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Does thoron (Rn-220) have a potential to be used as a groundwater tracer ?

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The radioactive noble gas radon has two important isotopes, ^{222}Rn ("radon", half-life $t_{1/2}$ = 3.8 d), and ^{220}Rn ("thoron", $t_{1/2}$ = 56 sec). Today's use of radon as a tracer for dating very young ground water assumes constant initial and steady-state concentrations, which is often not the case. A combination of radon concentrations and thoron/radon isotope ratio at steady state (^{220}Rn/^{222}Rn = δ^{222}Rn) could possibly increase the importance of radon as a groundwater tracer. If the δ^{222}Rn isotope ratio is *constant* along the flow path, we could infer the local steady-state radon emanation from a thoron concentration measurement. If it is *variable*, ground waters of different origin mix along a flow path, and dating is possible only as an average of the ages of the individual groundwater bodies. We hypothesize that the emanation dynamics of thoron is different from that of radon. The radon precursors, ^{226}Ra and ^{230}Th, are enriched on surfaces of aquifer materials, which sets the basis for its enhanced emanation into subsurface fluids. For the thoron precursors, ^{228}Ra, ^{228}Th and ^{224}Ra, there is only limited knowledge about their geochemical behavior in the natural environment. In contrast to radon, thoron has almost never been analyzed in shallow phreatic ground water. We detected thoron concentrations at the outlet of a mineral spring with *anoxic* ground water, by measuring the ^{216}Po thoron prompt. We hypothesize that dissolved Ra could be scavenged as a co-precipitate of Fe and Mn oxides/hydroxides and adsorbed on surfaces of aquifer materials, upon contact with the atmosphere. The decay of ^{228}Ra and ^{224}Ra subsequent to co-precipitation with Fe and Mn oxide/hydroxides probably yielded high enough "secondary" thoron to be measured in the spring water.

From here, large amounts of radon and thoron can be made available for transport. To assess the emanation dynamics of thoron, we have to analyze the Ra precursors of radon and thoron, i.e., ^{226}Ra, and ^{228}Ra and ^{224}Ra, respectively. These Ra isotopes might be concentrated up in the Fe and Mn oxide/hydroxide precipitates with time. ^{228}Ra measurements showed that the efficiency with which Ra is adsorbed on these precipitates was at about 10 per cent. We did not find any thoron to-date in *oxic* phreatic ground water and spring water, even when sampled directly at its emergence from the formation. This is in accordance with our model assumptions. In the future, we will try to detect thoron in hyporheic ground water. In summer, many hyporheic zones with a high content in organic carbon tend to have suboxic and anoxic ground water from the infiltration of river water. Here thoron could be used as a proxy for the steady-state radon concentrations and become part of the radon method for dating such very young ground water.