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Late Weichselian geomagnetic 'reversal' as a possible example of the reinforcement syndrome

A LATE Weichselian geomagnetic reversal has been reported[1,2] from Sweden. Mörner and Lanser[3] believed the Swedish reversed palaeomagnetic record to be a "real dipole magnetic reversal of greatest significance for global correlations" and to have been established and well dated in Canada, the North Atlantic and New Zealand and tentatively recognised in Czechoslovakia, the Northern Pacific, the Gulf of Mexico, Japan and France. Noël[4] has described further palaeomagnetic results from two Swedish varved-clay cores as accurately tracing the annual behaviour of the geomagnetic event and delimiting its initiation and termination. Recognition of the event in lavas and deep sea, continental shelf, varved-clay and lake sediments has been cited as confirming the reality of the event. That previous research, particularly in Sweden, has concentrated on palaeomagnetic measurements at numerous, different late Weichselian localities. Because of the difficulties in correlating between localities, interpreting palaeomagnetic records in coarse grained sediments and deciphering coring and sedimentological complexities in single cores, we have instead studied one carefully selected site in detail. We have come to the conclusion that Swedish late Weichselian palaeomagnetic data do not record a reversal or excursion of the geomagnetic field, but demonstrate that the Swedish geomagnetic field has been of normal polarity since 13,000 yr BP. The Swedish late Weichselian reversal had thus become an example of Watkins'[5] "reinforcement syndrome".

We have analysed 408 subsamples from two main cores collected at Björkeröds Mosse on Mt Kullen in north-western Scania in southern Sweden (56.2°N, 12.6°E). Björkeröds Mosse was chosen because it lies in the area considered to be the earliest ice-free part of Sweden[6]; its stratigraphy, vegetational and soil developments have been studied in detail[7,8]; it had a high rate of deposition of organic sediments; and its chronology is well known from both pollen and radiocarbon dating[7]. The sediments from Björkeröds Mosse span the supposed age of the late Weichselian geomagnetic reversal of 12,400 or 12,100 yr BP. Ten sections of 'D'-shaped core, each 1 m in length, were obtained using a Jowsey sampler[9]. The natural remanent magnetisation (NRM) of the 408 subsamples was measured on a 'Digico' magnetometer[10]. Twenty-two pilot samples were partially a.c. demagnetised stepwise in increasing peak fields. A peak alternating field of 100 oersted was selected to eliminate viscous components. The remaining 386 subsamples were cleaned at this field strength. NRM, cleaned declination and inclination, cleaned intensity, and low field reversible susceptibility of core III (1975) are shown in Fig. 1.

We interpret the palaeomagnetic directions as follows. In general, the geomagnetic field close to the time of deposition is recorded by the palaeomagnetic remanence. At a few lithologically distinct horizons, however, the magnetic remanence has been controlled by other processes. The scattered or offset declinations and inclinations in the laminated deposits of layer 1 at depths of 615, 520 and 440 cm (Fig. 1) occur in coarser grained sediments and are due to rough alignment in higher energy deposition environment, rather than to idealised alignment along the ancient magnetic field direction. The single, reversed inclination at a depth of 338 cm (Fig. 1) falls in a narrow dark layer about 2 cm thick. A dark layer at a similar stratigraphic level in Björkeröds Mosse has been reported by Mörner in core B892 to be "well established" as a geomagnetic excursion and to correspond to his Fjards interstadial. The layer in our core III (1975) is anomalous as, (1) its base is markedly (our results, in preparation) crenelated, (2) it does not occur in two other duplicate cores, and (3) the remanence is unusually stable as well as in a distinct direction. Its pollen spectrum and sediment chemistry correspond to the till which forms the banks of the lake. We prefer to interpret this intermediate palaeomagnetic direction and Mörner's[11] in core B892 to be due to slumping rather than a true reflection of the geomagnetic field.

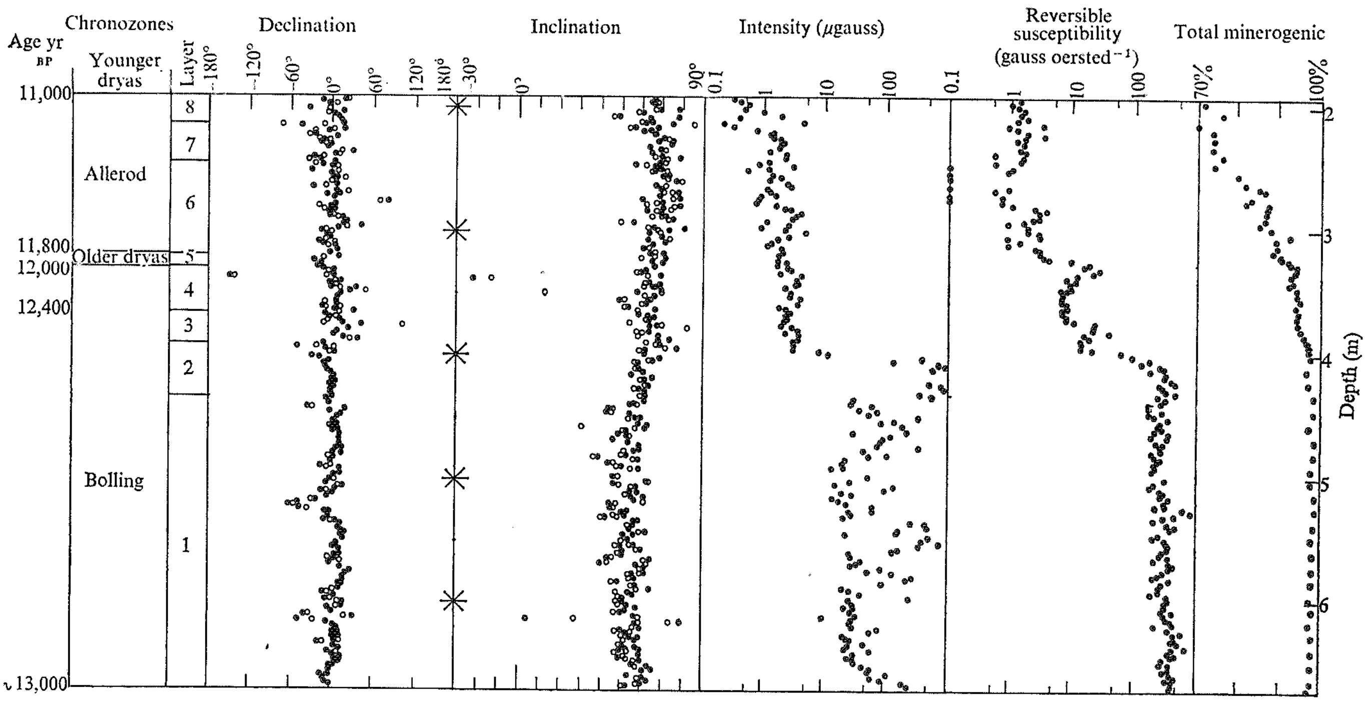

Fig. 1 Data from Björkeröds Mosse core III (1975). ○, NRM; ●, partial demagnetisation at 100 oersted. Crosses indicate end of core sections. Mean declinations were set to zero.

The remaining great majority of palaeomagnetic directions are all of normal polarity and are taken to indicate that the geomagnetic field was of normal polarity from 13,000 to 11,000 yr BP in Sweden.

The retention of aberrant magnetic directions and the between-core repeatability (our results, in preparation) of cleaned remanent intensity indicate that these normal polarity late Weichselian palaeomagnetic directions are almost contemporary with deposition and are unlikely to have been caused by later remagnetisation. Our data suggest previously reported reversed palaeomagnetic directions[1–4] are not reliable indicators of the ancient geomagnetic field, but have been distorted by mechanical sedimentation processes, slumping or weathering. Alternatively, but less likely, the reversed directions had been dated inaccurately. We suggest the proliferation of unusual palaeomagnetic directions in Scandinavia around 12,000 yr BP is a reflection of changing climatic conditions. In many localities the fluctuations of climate produced sediments of very variable mechanical properties, particularly at times of periglacial activity, which were poor recorders of the ambient magnetic field direction.

Using geomagnetic events in the Swedish late Weichselian is thus of doubtful value. Furthermore, reversals or excursions of the geomagnetic field from other parts of the world around this time should not be dated or correlated with the earlier Swedish results.

Watkins'[12] warnings on "the special problems posed by the search for short events" have unfortunately not been heeded. We endorse his comments[12] and on the basis of our work on the Swedish late Weichselian propose three minimum requirements for the recognition of geomagnetic excursions in recent sediments: (1) both magnetic declination and inclination changes should be repeatable to within 20° in at least two sections or cores at the same site; (2) results should only be taken from macroscopically homogeneous lithologies with an average grain size below 62.5 μm; and (3) magnetic directions should be stable under alternating field cleaning with peak field ⩾100 oersted.

Application of these criteria would prevent many spurious palaeomagnetic directions being interpreted as evidence for unusual geomagnetic behaviour. It would reduce the large number of excursions and events deduced from Brunhes sediments to a small total comparable to that recognised in igneous material[13]. It would also reduce the difficult dating problems arising from attempts to correlate recent excursions, dispel speculation[11] on very rapid changes in the main dipole field and enable geomagnetic excursions to be considered again as chronological indicators.

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