Biogeochemical reactions and transient pressure gradients in the unsaturated zone

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Monitoring concentrations of various gases in soils and in the unsaturated zone is of prime importance to understand exchanges at the ground-atmosphere interface. This is relevant for the use of atmospheric noble gases to quantify recharge processes, and for the monitoring of various gas emissions to the atmosphere, either due to geological processes (global carbon cycle, volatilization of methylated elements, radon emissions) or anthropogenic ones (CH_4 emission related to hydrofracturing, seepages at CO_2 sequestration sites or from VOC-contaminated sites).

Many organic and inorganic reactions, mainly biologically driven, are responsible for the production and consumption of molecular gases. The multiple-frequency variations in water content, temperature and biomass that characterize the soil and the unsaturated zone control these reactions and are responsible for large changes in the partial pressure of several molecular gases, including O_2, CO_2, CH_4, N_2O, H_2. Most importantly, the total pressure is not kept constant at the pore scale, especially when fractionation mechanisms are at play, such as differential solubility in water (e.g. O_2 vs. CO_2) or differential diffusivity (H_2, He). This results in transient pressure gradients distributed in the porous media, which in turn control the distribution and transport of inert trace gases, such as the noble gases.

Here we present results on the variability of the partial pressure of common molecular gases and its origin in soils and in the unsaturated zone of an experimental plot at the Roselend Natural Laboraory (French Alps) and how this controls the measured concentrations of noble gases, either naturally occuring (He, Rn) or injected as a tracer (Kr).