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Paleolimnological potential of chrysophyte cysts and scales and of sponge spicules as indicators of lake salinity

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Abstract

Chrysophyte cysts and scales and sponge spicules were enumerated, along with diatoms, from the surface sediments of 102 western Canadian lakes. The salinities of these lakes ranged from 0.042 to 369 g L^{-1} in late summer. Sponge spicules and chrysophyte cysts and scales were more common in fresher waters, although chrysophyte cysts were also present in subsaline and hyposaline waters at lower relative percentages. These siliceous microfossils can easily be distinguished and counted along with diatom valves, with little extra effort. It is likely that using these additional indicators will strengthen paleolimnological inferences of past lakewater salinity.

Introduction

Saline lakes provide many exciting research opportunities for paleolimnologists, and especially those interested in past climatic change, because salinity in closed-basin lakes can often be related to changing evaporation/precipitation ratios (Hammer *et al.*, 1983). Diatoms have often been highlighted in these studies, as diatom species closely track lakewater salinity gradients (Fritz and Battarbee, 1988), as well as other important environmental variables (Dixit *et al.*, 1992). Once the salinity optima and tolerances of the various taxa are estimated, fossil diatoms can be used to track past lakewater salinity, from which climatic trends can be inferred (Fritz, 1990; Fritz *et al.*, 1991).

Diatoms are powerful paleolimnological indicators, and there is no doubt that they will remain the mainstay of many paleolimnological studies. Lake sediments, however, also preserve a suite of other siliceous microfossils, which can be easily enumerated by paleolimnologists using the same preparation and counting procedures designed for diatom studies. This note describes the distribution of some of these indicators (i.e. chrysophyte scales and stomatocysts and sponge spicules) and provides an assessment of their potential for inferring trends in lakewater salinity.

Study Region

As part of the Paleolimnological Investigations of Salinity, Climatic and Environmental Shifts (PISCES) project, we identified and enumerated diatoms preserved in the surface sediments of 110 lakes in the Cariboo, Chilcotin and Kamloops regions of British Columbia, western Canada. Late-summer salinity measurements ranged from 0.042 to 369 g L^{-1} (average = 17.0 g L^{-1}; median = 2.1 g L^{-1}). Other important limnological gradients included brine type, nutrients and pH (see Cumming and Smol, in press).

Methods

The field and laboratory procedures are outlined in Cumming and Smol (in press). Briefly, surface sediment samples were removed from near the center of each lake using a Glew (1991) gravity corer and digested with a mixture of sulfuric acid and potassium dichromate. The resulting slurry was washed repeatedly in distilled water and then mounted on glass slides using Hyrax® (Smol, 1983). All siliceous microfossils were enumerated using oil immersion at 1000X magnification. The relative number of chrysophyte scales and cysts and sponge spicule fragments were each expressed (as a percentage) relative to the total number of diatom valves counted (e.g., if 40 chrysophyte cysts were enumerated whilst 500 diatom valves were counted, the ratio would be 40/(500+40) x 100 = 7.4 per cent, and would then be plotted against late-summer salinity for the lake (Fig. 1)).

Results and Discussion

Diatoms were well preserved in the surface sediments of 102 of the 110 lakes. As expected, diatom species distributions were strongly governed by the overriding salinity gradient, and highly significant transfer functions were developed to infer lakewater salinity from the diatom assemblages (Cumming and Smol, in press). The focus of this note is to evaluate the potential of other siliceous microfossils as paleosalinity indicators. Interesting trends emerge when chrysophyte cysts (stomatocysts) and scales, as well as sponge (Porifera, Demospongiae) spicules, are expressed relative to the number of diatom valves counted along the salinity gradient (Fig. 1).

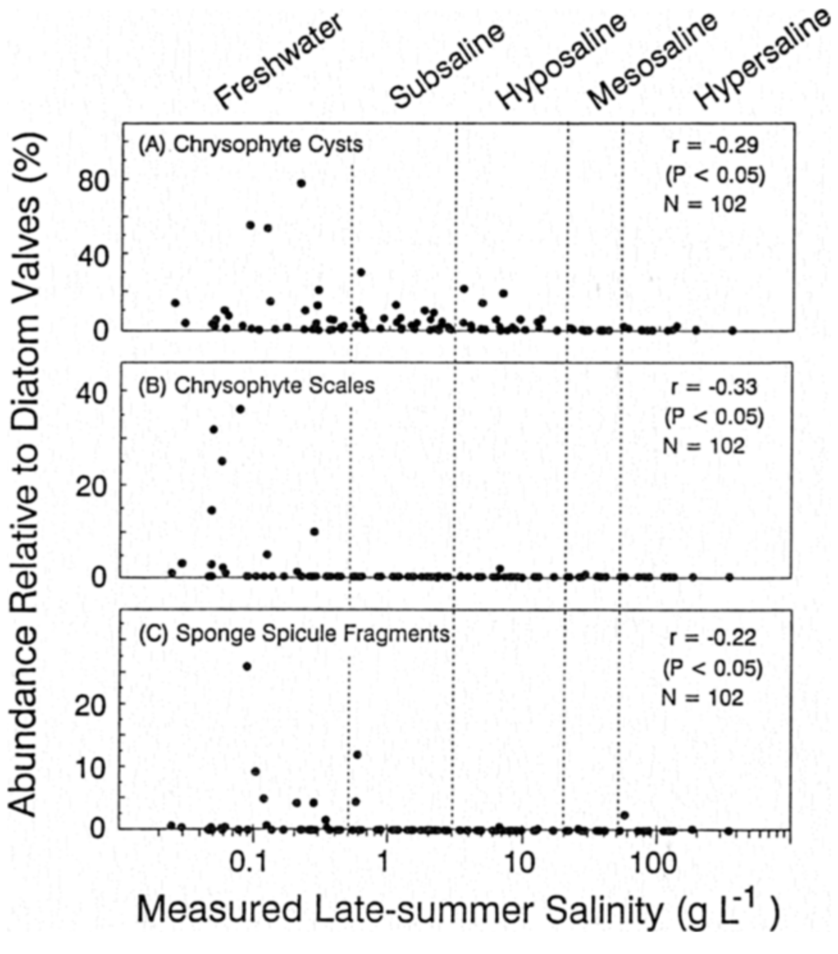

Fig. 1. The relative abundances of chrysophyte cysts and scales and sponge spicules relative to the total number of diatom valves counted in the surface sediments of 102 lakes in British Columbia. The microfossil percentages are expressed relative to late-summer lakewater salinity (note the logarithmic scale). The significance tests of the correlation coefficients were set, *a priori*, at $P < 0.05$ based on a two-tailed test, because no previous studies had been undertaken on the distributions of chrysophytes or sponge spicules along such a large salinity gradient. All correlations were significant. Salinity boundaries are delineated according to Hammer *et al.* (1983).

The distributions of chrysophyte cysts (Fig. 1(A)), scales (B), and sponge spicules (C) showed restricted distributions along the salinity gradient. Chrysophyte cysts and scales have been used extensively in paleolimnological studies of lake acidification and eutrophication (Smol, in press), but have largely been ignored in studies of saline lakes. Our data clearly show that chrysophytes in general (as represented by their endogenously formed cysts or stomatocysts) are rare or absent in mesosaline and hypersaline waters (Fig. 1(A)). Although no attempt was made to differentiate the cysts using International Statospore Working Group guidelines (Cronberg and Sandgren, 1986), there was a marked decrease in chrysophyte cyst diversity with increasing salinity. These data are consistent with the limited ecological data available for chrysophyte distributions with respect to lakewater salinity. For example, Sandgren (1988) concluded that chrysophyte biomass declined markedly with increasing conductivity. The simple enumeration of chrysophyte cysts and their expression relative to the total number of diatoms may increase the confidence of paleosalinity reconstructions, especially near the mesosaline/hyposaline boundary.

The distribution of chrysophyte scales (belonging to taxa of the chrysophyte classes Synurophyceae and Chrysophyceae) was even more restrictive than cysts with respect to the salinity gradient. In general, scales were only common in the freshwater lakes (Fig. 1(B)). The taxa we recorded included: *Mallomonas crassisquama* (Asmund) Fott, *M. pseudocoronata* Prescott, *M. caudata* Iwanov *em.* Krieger, *M. elongata* Reverdin and a number of indistinct small *Mallomonas* scales. These chrysophytes are known to be more abundant in alkaline waters (e.g. Cumming *et al.*, 1992). Interestingly, no scales were observed from the genera *Synura*, *Chrysosphaerella* or *Chrysodidymus*. If the *Mallomonas* scales had been identified and enumerated to the species level in the analyses, it is likely that a succession of taxa would have been evident along the salinity gradient, thus further refining our observations (e.g. Siver, 1991; Zeeb and Smol, 1991). Nevertheless, even if all the taxa are grouped as one category, it appears that a high relative abundance of chrysophyte scales is a good indicator of fresh waters.

Siliceous sponge spicules are generally an underused group of paleoindicators (Harrison, 1988). Interestingly, the distribution of spicules with respect to the salinity gradient was even more striking than the chrysophytes, and sponges were rarely common in waters with summer salinities greater than 1 g L^{-1} (Fig. 1(C)). This distribution is not surprising, given what is known about the ecological ranges of freshwater sponges (Harrison, 1974). Hence, sponge spicules may be used as an independent signal to differentiate the freshwater/subsaline boundary.

Conclusions

There is little doubt that diatom-based paleolimnological studies will be used increasingly to infer past environmental changes in saline lakes. The additional effort required to include cysts, scales and sponge spicules into these studies is minimal (e.g. the same microscope slides can be used, etc.). Even if these counts are left at the coarse taxonomic levels used in this study, these indicators corroborate lakewater salinity changes, and should increase the confidence of paleolimnological inferences. Equally, such combined studies will enhance our knowledge of the present and past distributions of chrysophytes and sponges. We hope this survey will encourage other paleolimnologists to include these indicators in their analyses.

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