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Helium isotopes and 36Cl in saline deep groundwater from the Osaka Basin, Southwest Japan

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Isotopic composition and concentration of helium and chlorine in groundwater are a useful indicator for identifying groundwater flow path and estimating a very old groundwater age. Morikawa et al. (2008) investigated the He isotopes in deep groundwater from the Osaka Basin, southwest Japan, in which unusual saline water containing upper mantle-like helium welled out (Especially in Arima and Ishibotoke area). Observed $^{3}He/^{4}He$ variation in deep groundwater was clearly related with the geological structure. The $^{3}He/^{4}He$ ratios decrease with increasing distance from the faults. It has been proposed a model that spatial distribution of $^{3}He/^{4}He$ ratio reflects the movement of fluids through the fault and following dissolution of crustal $^{3}He/^{4}He$ during groundwater flow. The amount of accumulated $^{3}He/^{4}He$ corresponds to the age for hundreds of thousands of years.

Chlorine-36 is a radioactive nuclide, which decays with a half-life of 301,000 years and is thus applicable to dating very old groundwater. Another possible application of this isotope is a method using subsurface produced ^{36}Cl to investigate the origin and evolution of saline water.

In this study, we investigated the distribution of $^{36}Cl/Cl$ ratio to examine the saline groundwater flow model inferred from the He results. Most of $^{36}Cl/Cl$ ratios in the deep groundwaters from the Osaka Basin (4.1-25.6 x 10^{-15}) are higher than those in Arima-type thermal water and sea water. These high ratios are not due to mixing of modern surface water which contains bomb-^{36}Cl, but an incorporation of subsurface products of nucleogenic ^{36}Cl during deep groundwater flow, since the data points are significantly plotted above the mixing line between modern meteoric water and Arima-type water. Spatial distribution of these data shows that the $^{36}Cl/Cl$ ratios increase straightforward towards the middle part of the basin. This trend is consistent with observed decreasing $^{3}He/^{4}He$ ratio toward the middle part of the basin. Considering a concurrent change in $^{36}Cl/Cl$ and He concentration, increasing $^{36}Cl/Cl$ ratio reflects increase of groundwater residence time towards the basin and thus shows groundwater flow direction.

Keywords: groundwater, helium, chlorine-36, groundwater age, Osaka Basin