

Impact of flood events on lacustrine carbonate isotope records

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Stable oxygen ($\delta^{18}\text{O}$) and carbon ($\delta^{13}\text{C}$) isotope compositions of lacustrine carbonates are among the most frequently used proxies in palaeolimnological / -environmental studies. Stable isotope analyses are often carried out on bulk carbonate samples, which are prone to contamination with detrital carbonates, transported into the lake by runoff processes and carrying the isotopic signal of catchment rocks, thus hampering the interpretation of the data in terms of past climatic and/or environmental changes. Despite the awareness of a likely detrital bias, the degree of contamination in most cases remains unknown and discrete contaminated samples undetected due to a lack of methods to disentangle endogenic and detrital carbonates in sediment records.

To address this issue and provide more comprehensive insights into effects of flood-related detrital input on the bulk carbonate isotopic composition, we conducted stable isotope measurements on sediments trapped on a 3–12 day basis over a three-year period (January 2011 to November 2013) at two locations in pre-Alpine Lake Mondsee, close to the inflow of the main tributary and in the deepest part of the lake basin. Lake Mondsee was chosen for the monitoring since the pelagic sediments are annually laminated consisting of couplets of light calcite layers and dark layers made up by a mixture of detrital clastic and organic matter.

Maximum calcite flux rates $>1.5 \text{ g m}^{-2} \text{ d}^{-1}$ were trapped between May and September, indicating the seasonal endogenic precipitation of calcite crystals. The comparison of the $\delta^{18}\text{O}$ composition of trapped carbonates, rain and epilimnion lake water revealed equilibrium calcite precipitation, allowing us to infer purely endogenic $\delta^{18}\text{O}$ (-9 to -11.3‰ VPDB) and $\delta^{13}\text{C}$ values (-6 to -9‰ VPDB) throughout the summer season. The endogenic calcite precipitation was interrupted by 14 peaks in carbonate flux (4 to $175 \text{ g m}^{-2} \text{ d}^{-1}$) triggered by runoff events of different magnitudes ($10\text{--}110 \text{ m}^3 \text{ s}^{-1}$ peak runoff). The effect of these events on mean seasonal $\delta^{18}\text{O}$ (0 to +3.5‰) and $\delta^{13}\text{C}$ composition (0 to +3.6‰) is closely related to sediment influx and, therewith, to runoff magnitude. However, while the strongest floods could be detected in the sediment record as discrete detrital layers (proximal: 2 events $>50 \text{ m}^3 \text{ s}^{-1}$, distal: 1 event $>80 \text{ m}^3 \text{ s}^{-1}$), lower magnitude floods ($>30 \text{ m}^3 \text{ s}^{-1}$) provide a 'hidden' detrital bias of 0 to 0.5‰. Evidence for detecting even this 'hidden' bias in sediment records is given by the linear relation between detrital carbonate content and the isotopic composition, resulting in a strong cross-correlation between $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ for samples containing $>5\%$ detrital carbonate whereas no relation was observed for purely endogenic samples. Hence, cross-correlation between $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ in bulk carbonate samples serves as a reasonable indicator for contamination with detrital carbonates, applicable in sediment records from hydrologically open lakes where evaporative effects on stable isotopes are negligible.