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Measurements of diffusion coefficient of dissolved He and fractionation between ^{3}He and ^{4}He during diffusion through rocks

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Fractionation between dissolved ^{3}He and ^{4}He can help to evaluate fluid transport mechanisms [1] and is considered significant because the mass ratio of ^{3}He to ^{4}He is relatively large. ^{3}He may become a more powerful tool to understand the history of He migration (diffusion and/or advection) in groundwater if we can understand well about fractionation of them during diffusion processes.

So far, only a few studies have investigated the fractionation of ^{3}He and ^{4}He during diffusion [2]. One of the reasons for the lack of data is the difficulty of the diffusion experiments for dissolved He. Sampling and measurement should be carried out carefully because such processes can easily affect the concentration and isotopic ratio.

We have developed a new experimental system using a “passive sampler [3]” to evaluate both the diffusion coefficient of He (D_{He}) and the ratio of D_{He} for ^{3}He and ^{4}He (α). The passive sampler consists of a gas-separator connected with a reservoir and a coiled silicon tube with a thin wall was used for gas-separator. Though diffusion experiments were conducted and passive sampler was immersed into downstream cell. For the evaluation of D_{He}, the sampler was directly connected to GC to measure concentration of He in the reservoir. A valve with a cap was connected to the gas-separator and ^{3}He/^{4}He of gas in the space between valve and cap was measured for α evaluation.

The experimental system was applied to 3 types of saturated sandstones (Tako, Kimachi and Izumi SS). The D_{He} for Tako, Kimachi, and Izumi SS was 18, 10 and 1.6 $x10^{-11}$(m^2/s), respectively. The α values for Tako, Kimachi, and Izumi SS was evaluated as 1.137, 1.139 and 1.179, respectively and seemed to increase with decrease of D_{He}.

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[1] Nakata et al., (2018), Geofluids.

[2] de Magalhães et al., (2017), Environmental Science: Processes & Impacts

[3] Gardner and Solomon (2009) Water Resour. Res.