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Rapid Measurement of the Remanent Magnetization of Long Cores of Sediment

A SIMPLE extension to the computerized slow-speed spinner magnetometer designed by Molyneux[1] permits the measurement and cleaning by an alternating magnetic field of the remanent magnetization of whole columns of sediment. The material is measured in the core tube in which it was collected, and the system has the advantages of being fast, non-destructive and more sensitive and accurate than other methods.

The instrument consists of a system for rotating a core up to 1 m long and between 4 and 7 cm in diameter at about 4 revolutions s^{-1}. The axis of the cylinder is vertical and is supported at the bottom by a plastic three-jaw chuck and at the top by three rubber-tyred plastic wheels. Four magnetic fluxgate sensing heads are mounted on a wooden slide that can be moved to any position (within 4 cm from either end) along the axis of the core. An important feature of the design is that the frame on which the slide moves is entirely separate from the supports of the core. Thus vibration from the rotating assembly cannot be transmitted to the detecting heads. At the lower end of the core, and separated from it by about 20 cm of shaft, there is a disk with 128 slots that permit light to fall onto a photocell. As each slot passes the photocell the computer attached to the cell causes the output of the flux sensitive heads to be converted into a digital number and stored within the computer memory in such a way that readings from a particular slot are always accumulated in a particular memory position. When sufficient (typically thirty-two) rotations have been made, the accumulated results are subjected to Fourier analysis and the results, in terms of an angle (with respect to a single marker slit) and a magnitude, are printed out. The time taken for a single measurement, assuming a collection period of thirty-two revolutions, is 8 s plus 7 s for the analysis and printing. A 1 m core can be completely measured in less than 20 min. The noise level of the system is inversely proportional to the square root of the collecting period, and at 32 s is equivalent to an intensity of magnetization of 0.2 e.m.u. $cm^{-3} \times 10^{-6}$, directions being typically repeated to within 1°. A.f. demagnetization up to a peak field of 250 oersted is simply attained by moving a pair of Helmholtz coils slowly up and down the length of the core while it is being spun.

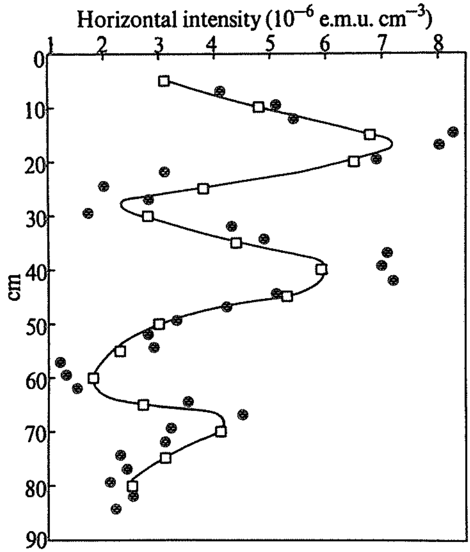

Fig. 1 Comparison of changes in horizontal intensity in a 1 m core. □, Measurements on a whole core; ●, measurements on separate samples.

To test the measurement of whole cores, separate samples 2.5 cm in diameter and 2.5 cm high were taken every 2.5 cm down the length of each core and measured on the spinner magnetometer in the standard manner[2]. A typical example of the variation of horizontal intensity of magnetization is shown in Fig. 1. Comparison of the results from the two methods shows that a higher sensitivity is obtained on measuring the whole core because of the larger volume of material involved. A greater degree of accuracy is also achieved because of the lack of the orientation errors inherent in the separate sample method.

The variation of declination with time has been established for Britain by observatory records[3] over the past four centuries, archaeomagnetic results[4] for the past ten centuries and for even older periods in the ^{14}C and pollen-dated sequence from Lake Windermere[2,5]. A comparison of the measured changes in declination in the cores with the above records allows ages

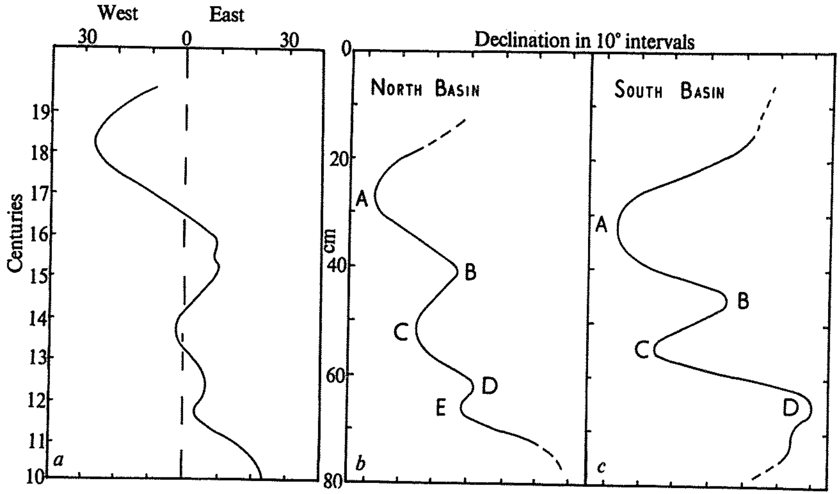

Fig. 2 Variation of magnetic declination. *a*, Observatory and archaeomagnetic data; *b* and *c*, data from cores from Lough Gall after a.f. cleaning, peak field of 50 oersted.

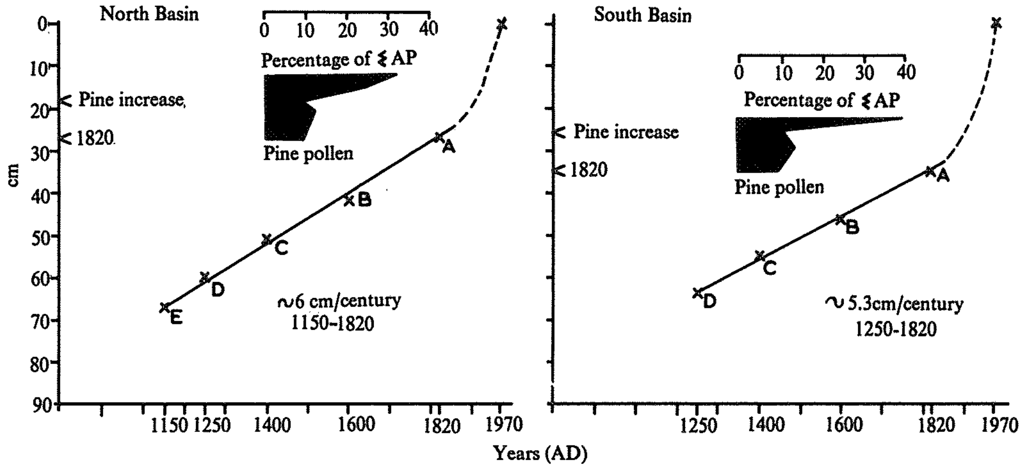

Fig. 3 Estimated accumulation rates in the upper sediments of Lough Gall, based on profiles of magnetic declination. (Dates derived from Aitken[4].) Insets show the rapid increase in pine pollen frequency in the cores.

to be attributed to the measured magnetic variations. If the magnetization was acquired at or soon after the time of deposition of the sediment, then the changes in magnetization down the core can be used to date the sediment.

This technique is well illustrated by the results from two 1 m cores from Lough Gall in Co. Armagh, Northern Ireland. The variation of declination after a.f. cleaning for the two cores is shown in Fig. 2. The changes of declination are clearly similar to the observatory records and the archaeomagnetic results. The similarity of the amplitudes suggests that the magnetization was acquired close to the time of deposition. By comparing the results with the archaeomagnetic data, rates of accumulation of the sediment have been estimated and are illustrated in Fig. 3. The rate of deposition is quite compatible with known records from hard water lakes, and the increase in rate to the present date is consistent with the high water content in the top section of the core. A good confirmation of the magnetic ages is given in both cores by the increase in pine pollen frequency from around 10% to between 30% and are 40% of the total tree pollen sum. The insets in Fig. 3 show the relevant section of the pollen diagrams from each of the two cores plotted against the calculated accumulation rates. The increase in pine pollen frequency reflects extensive plantation in the drainage basin of the lake between 1860 and 1890. In each case the pine pollen increase begins between 9 and 10 cm above the most recent westwardly swing in declination which took place in about 1820. The results from this lake are of particular importance as the sediment is of a calcareous nature and attempts at radiocarbon dating would be vitiated by contamination by ancient carbon.

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1 Molyneux, L., *Geophys. J. Roy. Astron. Soc.*, **24**, 429 (1971).
2 Creer, L. M., Thompson, R., Molyneux, L., and Mackereth, F. J. H., *Earth Planet. Sci. Lett.*, **14**, 115 (1972).

[3] Gaibar-Puertas, C., *Tortosa, Spain: Observ. del Ebro, Memo Noll* (1953).
[4] Aitken, M. J., *Phil. Trans. Roy. Soc. Lond. A*, **269**, 77 (1970).
[5] Mackereth, F. J. H., *Earth Planet. Sci. Lett.*, **11**, 332 (1971).

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