Impact of cosmogenic Ar-39 production on groundwater dating

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The constant activity of Argon-39 ($t_{1/2}$ = 269 yrs) in the atmosphere (100%mod) and its inertness in the subsurface makes it an ideal dating tracer on time scales from 50 to 1200 years. A potential limitation is the possibility of underground production by neutron activation of potassium. Over modern Ar-39 concentrations have for example been observed in U- and Th- rich deep crystalline rocks [1]. Cosmogenic neutrons in shallow depths have little impact if recharge is fast. However, unlike neutrons, muons reach deeper layers but their relevance for radioargon production via $^{39}K(\mu^-,\nu_\mu)^{39}Ar$ reactions was never considered so far.

We report on a large scale groundwater dating campaign in Funen (Denmark). In this area, over modern ^{39}Ar activities are observed in low U formations at relatively shallow depths. This is likely the result of ^{39}Ar production by muon capture [2]. In the presentation, calculated production rates are compared with ^{39}Ar and ^{37}Ar measurements. Additionally, ^{85}Kr, ^{222}Rn, ^{36}Cl and $^{3}H/^{3}He$ data are used to constrain residence time and production mechanisms. By considering the ^{39}Ar production rate- and the water residence time as function of depth, the integrated impact of cosmogenic ^{39}Ar production is evaluated for specific recharge scenarios. The results of over 100 ^{39}Ar measurements are then used for a regional mapping of groundwater residence times in this area highly affected by pesticides and fertilizers.

[1] O. Šrámek *et al*. 2017 [2] D.-M. Mei *et al*. 2010