The Role of Soil Air Composition for Noble Gas Paleotemperature Reconstructions in Tropical Regions

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Dissolved noble gases (NGs) in groundwater provide a well-established tool for paleotemperature reconstruction. Although most noble gas temperature (NGT) studies have been conducted in northern temperate latitudes, the few results from the tropics, in particular a study from Brazil, have provided important proofs of a significant glacial – interglacial temperature change in tropical regions.

However, reliable NGT determination requires a detailed understanding of the dynamics of reactive and inert gases in the soil air with which the infiltrating water equilibrates. Due to microbial gas consumption and production, the NG partial pressures in soil air can deviate from atmospheric air, an effect that could offset NGT estimates if not taken into account. Because biological activity is expected to be particularly strong in humid tropical soils, we studied NGs in soil air as well as young groundwater at different sites near Santarém (Pará, Brazil) and for comparison near Heidelberg (Germany).

Soil air data confirm a correlation between the sum value of O_2+CO_2 and NG partial pressures. 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.

The determination of reliable absolute NGTs also requires a correct accounting for bubbles of soil air that are entrapped and (partly) dissolved in the water during groundwater table fluctuations. The resulting excess air component is reasonably well described by the closed system equilibration (CE) model for excess air. A corresponding NGT determination 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. These findings allow for more reliable NG paleotemperature records, in particular in humid tropical areas such as the Brazilian Amazon region.

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