



## Estimating the groundwater residence time in eskers of the Amos region, northern Quebec by ${}^3\text{H}$ - ${}^3\text{He}$ and (U-Th/ ${}^4\text{He}$ ) methods

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An esker is a long winding ridge of stratified sand and gravel. The eskers of the Amos region (Abitibi-Témiscamingue, Québec) that were deposited during the last deglaciation, are known to be aquifers containing drinking water of exceptional quality. Yet little is known about their hydrologic regime and exchanges with other water sources. A better understanding of these systems is necessary to assess the vulnerability of these aquifers to contaminants and to implement a management plan for these resources. A multi-isotopic study of groundwater in the eskers of the Amos region (Saint-Mathieu-Berry, Barraute and Harricana moraine) was carried out in 2011-2012. Noble gas isotopes, together with major ions chemistry and stable isotopes were used to estimate the residence time of waters, to trace fluid flow paths and to determine the atmospheric temperature at the time of the recharge took place. Measured  ${}^3\text{He}/{}^4\text{He}$  ratios were primarily used to identify mixing between different water types carrying distinct helium components. The  ${}^{20}\text{Ne}/{}^4\text{He}$  vs.  ${}^3\text{He}/{}^4\text{He}$  relationship shows that waters flowing into eskers have three helium components: atmospheric, tritogenic  ${}^3\text{He}$ -rich and radiogenic  ${}^4\text{He}$ -rich. The measured  ${}^3\text{He}/{}^4\text{He}$  ratios (R) normalized to the atmospheric one (R/Ra) varies between  $0.224 \pm 0.012$  and  $1.849 \pm 0.036$ . Most radiogenic  ${}^4\text{He}$ -rich mineralized waters are those from fractured basement rocks of Archean age. Freshwater flowing into eskers show mixing between radiogenic helium and tritogenic  ${}^3\text{He}$ . A clear relationship between the well depths, salinity and the  ${}^3\text{He}/{}^4\text{He}$  ratios suggests that mixing occurs between these two groundwater bodies. Tritium measurements allow the calculation of  ${}^3\text{H}$ - ${}^3\text{He}$  ages varying from  $6.7 \pm 1.3$  yrs to  $9.7 \pm 1.3$  yrs for waters flowing through the Harricana moraine. Groundwater from Saint-Mathieu de Berry esker ranges from  $11.0 \pm 2.1$  yrs to  $32.5 \pm 1.6$  yrs. The  ${}^3\text{H}$ - ${}^3\text{He}$  ages plotted against the wells depth show a linear relationship for both, the Saint-Mathieu-Berry esker and the Harricana moraine allowing calculation of vertical infiltration rates varying between 0.9 and 7.0 m/yr. A calibrated  ${}^4\text{He}$  production rate allows estimation of (U-Th/ ${}^4\text{He}$ ) groundwater residence times. The oldest waters are those from the fractured bedrock and display an age of 8000 years. Intermediate waters with ages varying from 50 to 800 yrs are likely the result of mixing between deeper fossil water and freshwater flowing through the eskers. Interestingly, the oldest ages recorded in the Saint Mathieu Berry esker are located in a fault zone.