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MSc Thesis Summary, **2017-2018**
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Groundwater Dating with Krypton-85 in combination with Borehole Logging

Groundwater is a primordial drinking water source for billions of people on earth as well as a crucial resource for agriculture and industry. A sustainable exploitation, and a sufficient quality are the crux of this natural resource. Those parameters are directly linked with the groundwater residence time i.e. its age.

Principle

The environmental tracers are the main tools for groundwater dating. Those natural compounds broadly distributed in the Earth's surface incorporate the radioactive noble gases that are produced by anthropic activities as for example the Krypton-85. The latter, when used as tracer for groundwater dating, has two key strengths: first, its inertness makes it an almost ideal tracer and second, the analytical method uses the ratio between ^{85}Kr and the non-radioactive isotope ^{84}Kr, thus making it insensitive to sample loss and concentrations issues. Groundwater is then dated by measuring the remaining radioactivity of Krypton-85 as the production is assumed to stop when the water infiltrates. The dating is improved here by the development of new in situ samplers. The gas rather than the water (in the conventional method) is thus extracted from the well which greatly facilitates the field work.

In order to assess the age structure of the pumping well, this dating method is combined with logging methods. Indeed, a very innovative high-resolution thermal logging associated with speed flowmeter measurements and televiewing allows to assess precisely the position as well as the intensity of the inflows in the borehole. By placing samplers for the dating at defined depths and deconvolving the signal for the mixing processes, it is possible to assess the age structure of the well and thus its vulnerability towards anthropogenic pollutants. This information is particularly important in the context of emerging pollutions and micro-pollutants.

As the samples are taken in Canada and the analysis takes place in Switzerland, a transfer method based on a liquid nitrogen trap combined with activated charcoal was also developed in order to be able to send the samples.

Results

The borehole logging appears to be a very efficient method to characterize the fractures in the well. This method was applied to six boreholes in the area of Montreal, in the Quebec Province under the supervision of the Geotop Institute of the University of Quebec in Montreal (UQAM). The results demonstrate that the temperature results are very reliable and well reproducible. Combined with the spinner flowmeter, which enables the intensities assessment, and the televiewer, which allows visualization of the fracture morphology, very exhaustive profiles are obtained.

The in situ passive samplers also revealed to work very well. First of all, the quantity of Krypton sampled was higher than the minimum analytical requirements which allow the dating. Second, no atmospheric leak occurred during the whole process from the sampling to the analysis as the deep samples showed a significant depletion in Krypton-85 activity and a concordant pressure in the tank before the transfer to the bags. The corresponding age was calculated thanks to the Krypton-85 input function established by the German Federal Office for Radiation Protection.