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# Isotopic (H, O, and C-DIC) tracing of Rhone river water and mixing within Lake Geneva determined using the MIR submersibles

T.W. Vennemann

Institute of Mineralogy and Geochemistry, University of Lausanne, Lausanne, Switzerland (torsten.vennemann@unil.ch)

During a visit of the MIR submersibles to Lake Geneva in the summer of 2011, 60 water samples were taken from selected transects focusing on the Rhone Delta Canyon, the central axis of the deep lake, as well as transects from the centre of the lake into the Bay of Vidy, one of the most polluted bays of the lake. A Rosetta sampling system attached to the MIR 2 submarine allowed continuous CTD measurements during sampling. Predominantly horizontal transects within the meta- and hypolimnion of morphometrically different basins were chosen as they are difficult to do via vertical profiles from a boat. The hydrogen and oxygen isotope compositions of all the waters sampled below 60 and down to 300 m depth are homogeneous, averaging –88.8 ±0.63‰ and –12.41 ±0.12‰ for $\delta^2$H and $\delta^{18}$O values (rel. to VSMOW), respectively. The deep lake thus represents a well-mixed, homogeneous reservoir of water with about 70 to 80% of water derived from the glacier-sourced Rhone River (average $\delta^2$H of –103‰ and $\delta^{18}$O of –13.7‰) and 30 to 20% from smaller rivers of the pre-Alps and the Jura mountains (average of about –65‰ and –10.1‰). Average values for the metalimnion of the Bay of Vidy are –89.6‰ and –12.54‰ for $\delta^2$H and $\delta^{18}$O, respectively, and –88.4‰ and –12.34‰ for depths below 60 m, indicating a slightly larger influence of Rhone water entering the bay as a well-defined, lake-wide interflow in the middle of the metalimnion (about 20 m) during summer stratification (cf. Halder et al., 2011). The Rhone water interflow can be traced from the delta of the Rhone through the lake over more than 50 km. Samples taken with the MIR 2 at depths of 50 to 200 m within the canyons close to the Rhone delta are homogeneous though, averaging –88.4‰ and –12.33‰ for $\delta^2$H and $\delta^{18}$O, respectively, hence values typical of deep lake water but not indicative of a Rhone water interflow. The canyons close to the Rhone delta are thus likely to be related to erosion via the sediment load introduced by the Rhone river water during winter circulation, while a distinct separation of the silt-laden glacial Rhone River discharge into a sediment-rich and a clear-water fraction is present in summer. Average C-isotope compositions of dissolved inorganic carbon in the hypolimnion of the lake below 60 m of –7.1‰ (VPDB) also correspond to mixing proportions of 25:75 for Jura+pre-Alpine rivers (–11.1‰) relative to Rhone waters (–5.7‰). However, below 120 down to 300 m the $\delta^{13}C_{DIC}$ values decrease from –7.2 to –8.8‰ with increasing depth and decreasing $O_2$ content (from 10 to 4 mg/l), suggesting oxidation of methane released from the sediments or increased oxidation of organic matter at depth. Waters within the Bay of Vidy have an average $\delta^{13}C_{DIC}$ of –6.9‰ while surface waters have $\delta^{13}C_{DIC}$ values of –5.3‰ (or higher), related to photosynthesis and uptake of atmospheric $CO_2$ in the epilimnion of the lake during summer.

Halder J, Decrouy L, Vennemann T (2011), Rhone water interflow in Lake Geneva inferred from stable isotope compositions. In: The role of stable isotopes in the water cycle. Basin Conference 2011, Keystone, Colorado, USA.