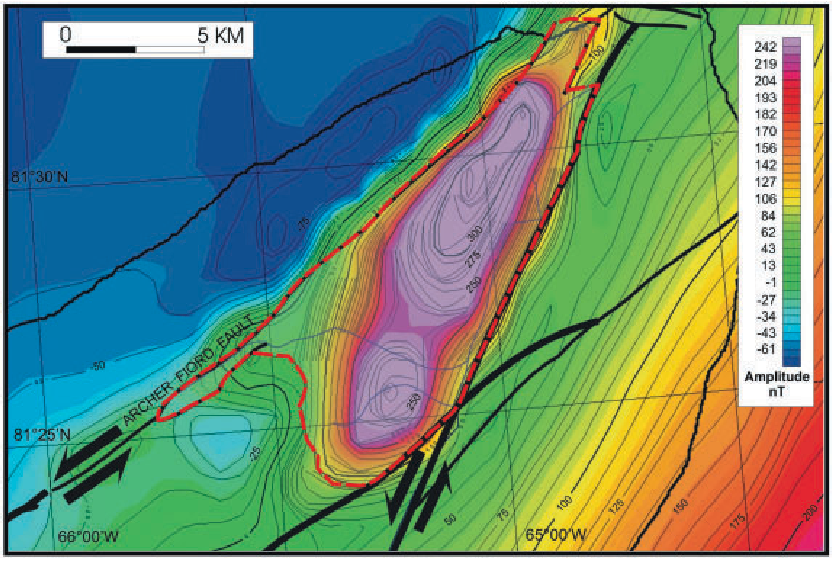

Fig. 9: Magnetic anomalies and position of Tertiary basin of northern Judge Daly Promontory. Outline of Pavy River Tertiary basin (in red) taken from TESSENSOHN et al. (in press). Fault structures simplified after VON GOSEN et al. (in press).

magnetic material or a tapering off of the Tertiary (SAALMANN et al. in press).

Another smaller, but very distinct anomaly occurs in the otherwise magnetically "flat" area of the western survey area and in continuation of the Pavy River Tertiary basin (Fig. 10). It's extent is just within the resolution limit of our survey, i.e. 2 km line spacing. The anomaly is marked by a large peak on one tie-line while on the neighbouring profile-lines the amplitude has decreased considerably. This points to a close-to-surface source. The source of the magnetic anomaly coincides with a small Tertiary basin in a "Triangle" of faults (VON GOSEN et al. in press, Tessensohn et al. in press) of north-central Judge Daly Promontory.

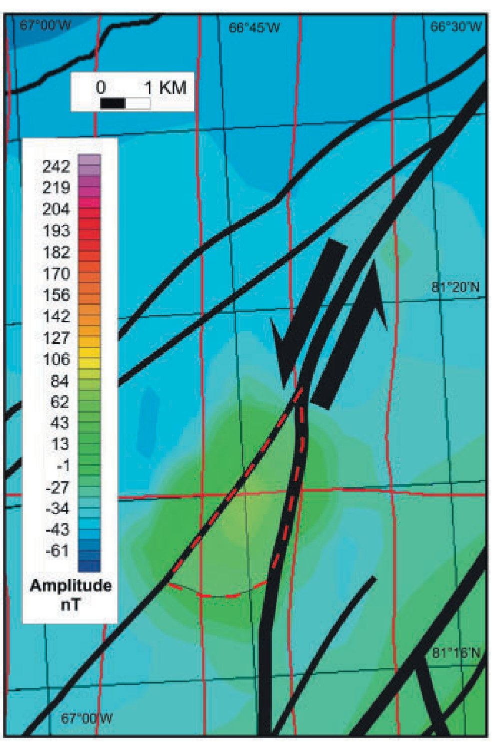

Fig. 10: Magnetic anomalies and position of the "Triangle" Tertiary basin. Survey lines shown in red. Outline of Tertiary basin (in dashed red) taken from TESSENSOHN et al. (in press). Fault structures simplified after VON GOSEN et al. (in press).

Tertiary basins in Hall Basin and Robeson Channel

The type of magnetic anomalies described here are not limited to the land areas of Judge Daly Promontery, but extend through the northern part of the Hall Basin close to the Ellesmere Island coast (Fig. 11) (subsequently called frontal anomaly), and continues through the centre of the Robeson Channel to at least the Newman Bugt (on the Greenland side) – Wrangel Bay (Ellesmere side), at the northern limit of our survey area (82 °N, see Fig. 5). It is reasonable to assume that the magnetic anomalies over the marine area are also caused

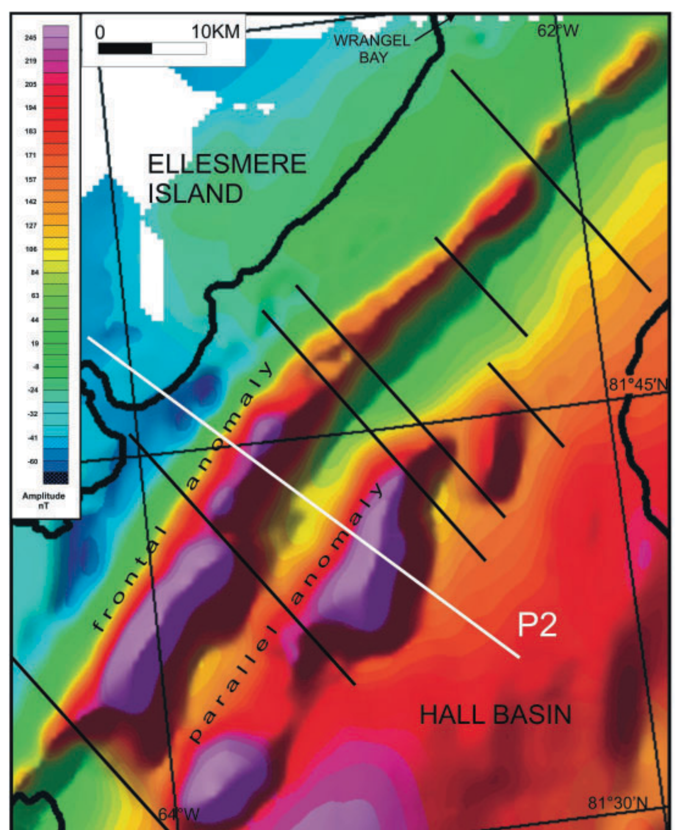

Fig. 11: Magnetic anomalies in Hall Basin and Robeson Channel. NW-SE orientated black lines indicate inferred faults. Colour scale and shadowing as in Figure 13.

by the volcanic sediments of an equivalent Tertiary basin.

A second group of linear anomalies (parallel anomaly) restricted to the Hall Basin runs parallel to the main line of anomalies and is interpreted to be another Tertiary basin separated from the frontal anomaly. Modelling over the frontal anomaly and parallel anomaly shows that it is not possible to model the double peak with a single body but that two separate sources are required (Fig. 12) (see Figs. 5 and 11 for location of cross-section profile P2). The geometry of the model bodies cannot be determined in detail as already argued above for the Cape Back anomaly. The anomalies are broader, partially the result of a deeper source (the water depths in this area reach 500-800 m, thus the distance to the survey level increases to 1100-1400 m) and a more tabular shape for the source body. Amplitudes of these anomalies are also smaller compared to those of the Tertiary basin along the Kennedy Channel coast indicating a smaller volume of magnetic material (assuming the same magnetization).

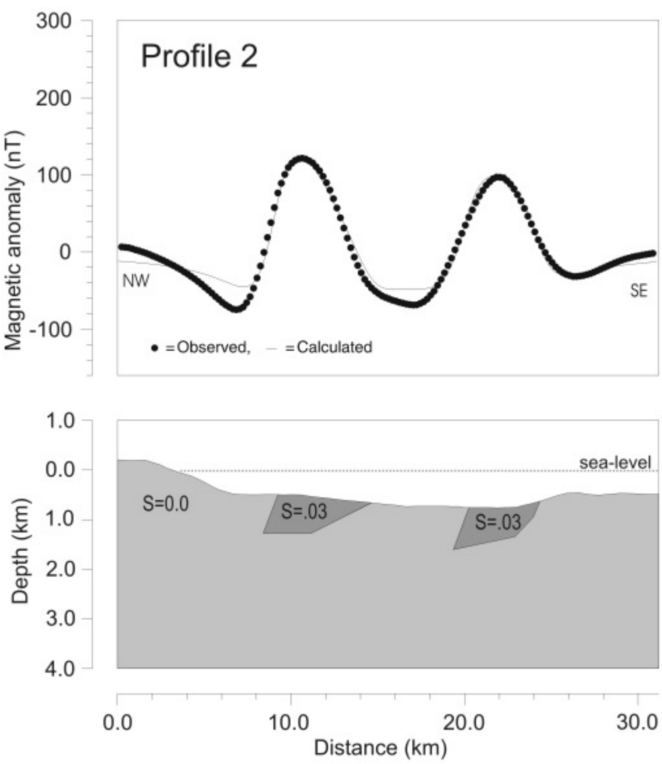

Fig. 12: Profile P2 across the main linear anomaly (frontal anomaly) in the Hall Basin – Robeson Channel and the anomaly running approximately parallel (parallel anomaly) in Hall Basin (see Fig. 5). Susceptibility S is given in SI-units.

A closer look at the anomalies – or anomaly chains – in the Hall Basin and Robeson Channel reveals an apparent segmentation of anomalies with small offsets. Individual segments of the anomaly chain trend in slightly different directions deviating from the general NE–SW trend. We, therefore, conclude that the main marine Tertiary basin consists of a number of individual basins separated by transverse faults. These NW–SE orientated faults are not restricted to the main basin chain, but are of more regional importance and appear to offset the parallel second Tertiary basin chain. In some cases these transverse faults appear to lead to coastal fjords or inlets of Ellesmere Island (Fig. 13). Within the block of large positive anomalies of Hall Basin and Kennedy Channel magnetic lineaments appear to follow the same trend (dotted lines in Fig. 13). Coincidentally the orientation of these NW-SE offsets is parallel to the orientation of dykes observed in northwestern Greenland and Lincoln Sea (Forsyth et al. 1998, GGU 1992). It must also be noted that this orientation is also consistent with the direction of Eocene plate convergence defined Oakey & Chalmers (2001) kinematic model and may represent differential compression along the plate margin.

IMPLICATIONS FOR LINCOLN SEA

In Figure 13, the results from this survey have been merged with data from the PMAP surveys 1989-91 (Nelson et al. 1991). The magnetic anomalies – and thus the inferred Tertiary basins – can be recognized as continuing to the NE into the Lincoln Sea. A small break in the anomaly chain occurs at approximately 82 °N along a line between Cape Frederick / Lincoln Bay on Ellesmere Island and Kap Sumner / Newman Bugt on the Greenland side. North of this location the high amplitude anomalies (L1) are trending in a more northern direction terminating just west of 58 °W. The original direction of the Robeson Channel anomaly chain is preserved along a line about 10 km offshore and parallel to the Greenland coast and is expressed by a gradient in the magnetic field (L2). This feature can be followed to about 56 °W.

The magnetic high between L1 and L2 has been interpreted as a volcanic province (VP) (Forsyth et al. 1998) and exhibits a magnetic pattern similar to other offshore extensions of volcanic provinces (e.g., Kap Washington volcanic province) along northern Greenland (Damaske & Estrada in press). This also offers an explanation for the origin of the volcanic material in the sediments of the Tertiary basins discussed in this paper. The higher amplitude L1-lineation is interpreted to be the northern extension of the primary chain of Tertiary basins of Hall Basin and Robeson Channel.

SUMMARY

Elongated magnetic anomalies over Judge Daly Promontory correlate with fault bounded Tertiary basins. The magnetic anomaly associated with the Pavy River Basin over the northern end of Judge Daly Promontory can be traced offshore, indicating a continuity of the Tertiary basins northward through the Robeson Channel towards the Lincoln Sea. The northern extension of the magnetic anomaly does not follow a simple continuous line, but appears to be broken in subsections of slightly differing directions, which may indicate a series of pull-apart basins related to sinistral (Paleocene?) strike-slip movement. Conversely, the offsets of these basins are oriented in the same direction as the Eocene plate convergence (Oakey & Chalmers 2001) and may represent accommodation of differential compression along the margin. The frontal magnetic lineament links with the volcanic province within the Lincoln Sea which may represent the source of the magnetic volcanic clasts within the Tertiary basins. It is unclear whether the northern or southern edge of the volcanic province represents the continuation of the plate boundary. The magnetic anomalies and onshore geological observations suggest that the Wegener Fault is not a simple strike-slip fault, but a complex system of synthetic and antithetic faults

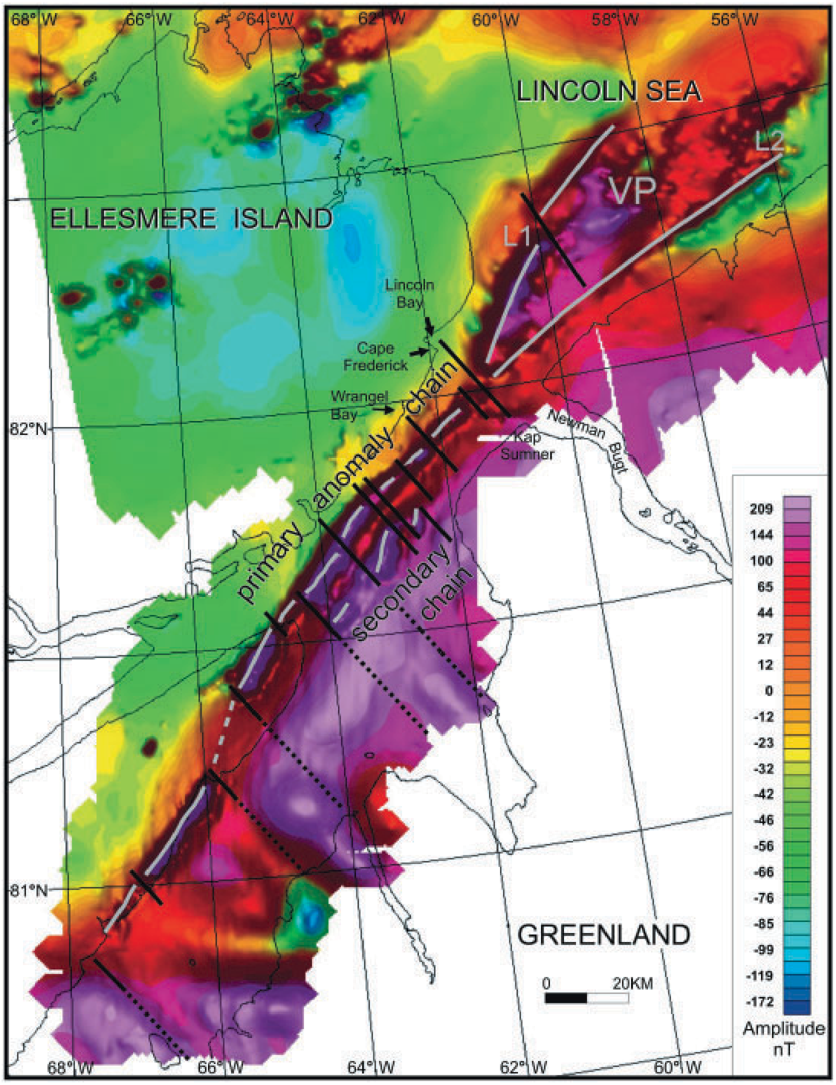

Fig. 13: Magnetic anomalies over northern Nares Strait and southern Lincoln Sea after simple merging (i.e. no level shift or grid knitting applied) of data from the new Nares Strait survey described here and Lincoln Sea data acquired during the PMAP campaigns 1989-91 (Nelson et al. 1991). L1 denotes the extension of the anomaly chain associated with the Tertiary basins of Hall Basin and Robeson Channel. L2 denotes a gradient parallel to the Greenland coast. VP denotes an interpreted volcanic province. NW-SE oriented lines indicate faults (inferred in the marine area) in the Tertiary basin chain. Note that magnetic lineaments (dotted lines) in the block of large positive anomalies of Hall Basin and Kennedy Channel follow the same trend.

forming a chain of blocks and basins with significant overprinting and/or reactivated by Eocene compression during the Eurekan Orogeny (Tessensohn & Piepjohn 2000).

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