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# Recharge and flow processes of groundwater on the outer rim slope of Hakone caldera

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The purpose of this study is to understand recharge and flow processes of groundwater on the slope of outer rim of Hakone caldera, central Japan from using environmental tracer methods. 99 stream and 38 spring water samples were collected from study area in middle of August to early September 2010, and analyzed for oxygen isotopic composition ($d^{18}O$).

The stream and spring waters in the western slope of study area have higher $d^{18}O$ value compared with that in other slopes as well as precipitation data presented by Miyashita (2009). The isotopic difference between western and other slopes are probably caused by a rain shadow effect of mountain, because the dominant wind directions during summer period, when intensive groundwater recharge occurs, is from SW to NE. In other words the precipitation of northeastern slope, which is leeward side, is more isotopically depleted than that of western slope, which is windward side. A comparison of spring water samples at the same elevation (about 1000m a.s.l., near the top of outer rim) indicate that $d^{18}O$ of those on the leeward northeastern slope are more isotopically depleted and about 1.0 per mil less than those from the windward west slope.

Therefore, it is necessary to evaluate the altitude effect of water samples in each slope (west, southeast and northeast), dividing from the spatial distribution patter of $d^{18}O$. Based on the relationship between $d^{18}O$ values and mean elevations of catchment for several selected springs, recharge-water lines were obtained in each slope. Altitude effect of recharge water in each slope was different: -0.2 per mil/100m for the western slope, -0.18 per mil/100m for the southeastern slope and -0.14 per mil/100m for the northeastern slope. CFCs (chlorofluorocarbon) and SF6 (sulfur hexafluoride) have been used to determine the average residence time for two spring waters, located on the middle (360m a.s.l.) and lower (45m a.s.l.) part of the northeastern slope. Consequently, the residence times of both spring waters were $<$ 20 years (probably about 10 years). On the basis of mean recharge elevation obtained by recharge-water line and distribution pattern of springs and result of the CFCs and SF6 datings, conceptual model of groundwater flow system in the outer rim slope of Hakone caldera are proposed.

Miyashita (2009) reported that the $d^{18}O$ of stream and spring waters was about 2 per mil higher than weighted mean $d^{18}O$ of precipitation at the same elevation. It has also been found that the difference in $d^{18}O$ between recharge water and precipitation was 1.5˜2.0 per mil in this study. The difference may be responsible for the evaporation of precipitation in the recharge process, and we calculated annual evaporation rate using the Rayleigh-type equation. The evaporation rates are about 15 percent of the annual precipitation in each slope.

Keywords: Hakone volcano, Oxygen isotope composition, Rain shadow effect, Altitude effect, Groundwater flow system, Evaporation rate