^{4}He/U-Th dating of pore waters from Quaternary sediments in Switzerland: potential and challenges

*Yama Tomonaga[1], Edith Horstmann[1], Gaudenz Deplazes[2], Rolf Kipfer[1]

1. Swiss Federal Institute of Aquatic Science and Technology (Eawag), 2. National Cooperative for the Disposal of Radioactive Waste (Nagra)

Dating based on the ^{4}He/U-Th method is used to estimate the residence time of pore waters in very low-permeable rocks and consolidated sediments. The residence time is inferred from the time necessary to accumulate radiogenic ^{4}He measured in the pore water being produced by the decay of U and Th in the sediment matrix [1].
In the Jurassic Opalinus Clay, the pore water still contains remnants of the original marine formation water that was entrapped during sediment deposition. The pore water composition was altered only by diffusive processes [2,3]. The fact that even ~100-Ma-old water signatures can be preserved in their original pore space suggests that such preservation might also be possible in much younger dense glacial deposits. The ^{4}He concentrations measured in the pore waters of glacial tills were translated into mean residence times of 15-25 kyrs [4] that agree rather well with the expected depositional ages of 25-31 kyrs [5]. These observations, as well as evidence from lacustrine sediments [6,7], suggest that, if the solute transport in the pore space is sufficiently attenuated, even unconsolidated sediments can "store" and host "old" pore waters.
In the present work we investigate if the ^{4}He/U-Th dating of pore waters can be used as a novel tool to complement the luminescence dating of unconsolidated Quaternary sediments. We applied the ^{4}He/U-Th method to date pore waters in the time range of 10 to 100 thousands of years which covers the age range of the sedimentary depositions targeted by the Quaternary drillings (QBOs) managed by the National Cooperative for the Disposal of Radioactive Waste (Nagra) in Switzerland. In particular, we focus on fine-grained lacustrine sediment layers that might provide low-permeability conditions suitable for the preservation of radiogenic ^{4}He concentrations in the pore space.
We report the preliminary results of the ^{4}He/U-Th dating based on the measurements conducted in sediment samples from the first QBOs, highlighting potential and challenges of the method with respect to the studied glaciofluvial sediments of the Swiss Midland.

References

[1] Torgersen, T., Clarke, W.B. (1985). Helium accumulation in groundwater, I: an evaluation of sources and the continental flux of crustal ^{4}He in the Great Artesian Basin, Australia. *Geochim. Cosmochim. Acta 49*, 1211–1218.
[2] Gimmi T., Waber H. N., Gautschi A., Rübel A. (2007). Stable water isotopes in pore water of Jurassic argillaceous rocks as tracers for solute transport over large spatial and temporal scales. *Water Resour. Res. 43*(4).
[3] Mazurek, M., Alt-Epping, P., Bath, A., Gimmi, T., Niklaus Waber, H., Buschaert, S., et al. (2011). Natural tracer profiles across argillaceous formations. *Appl. Geochem. 26*(7), 1035–1064.
[4] Hendry, M. J., Kotzer, T. G., Solomon, D. K. (2005). Sources of radiogenic helium in a clay till aquitard and its use to evaluate the timing of geologic events. *Geochim. Cosmochim. Acta 69*(2), 475–483.
[5] Wassenaar L.I., Hendry M.J. (2000). Mechanisms Controlling the Distribution and Transport of ^{14}C in a Clay-Rich Till Aquitard. *Groundwater 38*(3), 343–349.

[6] Tomonaga, Y., Brennwald, M. S., Meydan, A. F., Kipfer, R. (2014). Noble gases in the sediments of Lake Van - Solute transport and palaeoenvironmental reconstruction. *Quat. Sci. Rev. 104*, 117–126.
[7] Tomonaga, Y., Brennwald, M. S., Kipfer, R. (2015). Attenuation of noble-gas transport in laminated sediments of the Stockholm Archipelago. *Limnol. Oceanogr. 60*(2), 497–511.

Keywords: pore water, noble gases, unconsolidated sediments

