Noble gases in soil air and groundwater

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A detailed understanding of the dynamics of reactive and inert gases in the subsurface is important for reliable gas tracer studies such as noble gas temperature (NGT) determination and groundwater dating. A basic assumption of gas tracer methods is that infiltrating water equilibrates with soil air near the groundwater table. Due to microbial gas consumption and production, the partial pressures of the noble gases in soil air can deviate from atmospheric air, an effect that could offset NGT estimates if not accounted for [1]. Our study provides measurements of soil gas composition as well as noble gas (NG) contents in young groundwater at different sites near Heidelberg (Germany) and Santarém (Brazil). These study areas were chosen to compare soil gas composition under temperate and tropical climate conditions.

Soil air data confirm a correlation between the sum value of O_2+CO_2 and partial pressures of NGs both for enhanced as well as reduced values of O_2+CO_2 with respect to the atmosphere. We find significant NG enhancements in soil air by up to 7%. The strongest increase is observed in tropical Santarém, whereas NG excesses vary seasonally in temperate Heidelberg. An observed mass dependent fractionation of NG isotopes in Heidelberg can be explained by the seasonality of O_2+CO_2. However, there is no such effect in Santarém, indicating a year-long NG enhancement in soil air.

The determination of reliable absolute NGTs requires a correct accounting for bubbles of soil air that are entrapped and (partly) dissolved in the water during groundwater table fluctuations, creating the so-called excess air component. This effect is reasonably well described by the closed system equilibration (CE) model for excess air [2]. An according NGT fit was performed for the groundwater data from Santarém. A systematic underestimation of the real groundwater temperature is found under the assumption of atmospheric NG contents in soil air, while a good agreement is reached if the enhanced NG partial pressures in the local soil air are taken into account.

[1] Hall *et al.* (2005) *Geophys. Res. Lett.* **32**, L18404. [2] Aeschbach-Hertig *et al.* (2000) *Nature* **405**, 1040-1044.