Climate and CO2 saturation in an alpine lake throughout the Holocene

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ABSTRACT: This study shows that diatom sediment records can be used to investigate the long-term inorganic carbon dynamics in oligotrophic and poorly acid-buffered lakes. Using a training set of 115 high-mountain lakes in the Pyrenees, we found that both alkalinity and potential hydrogen (pH) independently explained some of the variability in diatom assemblages. Transfer functions for both variables were developed and applied to a Holocene record from Lake Redon and CO_2 changes calculated. CO_2 saturation broadly followed alkalinity, which in turn was related to summer and autumn air-temperature fluctuations. In general, warmer climate during the ice-free period led to higher supersaturation, due to increased alkalinity, which facilitated retention of CO_2 from respiration, and decreased primary production (assessed by diatom fluxes). Only during the early Holocene, there were periods of extreme undersaturation, corresponding to cold periods of low alkalinity (<20 microequivalents per liter [μeq L^{-1}]), and suggesting carbon limitation of primary production. The winter and spring climate, which determines the ice cover duration, appears to be relevant for CO_2 saturation only during periods when the organic-matter content of the sediments was low (<22%). Longer periods of ice cover led to lower lake CO_2 saturation, suggesting that the ice cover influence on internal nutrient loading may regulate lake productivity fluctuations under low allocthonous nutrient and organic-matter inputs. Alkalinity ~20 μeq L^{-1} and sediment organic matter ~22% appear as critical thresholds in the way lake CO_2 levels respond to climate fluctuations.

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