Noble gases as tracers for gas-exchange processes at bubble-streams in lakes and oceans

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In addition to 'traditional' methods used in limnology and oceanography, noble gases can be applied as highly sensitive tracers to analyse the transport and gas exchange induced by bubbles rising from the bottom of a water body. The concentrations of dissolved atmospheric noble gases in open waters generally correspond to the equilibrium concentrations determined by temperature and salinity during atmospheric gas exchange. As noble gases are chemically inert, only physical processes may change the noble-gas abundance and hence are responsible for deviations from the initial equilibrium. Secondary gas exchange processes induced by bubbles rising in a water body lead to specific noble-gas signatures which allow the analysis of bubble dynamics and the distinction of different gas sources. Two current studies on bubble transport employing noble gases will be presented.

In some areas of the Black Sea, high-intensity gas seeps release large volumes of gaseous methane (CH_4) from the sediment into the water column. Samples of seawater collected above active seeps in the deep part of the Black Sea are significantly depleted in dissolved noble gases compared to reference sites unaffected by gas release. Because concentrations of dissolved CH_4 are very high in the deep water, no significant differences could be detected between 'seep' sites and 'no-seep' sites. The magnitude of the noble-gas signal seems to relate to the gas-bubble flux from the seeps. Furthermore, the observed depletion patterns indicate that in addition to gas exchange of the rising bubbles, advective vertical water transport may contribute to the observed noble gas anomalies.

Lake Hallwil (Switzerland), a small eutrophic lake, is equipped with an aeration system to prevent anoxia in the deep water. This installation consists of diffusors releasing oxygen-rich gas bubbles at the bottom of the lake. We analysed noble gases in both the aeration gas and dissolved in the water of the lake. The measurements show that the aeration system leads to characteristic noble-gas enrichments in the lake water, which are related to (i) the composition of the gas input, (ii) the prevailing input flux of the aeration system, and (iii) the distance from the bubble source. In contrast, only minor changes of the dissolved oxygen concentrations could be detected due to fast oxygen consumption.