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Spatial and temporal variation of residence time and storage volume of subsurface water evaluated by multi-tracers approach in mountainous headwater catchments

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Headwater catchments in mountainous region are the most important recharge area for surface and subsurface waters, additionally time and stock information of the water is principal to understand hydrological processes in the catchments. However, there have been few researches to evaluate variation of residence time and storage volume of subsurface water in time and space at the mountainous headwaters especially with steep slope. We performed an investigation on age dating and estimation of storage volume using simple water budget model in subsurface water with tracing of hydrological flow processes in mountainous catchments underlain by granite, Paleozoic and Tertiary, Yamanashi and Tsukuba, central Japan.

We conducted hydrometric measurements and sampling of spring, stream and ground waters in high-flow and low-flow seasons from 2008 through 2012 in the catchments, and CFCs, stable isotopic ratios of oxygen-18 and deuterium, inorganic solute constituent concentrations were determined on all water samples.

Residence time of subsurface water ranged from 11 to 60 years in the granite catchments, from 17 to 32 years in the Paleozoic catchments, from 13 to 26 years in the Tertiary catchments, and showed a younger age during the high-flow season, whereas it showed an older age in the low-flow season. Storage volume of subsurface water was estimated to be ranging from 10ˆ4 to 10ˆ6 m3 in the granite catchments, from 10ˆ5 to 10ˆ7 m3 in the Paleozoic catchments, from 10ˆ4 to 10ˆ6 m3 in the Tertiary catchments. In addition, seasonal change of storage volume in the granite catchments was the highest as compared with those of the Paleozoic and the Tertiary catchments. The results suggest that dynamic change of hydrological process seems to cause a larger variation of the residence time and storage volume of subsurface water in time and space in the granite catchments, whereas higher groundwater recharge rate due to frequent fissures or cracks seems to cause larger storage volume of the subsurface water in the Paleozoic catchments though the variation is not so considerable. Also, numerical simulation results support these findings.