2-6 Challenges in Collecting Nanoscale Particles from Groundwater

— Development of New Ultrafiltration Techniques Maintaining In situ Pressure and Anaerobic Conditions —

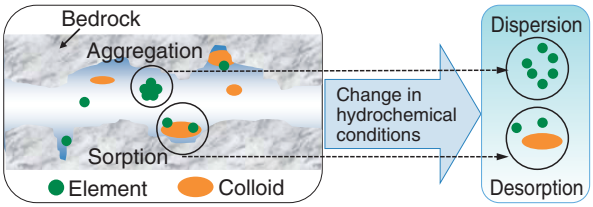


Fig.2-14 Change in colloids with the change in the hydrochemical conditions of groundwater
Physicochemical properties of colloids can be changed with the hydrochemical conditions of groundwater, such as pH, Eh, change by pressure release, and exposure to the atmosphere during sampling.

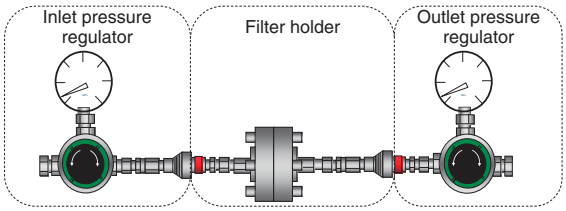
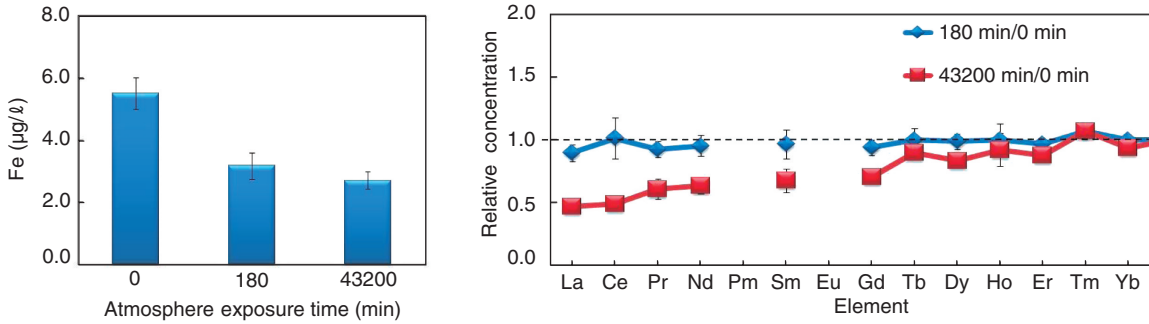


Fig.2-15 Schematic of the ultrafiltration instrument that maintains pressurized/anaerobic conditions
The instrument, made of Stainless Used Steel (SUS) materials, was designed to maintain anaerobic conditions at a high hydraulic pressure (10 MPa). The inlet and outlet pressure regulators can be used to adjust the differential pressure and thus prevent excess resistance pressure of the membrane filter (around 0.35 MPa).



∗ Error bars indicate the standard deviations of triplicate ICP-MS measures.
∗ Concentration of Eu was lower than detection limit of ICP-MS (<0.1 ng/ℓ), Pm does not exist in nature.

Fig.2-16 Concentration of Fe (left) and relative concentration of rare earth elements (right) in filtered groundwater at different atmosphere exposure times
The concentration of Fe decreased with the exposure time, suggesting that Fe in the groundwater aggregated on the filter by oxidation (left). The blue markers denote the data at 180 min normalized by the data at 0 min; red markers denote the data at 43200 min normalized by the data at 0 min. The concentration of the rare earth elements decreased with the exposure time, suggesting that the rare earth elements in the groundwater adsorbed onto the Fe colloids aggregated on the filter by oxidation (right).

Understanding the behavior of elements in an underground environment is important for safety assessment of the geological disposal of high-level radioactive waste. The behavior of elements in an underground environment is mainly controlled by groundwater flow and its interaction with rocks (e.g., adsorption). Additionally, the migration velocity of the elements is accelerated or delayed by colloids (particles in the size range 1 to 1000 nm). However, physicochemical properties of colloids can be changed when the hydrochemical conditions of groundwater change by pressure release and exposure to the atmosphere during sampling (Fig.2-14). This can pose problems when studying the colloids in groundwater. In this study, in order to solve the problem, an ultrafiltration instrument that maintains the in-situ pressure and anaerobic conditions was developed (Fig.2-15).

Ultrafiltration of groundwater at a depth of 200 m was conducted. Chemical analyses of the groundwater were also conducted on samples filtered under atmospheric conditions (exposure time: 180 and 43200 min) and pressurized/anaerobic conditions (exposure time: 0 min), i.e., by using the ultrafiltration instrument (Fig.2-16). The result of the analysis under atmospheric conditions indicates that Fe in the groundwater aggregated and formed colloids by oxidation. Moreover, it was expected that rare earth elements had been adsorbed onto the Fe colloids. Therefore, it was clear that the problem of the colloids changing could be solved by using the ultrafiltration instrument.

The filter in the filter holder can be set aside and transported while maintaining the pressurized/anaerobic conditions. Thus, the colloids adsorbed on the filter can be used for various analyses. In the future, we aim to elucidate the effect of the colloids on the behavior of the elements in groundwater by evaluating the physicochemical properties of the colloids collected by the ultrafiltration instrument.

Reference

Aosai, D. et al., Development of New Ultrafiltration Techniques Maintaining In-Situ Hydrochemical Conditions for Colloidal Study, Proceedings of the ASME 13th International Conference on Environmental Remediation and Radioactive Waste Management (ICEM2010), Tsukuba, Japan, 2010, ICEM2010-40074, 8p., in CD-ROM.