Denitrification and degassing of groundwater: implications for environmental tracer studies

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In a study towards the detection of trend reversal in groundwater quality in recharge areas of a granular aquifer in the Netherlands, agriculturally polluted with nitrate, we aimed to apply $^3H/^3He$ and CFCs dating. However, we found that the measured concentrations of helium and neon were below atmospheric equilibrium in 20 of the 34 groundwater samples: this groundwater had been "degassed".

The occurrence of pyrite in the subsurface is known to cause denitrification below the groundwater table. Subsequent exsolution of N_2 can cause degassing of groundwater. As we found no nitrate in degassed groundwater, we hypothesize that denitrification by pyrite oxidation had indeed caused degassing.

In this case, degassing had not affected the ratio between helium and neon, nor the neon isotope ratio. (Figure 1) This indicated that degassing had reached solubility equilibrium. Quick diffusive degassing would cause isotopic fractionation, which was not the case here. Therefore we could assume solubility equlibria to correct the measured tracer concentrations for degassing.

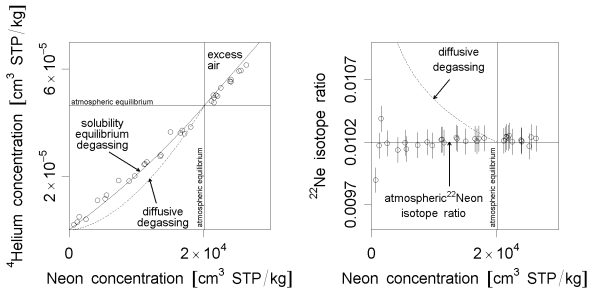

Figure 1: Degassing had not caused isotopic fractionation.

The travel time estimated by $^3H/^3He$ of degassed groundwater was very uncertain, due to uncertainty about the moment of degassing along the flowpath. To constrain the moment of degassing along the flowpath, we measured the total dissolved gas pressure at the monitoring screens, assuming it equaled the hydrostatic pressure at the depth of degassing.

Another source of uncertainty was the fate of the appearing gas phase. To determine the implications for environmental tracer studies, we examined the fate of the gas phase with the multiple-phase flow model STOMP.