

# Analysis and modelling of calcite dissolution in lakes

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In contrast to the biomineralization of carbonates in the ocean the calcite precipitation in productive hardwater lakes is a chemical process. High rates of photosynthesis trigger  $\text{CaCO}_3$  precipitation by increasing pH to values of  $\text{pH} > 9$ . There is a growing interest in the palaeolimnological community to understand this biogenic calcite precipitation in detail. Recently the grain size of calcites has been correlated with phosphorus concentrations (Lotter *et al.*, 1997) and stable isotopes from lacustrine carbonates are used as palaeo-indicators.

In order to interpret the geochemical information stored in calcite layers of 10'000 year long records of laminated lake sediments one has to address questions like the following:

Which fraction of precipitated calcite is preserved in sediments?

Which surface chemical processes control the particle size of calcites in the sedimentary record?

Under which conditions can calcite dissolution in the hypolimnion induce meromixis and anoxia?

In this contribution we make use of results from surface chemical studies on speciation (Van Capellen *et al.*, 1993; Schosseler *et al.*, 1998) and kinetics (Kunz and Stumm, 1984; Arakaki and Mucci, 1995) in order to interpret results from two comprehensive field studies.

## Study sites and methods

The North Basin of Lake Lugano at the Swiss/ Italian border is about 300 m deep and permanently stratified. Tritium and helium measurements indicate that the deep water has not been in contact with the atmosphere since the 1960s (Wüest *et al.*, 1992). The internal calcium cycle was quantified with sediment traps, pore-water studies, sediment cores and by calculating the transport by turbulent diffusion from concentration profiles in the water column (Fig. 1a). Calcite dissolution occurring under these meromictic conditions is compared with extensive time-series observations in Lake Sempach near Luzern. This lake is 86 m deep and yearly mixing is controlled by artificial aeration.

Different box models were used to quantify the calcium fluxes between tributaries, outflow, epilimnion, deep water and sediment. A dynamic model was developed to follow the dissolution of different size classes of calcites. The model combines the

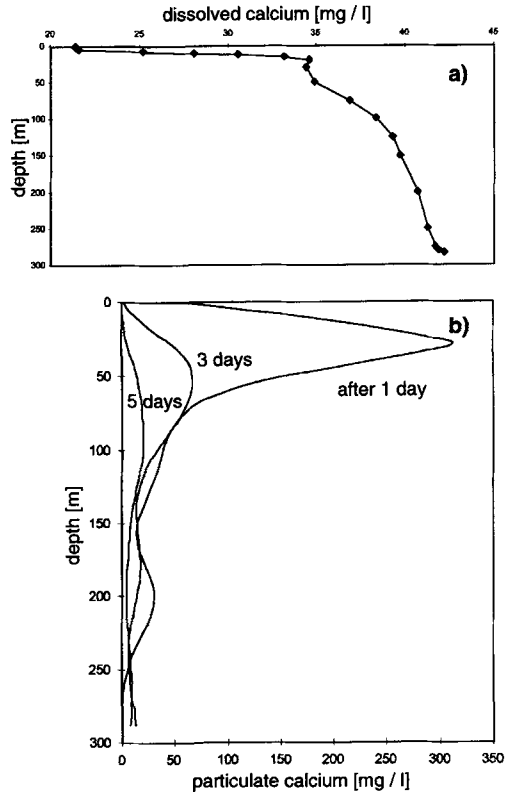


FIG. 1. (a) Concentration profile of dissolved calcium in Lake Lugano; the local maximum just under the thermocline is typical for this season. (b) Results from a dynamic simulation of the particulate Ca concentration in the water column of Lake Lugano. At time =0 the calcites were added to the epilimnion.

equations for sinking velocities and dissolution kinetics.

### Results

Calcite dissolution in Lake Lugano occurs mainly in the water column, not in the sediment. In the shallower Lake Sempach dissolution processes at the sediment-water interface are comparable to water-column dissolution. About 55% of the biogenic calcites are dissolved in Lake Lugano in the upper 85 m, whereas in Lake Sempach this fraction is only 15%. Particle size is an important factor in determining overall calcite dissolution. The dynamic model reflects the behaviour of calcite in the water column of Lake Lugano quite well (Fig. 1b).

### References

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