



Thoron (^{220}Rn) in spring water

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Thoron (^{220}Rn , half-life 55.6 s) is a shorter-lived isotope of the radioactive noble-gas radon (the longer-lived isotope is ^{222}Rn ; half-life 3.6 d). Both radionuclides are part of a natural radioactive decay chain, thoron from the ^{232}Th and radon from the ^{238}U series. They can be found in soil-near air and soil-gas, and, in case of radon, its occurrence in ground water is well known. We expected to find also thoron in groundwater. But, as radon and thoron result from different decay chains, the geochemical and geophysical behaviour of their precursors differs, too. The emanation of thoron out of solid material that contains the thoron precursor ^{224}Ra and the occurrence in aquatic systems are not well known. To assess the thoron emanation, we formulated two working hypotheses. The first one is based on the low solubility of the thoron precursors in oxic ground waters: ^{232}Th and its daughter nuclides will remain located at almost the same positions in the crystal lattice as their precursors. In that case, the thoron concentration in groundwater depends on the distribution of the precursors in the aquifer material ("primary emanation"). The second hypothesis is based on the enhanced mobility of the radium isotopes, the precursors of $^{220,222}\text{Rn}$, in anoxic ground water of springs. If the anoxic spring water gets in contact with oxygen, Ra tends to co-precipitate with Fe and Mn oxide/hydroxides and accumulates at surface coatings. From the decay of ^{224}Ra thoron emanates to the water phase ("secondary emanation"). We measured radon and thoron with a Rad7 solid-state detector coupled to a RadaQUA unit (closed gas loop, in contact with sprayed flowing water), which allows continuous measurement of radon and thoron in water. In order to test our working hypothesis, several springs containing oxygen were analysed - none of them showed any detectable thoron. At an anoxic mineral spring with Fe and Mn oxide/hydroxide precipitations at its outlet we have measured a thoron concentration of around 0.2 ± 0.1 Bq/L. The same anoxic ground water being abstracted from a deep well at a distance about 2 km from the spring is void of thoron. In another anoxic spring of a different chemical composition, but again with Fe and Mn oxide/hydroxide precipitations, we did not detect thoron either. However, analysing the precipitates of both springs for gamma radiation, the $^{220,222}\text{Rn}$ precursors could be identified. Hence, the absence of thoron in this water is most probably related to fast decay of thoron and the slow detection system to determine thoron. However, our results show that thoron measurements are principally feasible but only in anoxic ground water and hence argue in favour of thoron emanation surface-related Fe/Mn precipitate (the second hypothesis). In order to improve thoron determination we have to modify the measurement procedure to decrease the residence times of water and air.