# Groundwater study using drill holes in the Abukuma granitic province, NE Japan: the multi-isotopic approach to evaluate crack water stability

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Chemical nature or origin of groundwater in cracks has been poor understood because of difficulties on collection of water samples preserving its natural conditions. Little is known on the quantification on stability and mean residence time of crack water also. We conducted a study of groundwater in cracks by drilling two bore holes, and analysis using the multi-isotope approach. The sites have set in a granitic province called Abukuma, NE Japan, and drill holes 140m- and 180m-deep were made. In situ sampling of waters each drill holes are done with the single and double packer methods.

Chemical type of groundwater has a variety with depth, the shallower groundwater is categorized as Ca-$HCO_3^-$ type with slight $NO_3$ contamination whereas deeper one has Na-$HCO_3^-$ type. Stable isotope composition of water showed that all the sample water is of meteoric origin. However, the δD at deeper level has significantly low values obviously indicating that the groundwater does not originate from the present one.

The $\delta^{13}C$ values of DIC from two sites, Shirasawa and Miharu, show different profiles vertically. The $\delta^{13}C$ profiles indicate that carbon at the Shirasawa site is derived from biogenic source, but that at the Miharu site is influenced from other sources, such as "crustal fluid" upwelling from a deep geologic environment. The apparent $^{14}C$ date calculated using the evaluated $\delta^{14}C$ value is getting older to deeper depth at both sites.

At the Miharu site, the tritium is detected even at depth of 180m, indicating that relatively young water has invaded into the crack water. As the vertical profiles of δD and $\delta^{18}O$ show relatively small changes, the vertical mixing of crack water, surface water and crustal fluid likely occurs. However, the result beyond the 10000 yrBP in the apparent $^{14}C$ date suggests that the carbon mixing does not frequently occurred.

As for the Shirasawa site, the deeper the crack water, the lower the δD and $\delta^{18}O$ values are represented. Groundwater with very low δD and $\delta^{18}O$ values is likely recharged in an ice age consistent with the apparent $^{14}C$ date showing the older age of carbon in the crack water than 10000 or 20000 yrBP. The evidence shows that crack water can be trapped for a very long period even at a shallow depth (80-180m).