Satellite magnetic field over the Nares Strait region

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Langel, R. A. & Thorning, L. 1982. Satellite magnetic field over the Nares Strait region. – In: Dawes, P. R. & Kerr, J. W. (eds), Nares Strait and the drift of Greenland: a conflict in plate tectonics. – Meddr Grønland, Geosci. 8: 291–293.

The general characteristics of the total field magnetic anomalies from satellite data over the region adjacent to Nares Strait are briefly described. The interpretation of satellite data is still at an early stage, but it is favoured that the regional anomalies in this region reflect variations in composition and/or structure in the lower crust related to the Innuitian Ellesmere–Greenland mobile belt. An elongated negative anomaly occurs over Ellesmere Island parallel to the Innuitian mobile belt and to Nares Strait. This negative anomaly separates major magnetic highs over northern Greenland and the Alpha Ridge of the Canada Basin. The magnetic contrast is interpreted to represent either a change in the thickness of the Precambrian crust or a petrologic change brought about during the formation of the Innuitian mobile belt.

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During the last few years increasing attention has been directed towards the processing and interpretation of satellite magnetic anomaly fields, and a number of promising results have been presented (see Langel & Thorning in press, for full references). The information used has been OGO data (Orbiting Geophysical Observatories), i.e. scalar total magnetic field measured at altitudes from 400 to 600 km by the OGO 2, 4 and 6 satellites (Cain & Langel 1971, Langel 1974, 1980). This note draws attention to some interesting aspects of the satellite magnetic field over the Nares Strait region (Fig. 1). The nearby areas of Canada and Greenland are treated in more detail by Langel et al. (1980) and Langel & Thorning (in press), respectively.

Fig. 1. Index map of the Nares Strait region. The approximate southern limit of the Innuitian mobile belt is indicated (from Trettin et al. 1972). NP = North Pole.

The magnetic data

The magnetic field measured by the OGO satellites is comprised of several components: the Earth's core field, magnetic field components originating in the crust, external fields from the magnetosphere and ionosphere, and instrument noise. It is possible to isolate those components of the magnetic total field that are thought to have sources in the Earth's crust (Mayhew 1979). The main field has been subtracted using a model of degree and order thirteen derived from the satellite data itself (Langel et al. 1980). All individual passes have been evaluated, and passes showing variations exceeding approximately 20 nT probably caused by magnetospheric and ionospheric sources have been entirely omitted from further analysis. Remaining passes normally still exhibit fields of a few thousand kilometres wavelength of uncertain origin. These were removed by the fitting and subtraction of a linear function to each of the passes. As a consequence the absolute zero level of the data is floating. The resultant magnetic field represents anomalies of crustal origin.

Fig. 2 shows a contoured map of the reduced data over the Nares Strait region redrawn from a larger map of the entire polar region that is presented in Langel & Thorning (in press).

Interpretation of anomalies

Detailed discussions of the interpretation of satellite magnetic data are given in several of the papers already quoted, and will not be included here. It is sufficient to say that it is a field of geophysics only recently opened up, and much more work is necessary before any final answers can be expected. The forthcoming data from MAGSAT satellites, which are much more detailed than the OGO data hitherto used, will make the work even more rewarding.

Although the map (Fig. 2) is an average anomaly map and thus represents data from varying altitude, the general trends in the magnetic data are quite clear: two magnetic highs divided by an elongated low. The two highs are the North Greenland magnetic anomaly and the Alpha Ridge magnetic anomaly, and both of these are major ones seen on a global scale. The trend of the negative anomaly correlates well with the position of the Innuitian Ellesmere – North Greenland mobile belt.

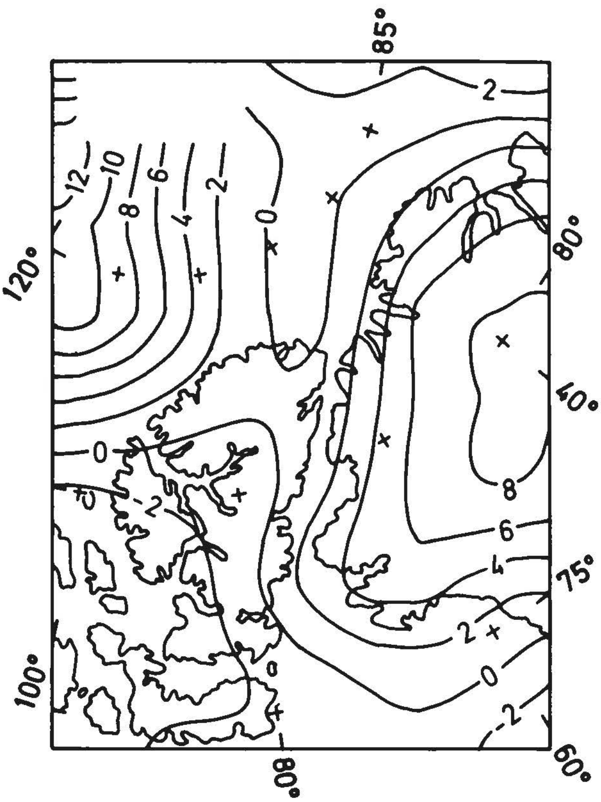

Fig. 2. Satellite magnetic field over the Nares Strait region as derived from OGO satellite measurements. The contours represent average magnetic anomalies in nT, and the data have not been processed into an equivalent source representation. Redrawn from Langel & Thorning (in press).

The sources of such long wavelength anomalies lie in the crust. The mantle just below the Moho is dominantly of non-magnetic mineralogy, no matter what the geothermal gradient (Wasilewski et al. 1979). Where the depth to the Curie isotherm is less than the depth to the Moho, the Curie isotherm defines the lower boundary of the magnetic crust. Thus, the magnetic anomaly fields are a result of variations in crustal thickness, average crustal magnetisation and depth to the Curie isotherm. To date only a few of the regional-scale anomalies delineated in anomaly maps from satellite data have been modelled. Of the models derived, two (Regan & Marsh 1982, Mayhew et al. 1982) indicate distinct regions of intrusions of highly magnetic material into the crust from the mantle. This, however, is not true for all anomalies and Mayhew (in press) has indicated that the anomalies in the western U.S. are anticorrelated with heat flow and probably largely reflect variations in the depth to the Curie isotherm. It would thus seem that many, if not most, anomalies of this scale reflect the structure and petrology of the *lower* crust or variations in the isotherm.

Relation to Nares Strait

Nares Strait, joining Baffin Bay to the Arctic Ocean, is considered by most workers to be the site of a dislocation zone of some importance. Taylor (1910) first suggested the idea of substantial strike-slip motion along the Strait. A late Phanerozoic age for the movement has been favoured by advocates of large displacement between Greenland and Ellesmere Island (e.g. Srivastava 1978 and several papers in this volume). However, it has also been argued (e.g. Burek 1973, Dawes 1973, Fahrig et al. 1973) — notably from different lines of evidence — that Nares Strait is the site of a much older, fundamental fracture of the crust, possibly dating back to the Precambrian.

The magnetic low generally follows the Innuitian mobile belt across the Queen Elizabeth Islands with the eastern boundary of the trough parallel to Nares Strait. As far as the crust adjacent to the magnetic low is concerned, the magnetic high over northern Greenland corresponds to continental crust of up to 42 km thickness (Pawlowicz 1969). To the west of the magnetic low is the high over the Alpha Ridge where the nature of the crust is more uncertain (Langel et al. 1980). Although few in number, the existing heat flow data for Ellesmere Island are not high (A. Judge, pers. comm.) as might be expected from an elevated Curie isotherm and corresponding thin crust. This suggests that the low depicts a structural or petrologic variation in the crust rather than an undulation of the isotherm. The apparent structural boundary along Nares Strait would tend to confirm this interpretation.

The contrast in the magnetic anomaly map between the northern Greenland high and the Ellesmere Island low is a large one. This would seem to indicate a fairly fundamental difference in crustal structure or petrology between the two locations. As already pointed out, the trend lines in the magnetic anomaly pattern closely follow the trend of the Innuitian mobile belt with the Greenland magnetic high over the thick Precambrian Shield. The magnetic low could then be interpreted as a fundamental change in the Precambrian basement, i.e. thinning, or even disappearance, of the Precambrian rock beneath the Palaeozoic sediments of the fold belt, as depicted in fig. 4 of Dawes (1973). Alternatively, it could reflect a petrologic change brought about during the Palaeozoic deposition and/or during the subsequent orogenesis of the Innuitian mobile belt. If the arguments of Burek (1973), Dawes (1973) and Fahrig et al. (1973) are correct and Nares Strait is the site of an extremely old, possibly Precambrian, fundamental fracture of the crust, then a change in the Precambrian basement seems the most likely alternative. In the absence of seismic refraction data, a definitive interpretation is difficult.

Along strictly speculative lines H. Frey and Langel have noted (in prep.) that in a reconstruction of Pangaea, many of the long wavelength anomalies detected in the satellite data are continuous, or nearly so, across the reconstructed boundaries. If this result can be upheld it implies that the anomaly sources were in existence prior to the break-up of Pangaea. This is true for the Greenland high and a high over the adjacent region of western Scandinavia in the Pangaea reconstruction. If the Alpha Ridge is continental type crust (Eardley 1961, King et al. 1966, Taylor 1978) it is conceivable that it was once located directly adjacent to the North Greenland magnetic high and thus formed part of the postulated "Pearya" landmass from which the sedimentary fill of the North Greenland geosyncline is thought to have originated (Dawes 1973).

Acknowledgements

R. A. L. thanks R. Horner and F. Gertler for their assistance in carrying out the necessary computation and M. A. Mayhew, H. Frey and P. T. Taylor for valuable discussion. L. T. publishes with the permission of the Director of the Geological Survey of Greenland.

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