Validation of Groundwater Dating Method Using ^{36}Cl for Low Permeable Rock

Background

On safety assessment of high level waste disposal, groundwater flow is important for evaluation of radionuclide transport (Fig.1). The groundwater flow in candidate rock for waste disposal is expected to be stagnant, thus collecting water for chemistry analysis would be difficult. Therefore, we have researched groundwater dating methods using ^{36}Cl and ^{4}He which are applicable from tens of thousands to million of years (Fig.2), and developed these methods for low permeable rock. We have already established the ^{4}He method for low permeable rock. It is necessary to establish the ^{36}Cl method.

Objectives

The purpose of this study is to validate the developed ^{36}Cl dating method for application to low permeable layers in the Great Artesian Basin.

Principal Results

The Great Artesian Basin is suitable for validating groundwater dating methods because it has relatively simple geological formation and is stable over the long term. We conducted borehole investigation at Richmond and Marree in the Great Artesian Basin (Fig.3). We collected core samples and applied ^{36}Cl method that we developed for low permeable rock.

1. ^{36}Cl sample collecting method from low permeable rock

Squeezing and leaching were conducted for collecting ^{36}Cl sample from low permeable rock. The ^{36}Cl concentrations of squeezing and leaching are consistent with each other. Therefore, it is confirmed that water sample could be collected by squeezing and leaching (Fig.4).

2. Profile of ^{36}Cl and transport mechanism

The Profile of ^{36}Cl was investigated. ^{36}Cl concentration decreases with depth exponentially. It was presumed that ^{36}Cl was supplied by rain and transported by diffusion with radioactive decay (Fig.5). The profile of ^{36}Cl was expressed by exponential function using diffusion-equation under steady state. Moreover, the profile of ^{36}Cl could be reproduced by diffusion equation using diffusion coefficient and porosity measured in laboratory test (Fig.6).

3. Characterizing groundwater velocity through low permeable rock using ^{36}Cl

The validity of ^{36}Cl dating developed for low permeable rock was confirmed by no difference between colleting methods and reproducibility of the ^{36}Cl profile. From Peclet Number with diffusion dominant condition, the groundwater velocity is quite smaller than 7×10^{-14} m/s at Richmond and 2×10^{-13} m/s at Marree, respectively. From these results, the very slow groundwater flow was proved in low permeable layer.

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Future Developments

Developed ^{36}Cl dating method for low permeable rock will be conducted in Japan to confirm applicability and usefulness of characterization on very slow groundwater flow.

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Reference

Research and development of groundwater dating (Part 8) - Validation on ^{36}Cl dating method to characterize low permeable layer-, Civil Engineering Research Laboratory Rep. No.N07038. (in Japanese)

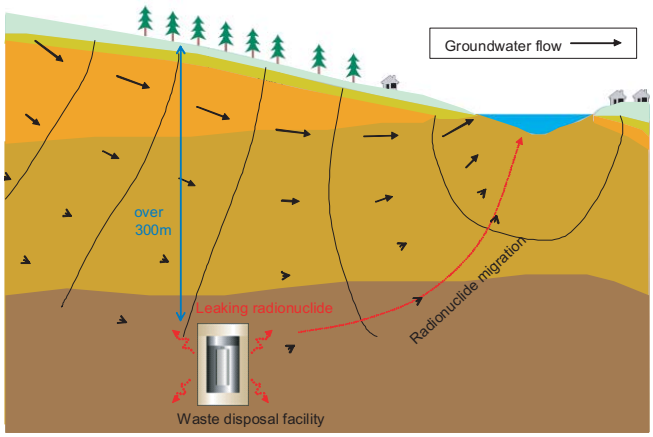

Fig.1 Concept of waste disposal in deep geological formation

Very slow groundwater flow is expected in deep geological formation, therefore waste facility plan to construct over 300 m in depth

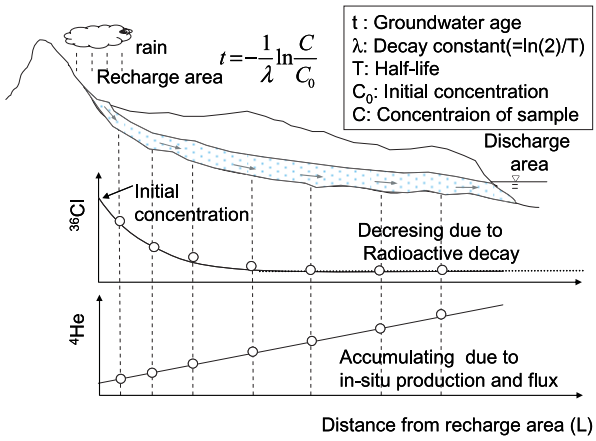

Fig.2 Concept of groundwater dating method

^{36}Cl has half-lives with 301,000 year, groundwater age are determined by concentration change due to radioactive decay

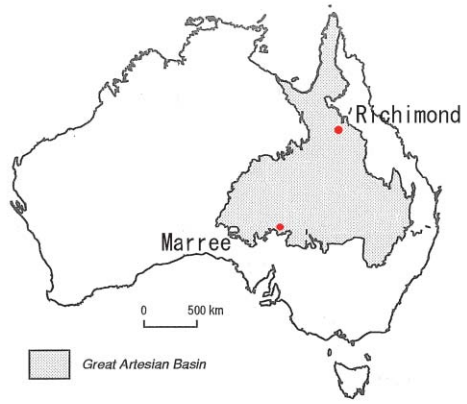

Fig.3 Location of borehole in Great Artesian Basin

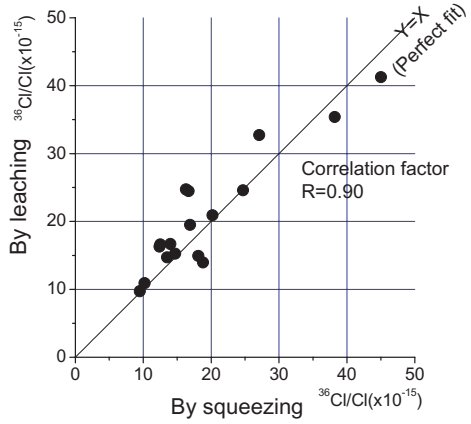

Fig.4 Comparison of sampling method for ^{36}Cl/Cl

Squeezing: water depleted by compressing
Leaching: exchange water by diffusion

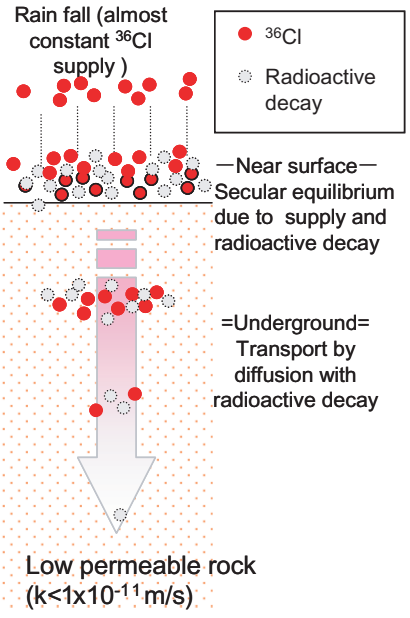

Fig.5 Transport mechanism of ^{36}Cl

^{36}Cl concentration is almost constant near surface, and is transported by diffusion with radioacitive decay in underground.

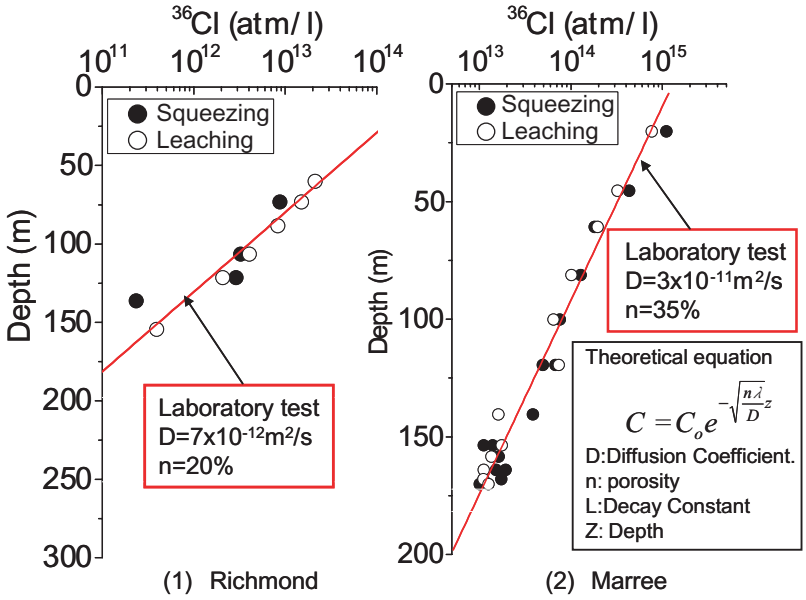

Fig.6 Profile of ^{36}Cl concentration

Measured data was reproduced by diffusion equation using diffusion coefficient and porosity measured in laboratory test (Red line).