DIRECT GEOPHYSICAL EVIDENCE FOR DISPLACEMENT ALONG NARES STRAIT (CANADA-GREENLAND) FROM LOW-LEVEL AEROMAGNETIC DATA: A PROGRESS REPORT

Project 650007

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Abstract

A low level aeromagnetic reconnaissance of Nares Strait shows a sinistral offset of approximately 25 km in a band of 500-gamma anomalies extending from Bache Peninsula on Ellesmere Island to the southern side of the Humboldt Glacier on Greenland.

A line of isolated 200 gamma anomalies extends north from Judge Daly Promontory along Robeson Channel to the Arctic Ocean. These anomalies, which appear to be due to a swarm of closely spaced dykes, line up with the prominent fault zone on Judge Daly Promontory, which has been mapped with a 19 km sinistral displacement. Volcanic fragments with an olivine-basaltic composition have been found in Tertiary rocks along the fault zone and the aeromagnetic evidence also suggests that the dyke system extends across Judge Daly Promontory.

Thus it is concluded that at least 19 km of sinistral strike-slip displacement has occurred along the Strait itself, supporting Wegener's 1912 hypothesis.

Résumé

Un levé aéromagnétique de reconnaissance à faible altitude effectué au-dessus du détroit de Nares montre un décalage sénestre d'environ 25 km dans une bande d'anomalies de 500 gammas comprise entre la péninsule de Bache sur l'île Ellesmere et le versant sud du glacier Humboldt au Groenland.

Une ligne d'anomalies isolées de 200 gammas s'étend du promontoire Judge Daly au nord jusqu'à l'océan Arctique, en passant par le détroit de Robeson. Ces anomalies, qui semblent résulter de la présence d'un faisceau de dykes très rapprochés, s'alignent avec la zone faillée bien visible du promontoire Judge Daly, que l'on a représenté sur la carte avec un déplacement sénestre de 19 km. On a découvert dans des roches tertiaires des fragments volcaniques de type basalte à olivine, le long de la zone faillée; les indices aéromagnétiques suggèrent aussi que le réseau de failles se prolonge à travers le promontoire Judge Daly.

Ainsi, on conclut qu'il s'est produit un décrochement sénestre d'au moins 19 km le long du détroit lui-même, ce qui semble confirmer l'hypothèse de Wegener formulée en 1912.

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Introduction

The question of whether there has been significant relative movement along the Nares Strait between Ellesmere Island and northern Greenland has been a contentious issue since Alfred Wegener first published his famous book on continental drift more than seventy years ago. In 1982, the available geological and geophysical evidence for and against such movement was well summarized in a volume published by the Geological Survey of Greenland edited by Peter Dawes of the Greenland Survey and William Kerr formerly of GSC (Dawes and Kerr, 1982). This was the proceedings of a symposium held in Halifax by the Geological Association of Canada in 1980. In the volume, one of the pieces of published geophysical evidence cited for minimal relative displacement was a vertical component magnetic anomaly which extended right across the Kane Basin (Riddihough et al., 1973). The anomaly in question was obtained by a high level (11 500 feet) airborne magnetic survey flown by the Earth Physics Branch. The flight line spacing for the survey was 75 km, which resulted in two lines being flown in a northeasterly direction across Kane Basin. The contoured magnetic data were the vertical component values averaged over a 60 second time period which represented a distance of 7.3 kilometres on the ground. Thus the ability of the data to resolve the underlying geology was not very high and indeed the main objective of the survey was to map the various components of the main earth's field.

Accordingly a low-level aeromagnetic reconnaissance of the Kane Basin was planned to be undertaken as part of the co-operative project between the National Aeronautical Establishment and the Geological Survey of Canada. A series of parallel flight lines were laid out at a 10 nautical mile line spacing to cross the inferred elongated anomaly at right angles. The first aeromagnetic field operation was carried out in April 1981 using the NAE Convair 580 aircraft (Hardwick, 1978) which was equipped with a high-sensitivity

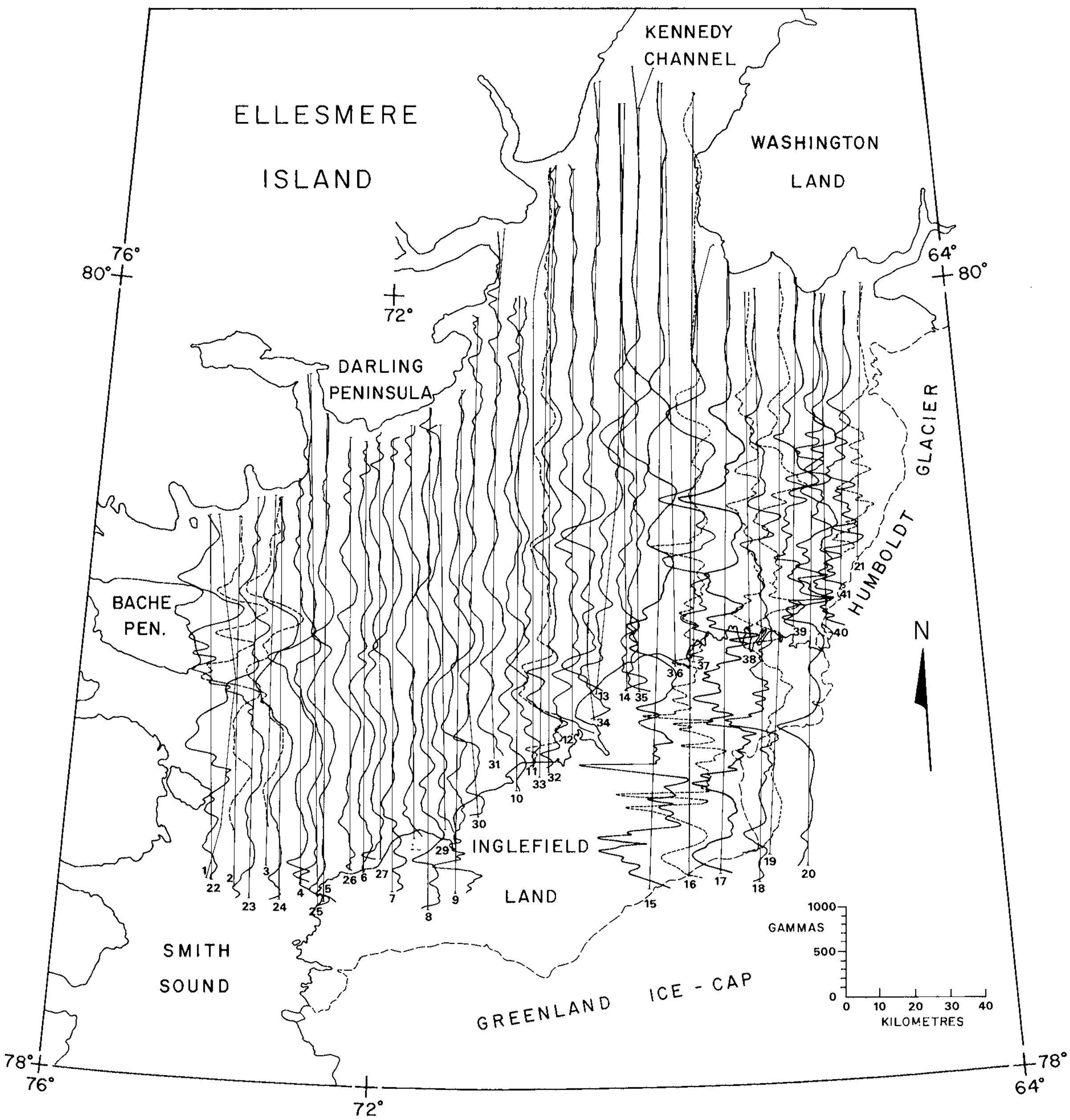

Figure 63.1. *Filtered aeromagnetic profiles in the Kane Basin, NWT.*

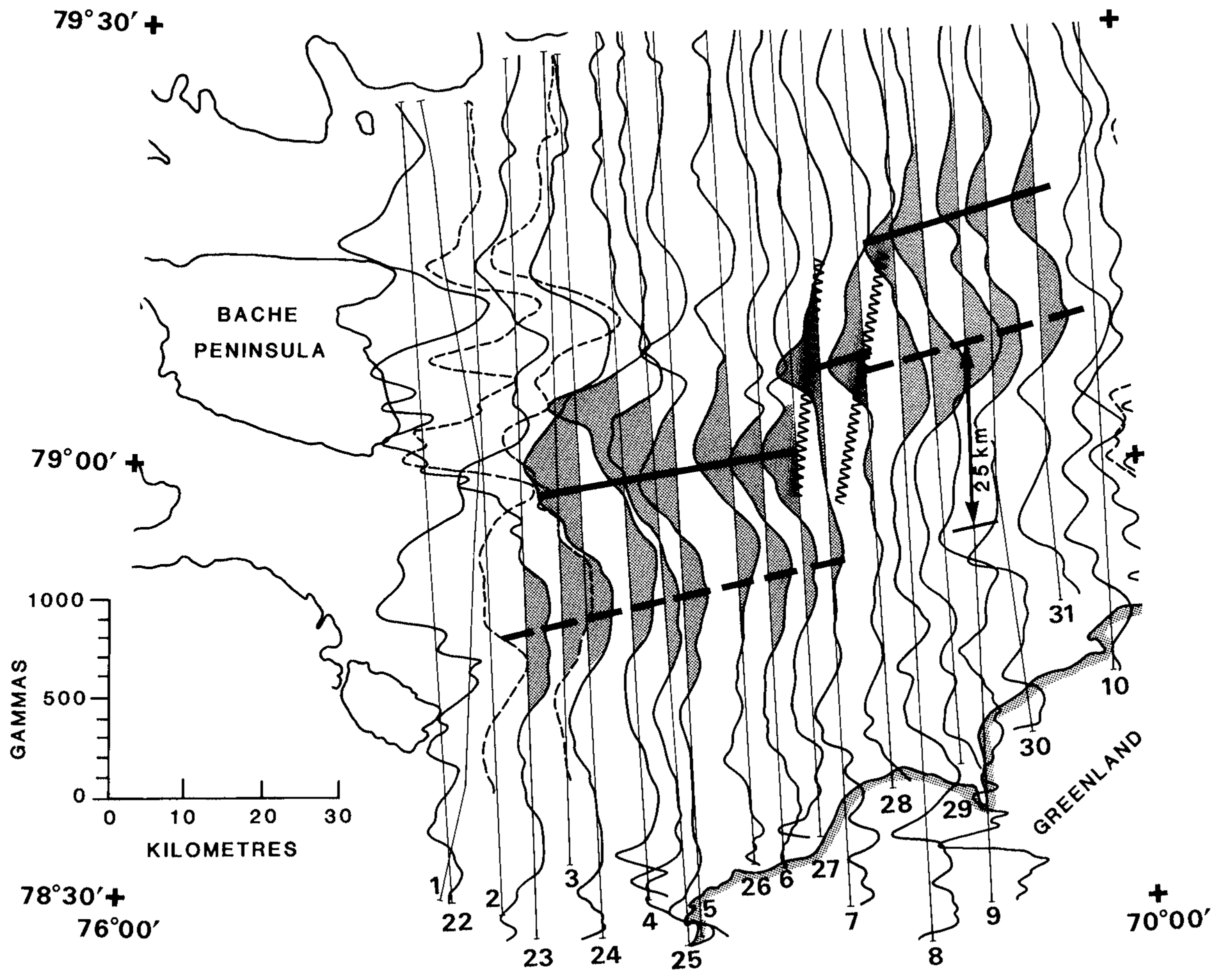

Figure 63.2. Enlarged portion of Figure 63.1 showing 25 km offset in the magnetic anomalies which strike in an east-west direction from Bache Peninsula on Ellesmere Island.

cesium-vapour magnetometer system. The US Air Force Base at Thule, Greenland was used as a base of operations. The lines were flown at a height of 305 m using the VLF Global Navigation System as the prime navigation aid. The results of the 1981 aeromagnetic reconnaissance indicated that the elongated anomaly did not extend right across Kane Basin but it was decided that the flight line spacing was too great to be sure of the continuity of the anomalies between the flight lines. Accordingly additional work was carried out in Kane Basin in April 1982 to fill in between the flight lines so that the spacing was reduced to 5 nautical miles. In 1982, it was decided to extend the reconnaissance to the north to obtain orthogonal aeromagnetic profiles across the Kennedy and Robeson channels and additional work was also carried out in 1983.

Results

Figure 63.1 shows the 40 stacked magnetic profiles in the Kane Basin which resulted from the 1981 and 1982 field operations filtered to eliminate the long wavelength component including the core field. This procedure enables both the profile and its associated flight line to be more easily recognized. The typical magnetic response of the Precambrian rocks in the southeast part of the Kane Basin is readily apparent. The smooth nature of the profiles in the northeast part of the Kane Basin is indicative of a sedimentary basin which appears to extend under the Paleozoic rocks of Washington Land. There is a disruption in the trends of the line of highs and lows some 500 gammas or so in amplitude which extend from Bache Peninsula in an easterly direction across Kane Basin. These offsets which occur about 60 km east of Bache Peninsula are shown in greater detail in Figure 63.2. The total offset is about 25 km in a sinistral sense and is best seen by tracing the dominant low across the lines. Presumably the rocks in the Bache Peninsula which produce the anomalies are the diabase sills of Late Proterozoic age mapped by Christie (1967). Thus the age of the diabase sills, which have been dated by potassium-argon techniques (see Peel et al., 1982) at about 1200 Ma, predate the onset of continental drift in the Mesozoic.

Figure 63.3 shows the 34 profiles flown north of Kane Basin between the high cliffs which bound either side of the Kennedy and Robeson channels. In Kennedy Channel, the profiles are mostly flat but striking north of Judge Daly Promontory are a series of distinctive isolated anomalies 200 gammas or so in amplitude. From the continuity of the anomalies, they appear to be due to parallel dyke-like intrusions which extend a distance of 107 km from Judge Daly Promontory to the Arctic Ocean.

Interpretations of the anomalies on lines 61 and 64 were carried out using an interactive least-squares modelling program (Teskey, 1982). Figure 63.4 shows an interpretation of the results on line 61 which is about 13 km north of Judge Daly Promontory. The depth of water at the prominent

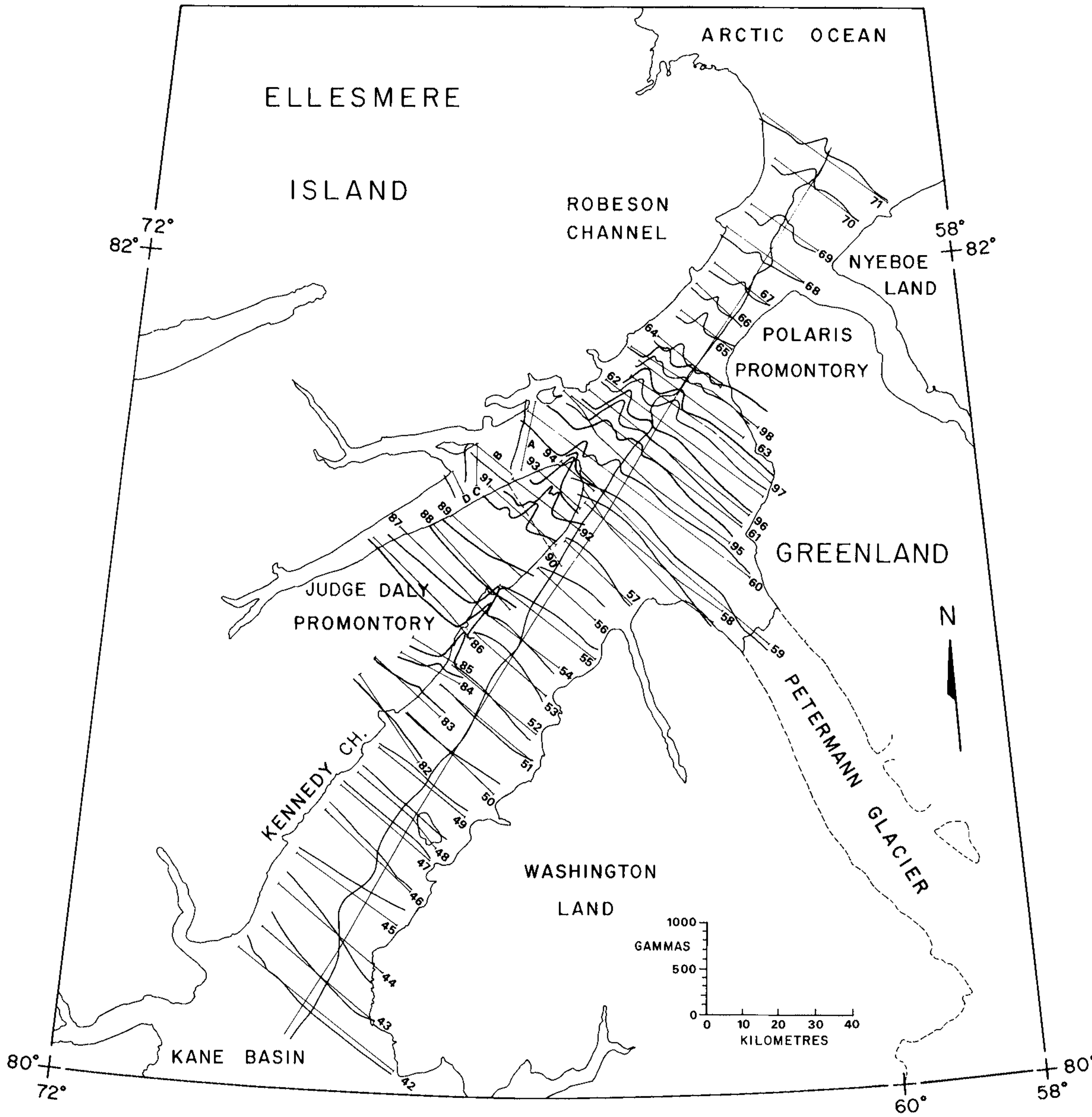

Figure 63.3. *Aeromagnetic profiles obtained in Kennedy and Robeson Channels, NWT.*

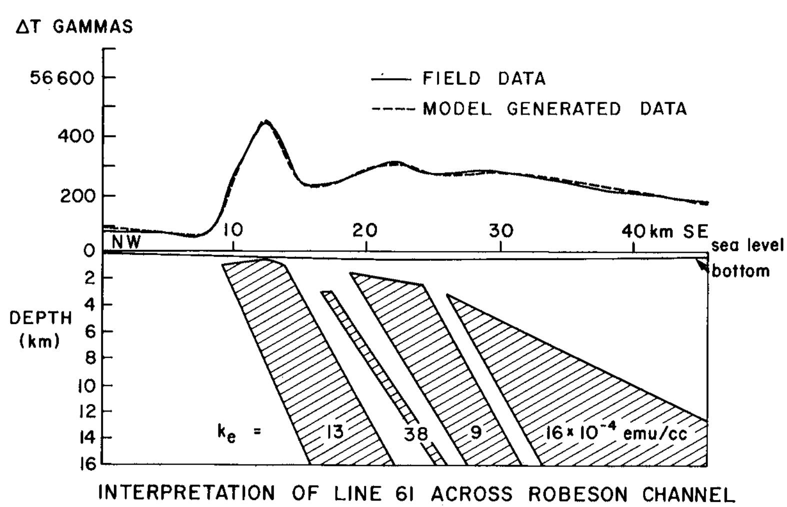

Figure 63.4

Interpretation of the total field data along line 61 across Robeson Channel, 13 km north of Judge Daly Promontory.

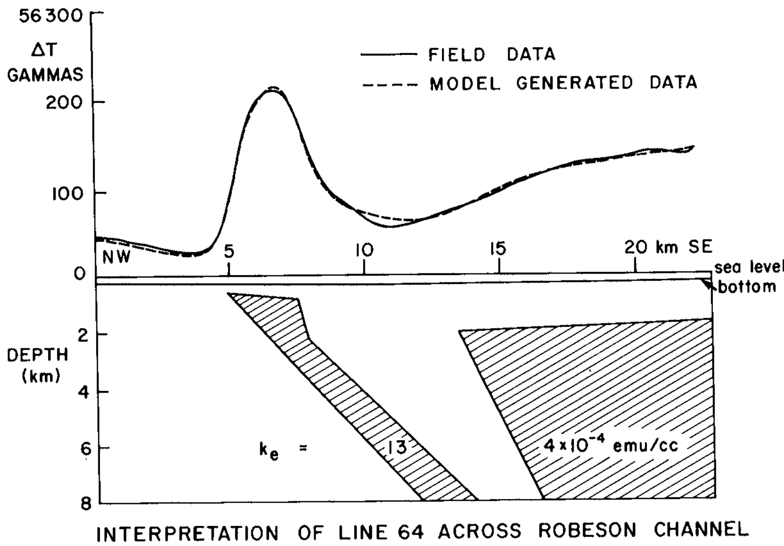

Figure 63.5

Interpretation of the total field data along line 64 across Robeson Channel, 40 km north of Judge Daly Promontory.

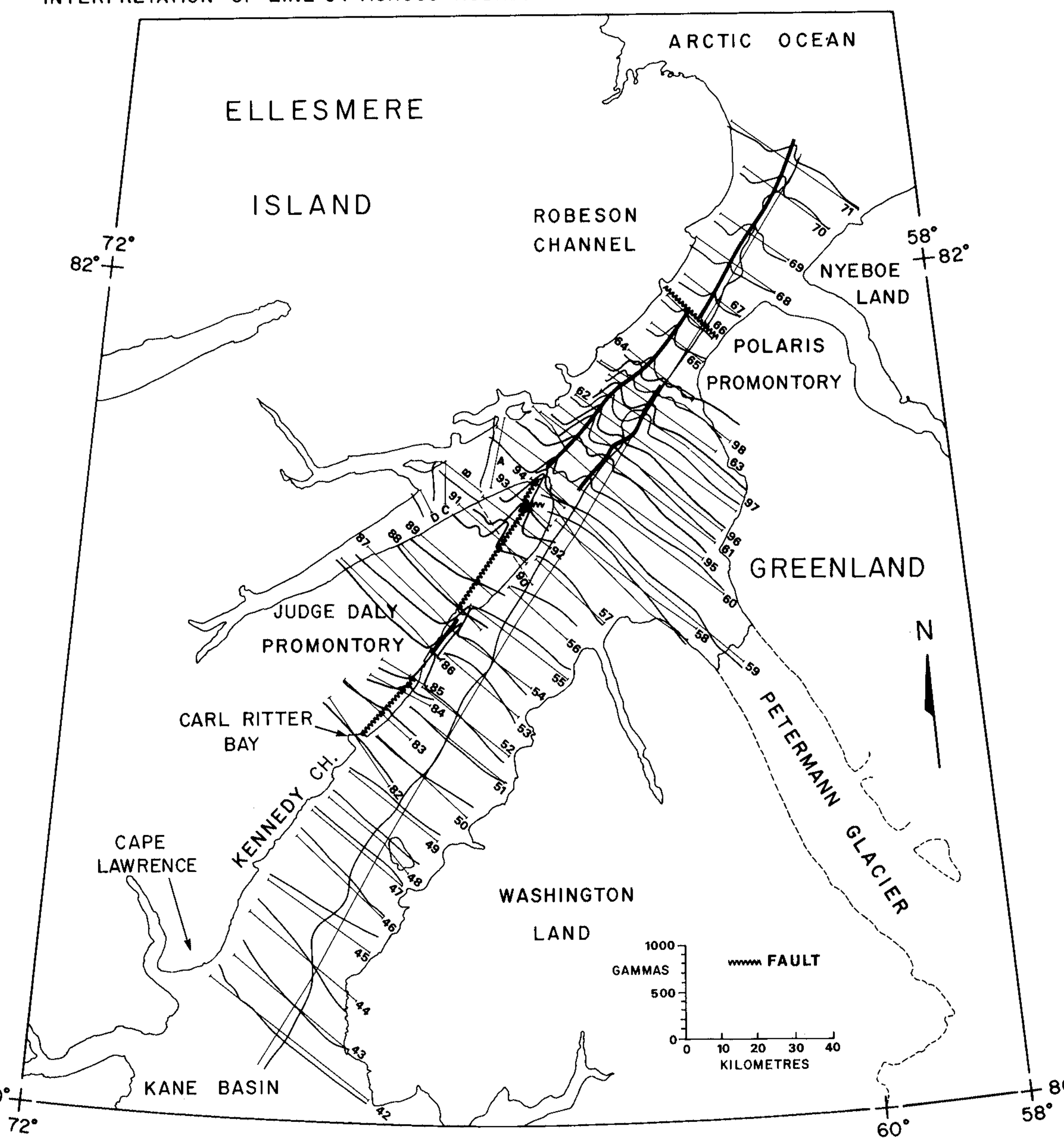

Figure 63.6. *Inferred correlation of the anomalies between the flight lines in Robeson Channel and with the mapped fault in Judge Daly Promontory.*

400-gamma anomaly approximately 12 km from the northwest end of line 61 is approximately 700 m. The computer program has calculated that the causative dyke which dips at 65° to the southeast is at no great distance below the bottom of the strait so the distance from the survey aircraft to the top of the dyke is approximately 1000 m. The dyke has a thickness of 4.5 km but in reality it may be a swarm of thin dykes which cannot be resolved at that height and that may also be the case for the causative bodies to the southeast.

Figure 63.5 shows an interpretation of the aeromagnetic data on line 64 which is approximately 40 km north of Judge Daly Promontory. The causative body also dips at a high angle to the southeast indicating that the fault plane also dips to the southeast; and again its top is at no great distance below the bottom of the strait. The effective susceptibility (which would include any remanent magnetism contribution) has been calculated by the program to be 13×10^{-4} emu/cc which is equivalent to about 0.5% magnetite content and is exactly the same as the value for the same anomaly on line 61. Its thickness is however somewhat smaller being only about 1000 m.

Figure 63.6 shows the inferred correlation of the anomalies in Robeson Channel. It transpires that the dyke anomalies line up with a prominent fault on Judge Daly Promontory that has been mapped by Christie (1964), and others appropriately called the Judge Daly fault. The fault appears to extend to the south as far as Carl Ritter Bay according to Miall (1982) and is associated with a Tertiary inlier. Volcanic rock fragments with an olivine-rich basaltic composition have been found along the fault system and Miall concluded that it was derived from a volcanic source under the waters of Nares Strait. Sinistral displacement along the fault has been estimated by Mayr and DeVries (1982) to be 19 km.

We concluded from this evidence in a paper presented at the GSC Current Activities Forum in Ottawa in January 1984 that the dyke system north of the Promontory had been injected into an existing fault system, and that the dyke probably extended across the Judge Daly Promontory.

Accordingly to prove this inference we flew 13 additional low-level aeromagnetic profiles (lines 82 to 94 in Fig. 63.3) across the rugged topography of the Promontory in April 1984. Four additional lines were also flown to fill in between the lines in the Robeson Channel immediately to the north (lines 95 to 98). The results from these lines are also included in Figure 63.3. The dyke had a recognizable expression on ten of the profiles flown in 1984. The dyke anomaly was not present on two of the lines in the central part of Judge Daly Promontory so it may be confined to the Tertiary outliers mapped by Miall (1982). Nor does the dyke appear to extend into Carl Ritter Bay; it may however be present farther south. Further work across the Ellesmere Island shoreline of southern Kennedy Channel is required to check this possibility especially in the vicinity of Cape Lawrence.

Conclusion

The low-level aeromagnetic reconnaissance has been able to define a fault system that runs parallel to the Nares Strait for approximately 200 km, and which from geological evidence on Judge Daly Promontory has had at least 19 km of movement along it. This evidence coupled with corroborating evidence in Kane Basin appears to be the first direct geophysical evidence that there has been some relative motion along the Nares Strait in a left-handed sense. We hope that we have also demonstrated that it is necessary to fly low-level reconnaissance surveys to obtain diagnostic magnetic data that can detect the rather subtle features that are important in elucidating the Nares Strait problem.

We believe there has been substantial differential movement between Ellesmere Island and Greenland with only part of the movement being confined to Nares Strait itself. This view has been strengthened during the survey flights by visual impressions of the topography on either side of the Nares Strait. The topography of the land on either side of the Strait is markedly different in spite of the apparent continuity of the geology across the strait. On the Canadian side the topography is quite rugged due no doubt to the influence of the middle Tertiary Eurekan orogeny whereas on the Greenland side the topography is relatively flat except for incised valleys indicative of a rather mature topography. The photograph on the title page of the volume edited by Dawes and Kerr (1982) which is a view across the Nares Strait near Franklin Island illustrates this fact very well indeed.

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