Geochemical study on groundwater and thermal water in and around Iwate volcano, Japan: dispersion feature of magmatic volatiles through the groundwater flow system

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Iwate volcano, typical polygenetic volcano, located in the NE Japan is composed of two stratovolcanos, East Iwate and West Iwate. Groundwater flow system in and around this volcano is strongly restricted by the complex structure of volcano made by several times collapses of volcanic body (Kazahaya *et al.*, 1998). Understanding the groundwater flow system is very important to evaluate the amounts and the influence range of the magmatic volatiles from volcanic body. In this study, we show the feature of chemical and isotopic compositions of the groundwater and thermal water which have collected from variety of depth and discuss the groundwater flow system and the supply of magmatic volatiles to the groundwater and thermal water in and around Iwate volcano in conjunction with the subsurface geological structure.

Two big springs called Kanazawa-Shimizu spring and Oide spring with flow rates reaching 50000 tons/day are placed in the north and east flanks. The previous study of spring water shows that the shallow groundwaters in north and east flanks recharged at the summit area of Iwate volcano. The flow systems are restricted in north and east directions which correspond to the places of younger collapses of volcanic body (Kazahaya *et al.*, 1998). Both Kanazawa-Shimizu and Oide springs have high concentration of major chemical components and high $^{3}He/^{4}He$ ratios (3.2Ra and 4.0Ra). The groundwaters in this north and east flanks also have relatively high concentration of major chemical components and relatively higher $^{3}He/^{4}He$ ratios (1.1-4.1Ra) than the atmospheric value. In contrast, the thermal waters at several hundred meters depth boreholes have lower $^{3}He/^{4}He$ ratios (0.1-0.6Ra) in the same area. These results suggest that the larger amount of magmatic volatiles at the summit area is supplied to the shallow groundwater system and less amount of that have been injected into the deep aquifer system.

In the southwest flank, an active fault named Shizukuishi fault is placed. The thermal waters along this fault are collected from boreholes with about 1000m depths and have high Cl^- and HCO_3^- concentrations and high $^{3}He/^{4}He$ ratios (2.5-3.0Ra). Additionally, the groundwaters in this area also have high HCO_3^- concentrations and $^{3}He/^{4}He$ ratios (1.7-5.3Ra). The recharge area of these groundwaters is placed at comparatively low altitude of the south flank of volcano and does not cover the fumarolic area, suggesting that the magmatic or mantle derived volatiles are likely supplied through the fault system.

The vertical profile of radiogenic ^{4}He concentration in W-E section of Iwate volcano which should be related to a residence time of groundwater indicates that the groundwater at shallow depth inside the Iwate volcanic body have very low concentration of radiogenic ^{4}He, whereas the thermal water in the Tertiary volcanics and pre-Tertiary sediment have high concentration of radiogenic ^{4}He. Accumulation of radiogenic ^{4}He suggests that the age of the waters is older. It is concluded that the groundwaters in the Tertiary volcanics and pre-Tertiary sediments have a long residence time and is isolated from the shallow groundwater flow system.

Based on the above results, the groundwater flow system and supply of the magmatic volatiles in and around Iwate volcano is summarized as follows. In the north and east flanks, large shallow groundwater systems exist where waters recharged at the summit fumarolic area of Iwate volcano, and have been supplied with the magmatic volatiles. A deeper groundwater aquifer is isolated from the shallow groundwater flow system and slowly accumulates magmatic volatiles. In the southwest flank, the magmatic volatiles are likely supplied via fault to the deep thermal waters and the shallow groundwater. These results suggest that the difference in the subsurface geological structure leads the difference in the supply process of the magmatic volatiles to surrounding groundwater systems.