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Research Note

Rapid Measurement of the Magnetic Susceptibility of long Cores of Sediment

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Summary

Apparatus to measure the initial (low field) susceptibility of whole cores of sediment has been constructed and tested. The instrument is complementary to that designed to measure the horizontal remanent magnetization of whole cores. Measurements on lacustrine sediments have shown that magnetic susceptibility is a sensitive stratigraphic indicator and consequently ideal for correlating between cores.

Adaption of the electronics of the computerized slow speed spinner magnetometer (Molyneux 1971) and the use of a different kind of measuring head allow the measurement of the initial (low field) susceptibility of long cores of sediment. As in the adaptation for measuring the remanent magnetism of long cores (Molyneux *et al.* 1972) the instrument is both fast and sensitive.

The instrument

The instrument consists of a non-magnetic trolley, on which the core tube is supported, and a coil system connected to an adaptation of the electronics of the computerized slow speed spinner magnetometer. The coil system consists of a solenoid 10 cm long, which produces a 10 kcs field of about 1 Oe, and a central pick-up winding 1 cm in length. The solenoid surrounds the core tube leaving an annular gap of about 1 cm. A similar coil is used as a reference system. The difference signals from the two pick-up windings are fed into a tuned amplifier fitted with a phase sensitive rectifier which is in turn connected to an analogue-to-digital converter; thus the difference signals are made available to the computer as 12 bit numbers. The trolley lies on a sloping board and is connected by a non-extensible string to a windlass similar to the type used to draw water from a well. On the shaft of the windlass there is a disc with four slots, the diameter of the windlass being such that the angle between slots corresponds to a 2 cm linear movement of the core. A lamp/photo-cell arrangement, the segment cell, monitors these slots and another lamp/photo-cell, the reference cell, is operated by a shutter attached to the trolley which carried the core tube.

A measurement is made as follows: firstly it is decided over what length the measurement is to be made: 60 cm or 30 readings is a typical length, and this number is set into the computer program; then the trolley is positioned so that the shutter obscures the reference cell, in such a manner that the cell becomes illuminated when the segment cell is mid-way between slots. The windlass is then turned and as each

slot passes the segment cell an analogue-to-digital conversion is made and the result added into a memory location unique to that particular position of the core of sediment. When the pre-set number of slots has passed the segment cell the computer normalizes the results so that the mean of all the readings is zero. The program is organized so that a list of the results in terms of susceptibility for each 2-cm interval can be printed out. For a core of high susceptibility a single run is all that is needed, but for a weak core the noise level is too high and the program has been arranged so that an average of many traverses of the core can be made so as to produce a satisfactory signal/noise ratio. For a single traverse the peak value of noise is about 2×10^{-7} Gauss/Oe while for eight traverses the peak value drops to about $0{\cdot}8\times10^{-7}$ Gauss/Oe. Over this range the expected relationship between signal to noise level and square root of the number of traverses is observed and there is every reason to believe that it will hold for a larger number. Since a traverse can be completed in about 15 s a very high sensitivity is possible in a reasonable time, but so far in measuring the sediments from various lakes we have not had to use more than eight traverses to get a good signal/noise ratio.

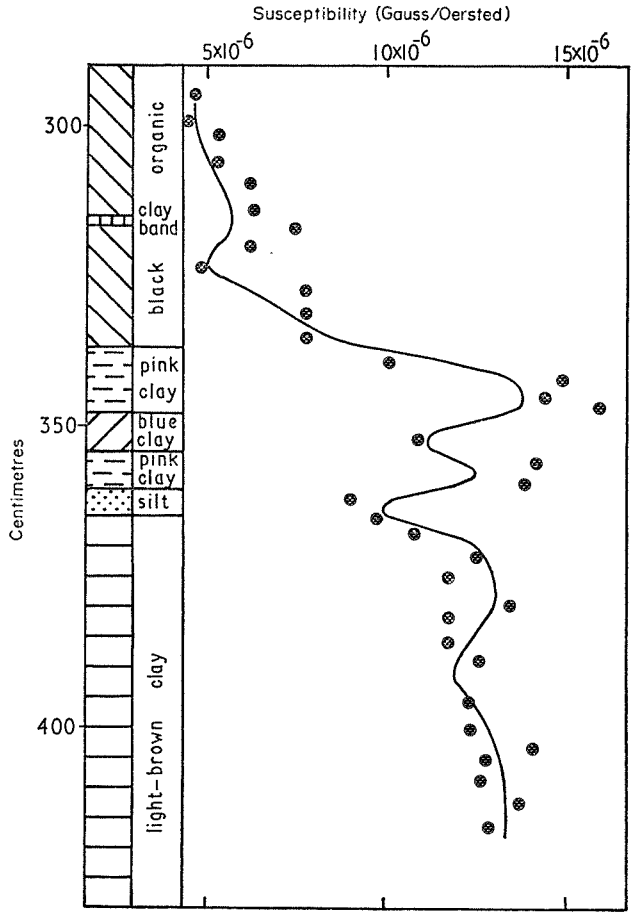

FIG. 1. Comparison of whole core (continuous curve) and subsample (solid circles) measurements of initial susceptibility *vs.* depth for the complex stratigraphic succession from 290 to 430 cm depth from Lake Windermere.

A typical 1-m core can be measured, using a series of overlapping traverses, in less than 20 min which compares favourably with about half a day required for the sampling, labelling and measuring of the individual sub-samples using previous methods. The whole core method has also very high sensitivity which comes partly from the large effective sample size and partly from the ease of combining many measurements which makes this method of signal/noise improvement a practical proposition.

Calibration

The calibration of the instrument was established by measuring a core tube filled with salts of known susceptibility, and then checked by measuring a sediment firstly in the core tube and then in separate subsamples using an existing instrument (Collinson, Molyneux & Stone 1963). Measurements made beyond the ends of the core tube show that the signal was reduced to 66 per cent at a distance of about 3 cm from the end of the sample suggesting that during normal core measurements the ' sample ' had a working length about equal to the width of the core tube ($\sim$6 cm).

Applications

An example of the application of the apparatus is shown by Fig. 1. Measurements were made on a whole core, and afterwards on separate, cylindrical samples, 2·5 cm high, 2·5 cm diameter, which spanned a succession of different clay types. The different susceptibilities of the various clays were clearly recorded by both sets of measurements. The clays lie at the important stratigraphical boundary between Late-Glacial and Post-Glacial sediments. The apparatus can thus be used to determine the stratigraphy of cores and to correlate between cores before they are opened.

Studies on more recent lake sediments from Lough Neagh have shown that susceptibility is a diagnostic measurement of changing agricultural use of the surrounding land, and the consequent varying inwash of particulate material and clay minerals into the lake. Measurements of susceptibility have proved to be particularly useful for indicating the most efficient way of planning follow-up work of detailed and time-consuming pollen, diatom and chemical studies (Thomspon 1972). In addition to being applicable to the investigation of lacustrine sediments the apparatus is ideally suited for oceanographic studies.

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