Spatial heterogeneity of diatom stratigraphy in varved and non-varved sediments of a small, boreal-forest lake

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ABSTRACT

Spatial and temporal heterogeneity of recent diatom stratigraphy were assessed for a small (23 ha) dimictic lake in Northern Sweden (Kassjön). Varves are confined to water depths >10 m. Six freeze cores were taken along a transect covering a range of water depths (3–12 m) and both varved and non-varved sediments. Core profiles were compared for dry mass accumulation, loss-on-ignition (LOI), and diatom relative frequency stratigraphy and accumulation rate. Excluding the 3.2 m water depth, non-varved core, all parameters showed good repeatability between cores, apart from diatom accumulation rates which were more variable. The 3.2 m core was atypical and had lower LOI values, low planktonic diatom percentages and high values of benthic taxa that were not abundant in the deep-water sediments. Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) ordinations were compared; both methods clearly differentiated the shallow water core, and showed the general similar ecological trends of the deeper-water cores. CCA axes constrained by “environmental” (i.e. core location) data resulted in slightly lower eigenvalues than that obtained by Correspondence Analysis (CA), but the axes were significantly non-random. A Partial-CCA of the four varved cores alone (with effects of sediment depth, i.e. age, partialled out), indicated that there was no significant difference between their diatom assemblages.

Introduction

Varved or annually laminated sediments offer a number of advantages over visually or stratigraphically homogenous lake sediments, and are increasingly being used as the basis for palaeolimnological and palaeoecological study (Renberg 1978; Simola 1977). Varves potentially offer high resolution (associated with low mixing rates required for their formation), an implicit chronology, and hence the ability to calculate accumulation rates of parameters being studied (Renberg 1981a; Segerström et al. 1984).

Diatom stratigraphy in lake sediments varies due to variable diatom productivity, spatially heterogenous sources, transport, and depositional processes (Anderson 1990a). While most palaeolimnological studies have to assume that one core is a representative sample of the whole lake, many workers choose to ignore the implications of qualitative

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Any attempt to assess spatial variability and/or heterogeneity in diatom stratigraphy requires correlation of the different cores. For financial reasons it is unusual to date multiple cores, and where it has been done variable deposition of $^{210}$Pb requires some matching of cores to obtain a reliable chronology (Murchie 1985). Cores are, therefore, usually matched biostratigraphically (Battarbee 1978; Anderson 1986; 1990a, b), with correlation facilitated by numerical sequence slotting of microfossils (Anderson 1986), and ordination techniques (Birks 1987). All these approaches inevitably involve some subjectivity, and a degree of circularity if the correlations are then used to construct a chronology and diatom accumulation rates, although correlations can be substantiated by other parameters (Dearing 1986; Anderson 1986). Varves provide an accurate way of correlating cores and avoid this circularity (the correlation and chronology are independent of the biostratigraphy).

Varves are, however, normally confined to deep areas of lakes where bioturbation and resuspension processes are limited (Nipkow 1928; Renberg 1981b; Leavitt & Carpenter 1989), or areas of the lake where the epilimnion and hypolimnion are chemically differentiated (Anthony 1978). As such, lakes with varves also offer the possibility of assessing the effect of spatially variable processes on the stratigraphical record (Leavitt & Carpenter, 1989). Varved cores can be compared to mixed cores outside the area of varves, although correlation may again be problematical. In this study, as with that of Leavitt & Carpenter (1989) a clay inwash horizon provides a baseline for correlation between varved and non-varved cores.

This study presents diatom stratigraphy from a transect of cores covering a range of water depths in a varved lake in northern Sweden. It compares quantitative and qualitative biostratigraphy between cores, and assesses the implications for diatom stratigraphical interpretation and process studies.

**Study site**

Kassjön is a small (23 ha) dimictic lake in Northern Sweden (63° 55'N, 20°01'E). Maximum water depth is 12.5 m and varved sediments are confined to water depths >10 m (Fig. 1). The lake was formed ~6300 yr ago by land uplift, and the sediment record in Kassjön is continuously varved (Segerström 1990). The catchment area is 1300 ha with 75% boreal forest (mixed *Picea abies, Pinus sylvestris* and *Betula* spp.), and 25% cultivated land. Drains were cut in the catchment to the north of the lake in 1900–1902, the resulting erosion deposited a clear clay marker horizon across the whole-lake (Segerström et al. 1984). The varves have a thin dark winter layer of fine organic material, usually a thin spring mineral grain layer and a thicker summer-autumn layer of organic matter and biogenic silica (Renberg 1981a).

**Methods**

Six cores were taken in March 1979 using a freeze corer (Renberg 1981b), along a transect from the deep-water sediments in the centre of the lake towards shallow water, close to the