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MAGNETIC SECULAR VARIATION IN POSTGLACIAL MARINE SEDIMENTS AT BRØNLUND FJORD, PEARY LAND, EASTERN NORTH GREENLAND

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As Peary Land has a high latitudinal position records of the geomagnetic secular variation may be expected to reveal high amplitudes and details in declination that may not be visible in palaeomagnetic records from lower latitudes.

Undisturbed marine Holocene sediments suitable for palaeomagnetic sampling are not common in North Greenland because of periglacial disturbances. However, a 10 m high cliff section between 16 and 26 m above sea level, suitable for sampling, occurs about 400 m south-west of Brønlundhus(30.5°W; 82.17°N). These sediments occur abundantly along Jørgen Brønlund Fjord (fig. 63) where they attain altitudes of 60 to 70 m above present day sea level (Kirkeby, 1964) and date back to about 8000 y B.P. (Weidick, 1976).

Geology

The sediments are finely laminated, marine deposits dipping gently 3 to 4° NNE with rhythmically alternating laminae of clay, silt, and fine sand. The combined thickness of a clay + sand set varies generally between 2 and 10 cm. The laminae of the lower part ($<6\frac{1}{2}$ m) are generally thinner than those in the top part of the section where sand laminae dominate. Although the sediments may not be truly varved, each set may well represent one year's sedimentation. If so, the estimated number of cycles (some 200 to 400) may indicate the relative time scale in years.

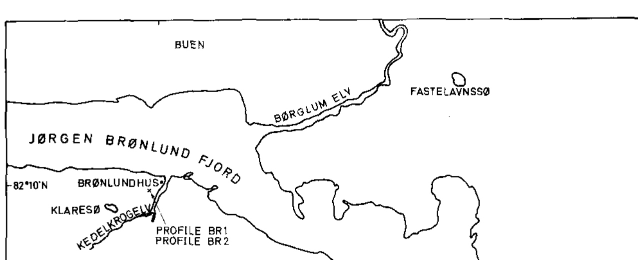

Fig. 63. Map of south-east Peary Land showing the positions of the profiles in the postglacial marine cliffs sampled for palaeomagnetic studies. The two profiles are situated west of Kedelkrogelv, 400 m SW of Brønlundhus (30.5°W; 82.17°N, Høy, 1970).

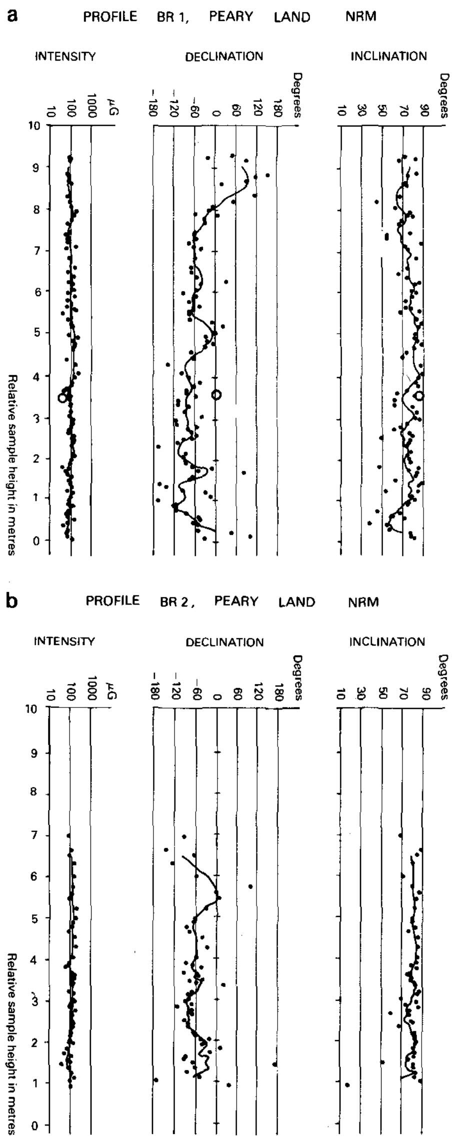

Fig. 64. Records of NRM intensity (µG), declination and inclination for individual samples. Vertical scale in metres. The continuous curves are 5 point running means. a. Profile BR 1. Deviating open circles at 3.52 m are from a minor slump structure and suggest the DRM to be of syn-depositional origin. b. Profile BR 2. The profile is sampled about 15 m NE of profile BR 1 and shows about the same variations in declination and inclination.

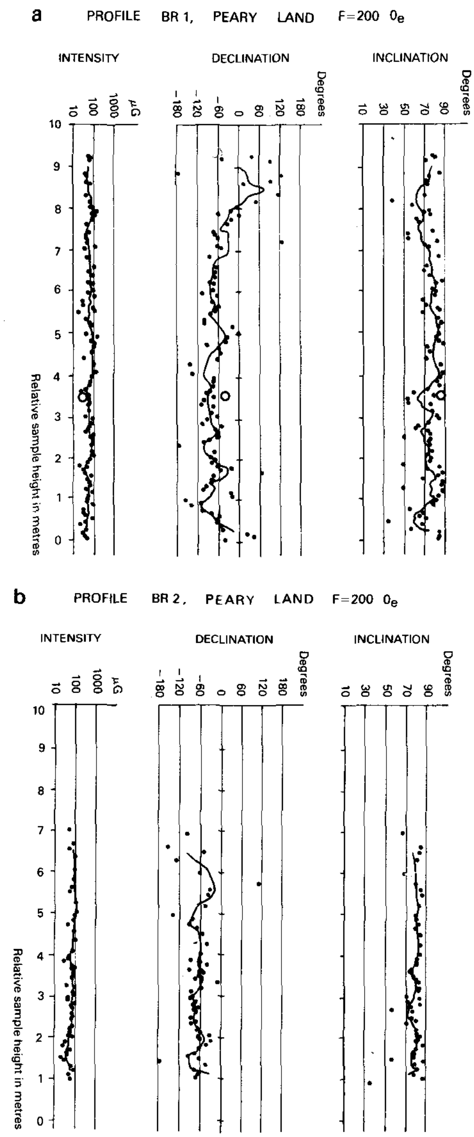

Fig. 65. Remanent magnetization after a.f. cleaning in 200 Oe. Pilot samples were directionally very stable during a.f. demagnetization, and only minor changes are found at 200 Oe when compared with the NRM records in fig. 64. For explanation of open circles, see fig. 64a.

Time scale and age of the magnetic profiles

Whereas no fossils were found exposed in the cliff face, marine bivalves are common on the abrasion surface on top of the cliff 26 to 27 m above sea level. Numerous shells of *Mya Truncata* and *Hiatella arctica* were collected from the surface, between 1 and 2 m above the top of the profile BR 1 (fig. 64a). The shells were dated by H. Tauber, by courtesy of the Geological Survey of Denmark, who obtained a conventional C-14 age of 7390 ± 110 B.P. (sample K-3285, GGU No. 256550, C^{13} = –0.4 0/00 PDB). Although this age is at the present limit of the bristle-cone calibration curve (Ralph *et al.*, 1973), a tree-ring correction of about 700 ± 100 years is applicable. This gives a tree-ring corrected age of about 8100 ± 200 years B.P. A small twig, also found in the top metre of the profile, was too small for dating. This conventional radiocarbon date (at altitude 26 to 27 m) compares well with three older dates between 7420 ± 120 B.P. and 7740 ± 130 B.P. obtained for samples from around Jørgen Brønlund Fjord at altitudes between 32 and 40 m (Weidick, 1977, 1978; Knuth, 1964), whereas samples from altitudes between 8 and 17 m above sea level give conventional ages of 6250 B.P. or younger (Weidick, 1973, 1977; Trautman & Willis, 1966; Rubin & Alexander, 1960).

When looking in detail at the smoothed curves of postglacial uplift rates of the Jørgen Brønlund Fjord area (Weidick, 1976; Funder, 1979) the reciprocal rate varies between *c.* 35 y/m around 8000 B.P. and 65 y/m around 7000 B.P., or, on average, about 50 y/m. If the sediments of the cliffs in question were deposited in shallow water the duration of the deposition time of the 10 m cliffs may roughly be constrained to not less than about 500 years.

The 10 m marine sequence was apparently deposited some time after the final retreat of the local ice, because the sequence is undisturbed by glacial movements. The maximum marine transgression in the area, which was at some 60 to 70 m above present day sea level, has been dated to *c.* 8000 B.P. (Weidick 1976). Our sequence, therefore, was deposited in the interval between *c.* 8000 and 7390 ± 110 B.P. (conventional C-14 years). A consideration of the local topography and the present altitudes suggests that an age in the younger half of this interval is most likely, and that the duration of deposition may have been in the order of 400 ± 200 years. The rate of deposition is about two orders of magnitude higher than that of the limnic organic sediments of about the same age in the nearby lake Klaresø (fig. 63; Fredskild, 1969). Potentially therefore, a more detailed geomagnetic record should be obtainable from the marine sequence than from the Klaresø sediments which were also sampled (Abrahamsen & Marcussen, 1980; this report).

Sampling

Two sections in the cliff 15 m apart were sampled. The most complete profile, BR 1, with 96 samples covers 9.3 m or the whole cliff except the top metre. The profile BR 2, from which 54 samples were taken, duplicates the levels between 0.9 and 6.9 m of profile BR 1.

The samples were obtained by gently pressing 1 inch cylindrical polystyrene beakers horizontally into the sediment, and controlled by means of a spirit level. The azimuths were measured by a magnetic compass (±1°), and the local declination was checked by a sun compass (±½°). The samples were taken, on average, about every 10 cm and preferably in the 2 to 5 cm thick clay laminae. The exposed surface of the clay was very stiff because of the drying out in the arid arctic climate. The surface of the cliff was therefore cleaned to a depth of 20 to 30 cm with a spade, until close to the frozen surface of the permafrost underneath. Here the clay was still moist and soft, because of the differential thawing of the permafrost surface during the summer.

Magnetic measurements

The NRM (natural remanent magnetization) of all samples was measured in the laboratory on a Digico spinner magnetometer, and after the pilot investigation all samples were partially demagnetized in an alternating magnetic field of 100 and 200 Oe peak. The magnetic results are shown in figs 64 and 65.

One sample from a minor slump structure at 3.52 m (open circles in figs 64a & 65a) deviates in both angles, the NRM declination of 7° being about 90° away from the otherwise well clustered local mean of about –80°. This suggests that the remanence is a true DRM (detrital remanent magnetization) of depositional origin acquired at, or very soon after, the initial settling of the magnetic particle and before the slumping.

The NRM intensity is at a rather constant level around 100 μG, which is amazingly high considering that, apart from the Precambrian Midsommersø dolerites, most of the surrounding rocks in the area are very pure dolomites and limestones. Demagnetization experiments gave median destructive fields between 200 and 300 Oe, and the decay curves imply that the major carrier of the remanence must be fine-grained magnetite. The only possible source rocks of magnetite known in the area (Abrahamsen & Marcussen, this report) are the relatively abundant Proterozoic sills and dykes of basaltic composition, the so-called Midsommersø dolerites (Jepsen, 1971). It is, therefore, most likely that the remanence is caused by detrital particles of magnetite which originate from the mechanical abrasion and decomposition of the nearby Midsommersø dolerites.

Secular variation

Present day declination and inclination at Brønlundhus are 45°W and +82°, respectively, while the central axial dipole inclination is 86.1°. Geomagnetic secular variation in eastern North Greenland is known only for the past few tens of years while in South and West Greenland the secular variation of declination is roughly known for the last 400 years (Wilhjelm, 1971).

The historically known inclinations vary fairly slowly (less than 0.02°/y), but the declination may vary quite rapidly, up to about 0.5°/y. The amplitude of the declination may be ± 60° to 90° or even more, because of the high latitude and hence the proximity of the dip-pole, the position of which changes with time. Historic observations of the declination show an apparently cyclic variation with periods of 400–500 years, whereas palaeomagnetic investigations from lower latitudes have shown periods in the secular variations between a few hundred and a few thousand years (Creer, 1977; Abrahamsen & Readman, 1980).

The inclination in profile BR 1 varies between 65° and 85°, and a cyclic variation appears to be present in the NRM as well as in the cleaned record. The broad cycle is not seen in the shorter profile BR 2, but minor wriggles are well reproduced especially in the cleaned record; the scatter is minor, and the 5 point running mean curve varies around 80° ± 5°.

The declination is systematically westward with mean values roughly around 60°W ± 30°, except for the top 1½ m of profile BR 1, where the mean declination is around 60°E. The declination in the lower half of profile BR 1 is very well reproduced in profile BR 2, while the top part of profile BR 1 was not duplicated by the sampling of the shorter section for profile BR 2.

Discussion

It may be concluded that at least one major cycle of declination variation is present in profile BR 1 with an amplitude of about ± 60°. This cycle may well be a double cycle because of a peak around 5 m, which is also seen in profile BR 2 at 5½ m.

The relative time scale of the cliff is not exactly known. If we suppose, as suggested above, that profile BR 1 covers about 400 ± 200 years, we may conclude that the periods of the cycles recorded in declination as well as in inclination appear to be about 400 ± 200 and 200 ± 100 years, and the absolute age of the variations is approximately around 7600 ± 200 B.P. (C-14), equivalent to about 8300 ± 200 B.P. (tree-ring corrected).

The periods of the minor wriggles, between 50 and 100 years only, are very short compared with present day secular variations, and might be due to some kind of sedimentological or structural noise. However, as the wriggles reproduce well between the two profiles, it is suggested that the shorter periods seen in the profiles are real, and represent records of rather short periodic, high latitude geomagnetic secular variation.

The reason why such rapid variations are not generally seen in records from lower latitudes could be due to either the unusually high depositional rate, or a special effect at high geomagnetic latitudes. Rapid variations could, for example, be caused by local excentric and approximately axial radial dipoles in the outer core (Alldredge & Hurwitz, 1964; Creer, 1977) being superposed on the main dipole field, but too weak to be recorded at latitudes below ~60°, where most palaeomagnetic data from Quaternary sediments are derived. It is thus interesting to note that Alldredge & Hurwitz place one of their stronger radial dipoles (fitted to older, observatory-based present-day geomagnetic fields) at 77°N, 19°W, rather close to Peary Land, and only 13° from the axis of rotation. Further, it may be noted that the regional magnetic field values in the Polar Sea are systematically low by 120 to 220 nT (Vogt *et al.*, 1979) as compared with the IGRF-1975 field. The accuracy in determination of high latitude radial dipoles is therefore likely to be lower than the accuracy of those situated at mid latitudes.

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