Hydrothermal system in the volcanic terrain from a viewpoint of alteration: an example of the Unzen USDP-4 scientific drilling.

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Magmatic heat source may form hydrothermal systems inside and around the volcanic terrain. Reactions between fluid and rocks in the terrain may produce secondary and alteration minerals. Drilling samples supply useful information of not only the geology but also the hydrothermal alteration inside the volcanic terrain. For the purpose of describing the hydrothermal or ground water system around the volcano, this study has revealed the characteristics of the hydrothermal alteration of the drill core and cuttings by naked eye, thin section, X-ray diffraction and stable isotope methods.

USDP-4 drilling for understanding eruption mechanisms and magmatic activity, begun at the site of about 840m above sea level on the northern side of the Mt. Heisei-shinzan in 2003. The length of the USDP-4 drill hole is 1995.75m. Cuttings were sampled at every 2m of the drill hole. Sixteen cores, named as C1 to C16, were sampled at the points deeper than 1582m of the drill hole. The drill cores consist of hornblende-bearing andesite to dacite lavas or pyroclastic rocks. According to microscopic observation of the USDP-4 cuttings at the thin sections, fresh volcanic rocks are at the surface to 200m depth. Altered rocks without clay minerals appear 700m, and smectite or calcite appears deeper than 1100m. The hydrothermal alteration in the core shows general correlation with depth. Smectites occur shallower than 1600m. Chlorite appears in the core deeper than 1700m, indicating that the hydrothermal fluid was around 190 degrees at the depth. On the other hand, kaolinites occur only at several depths, which correspond to the crushed or strongly altered parts. It is considered that the relative high temperature fluid rose along the fractures and faults, which could provide good pathways for migration of volcanic related fluids. Hydrothermal breccia-bearing veins, several centimeters to 1m wide, can be observed around 1590m, indicating that some hydrothermal solution rose explosively. Quartz vein could not be observed at any depth by naked eye. Tuffisite vein is usually green-colored caused by chlorite-alteration. Although the alteration is observed around the tuffisite vein, it becomes weak outward, indicating that the tuffisite veins were good pathways for the fluid during the hydrothermal period. In addition, the calcite veins often cut the tuffisite veins, suggesting that the calcite was precipitated at the latest stage of the hydrothermal period.

Oxygen and carbon isotope ratios were measured for the vein calcites with several mm width and the cuttings. At deeper than 1300m, the carbon isotope ratios are almost the same, being independent of the depth, while the oxygen isotope ratios decrease with increasing depth. However, both isotope ratios vary at shallower than that, which is possible to indicate effect of shallower ground water.

These occurrences of the alteration minerals and the stable isotope compositions of the calcite indicate that the hydrothermal system has a large-scale fluid circulation inside the Unzen volcanic terrain, and also indicate that the fluid temperature increases with depth. However, it is supposed that the total hydrothermal alteration inside the Unzen volcano is weaker than typical epithermal ore deposits or geothermal areas. The first reason is that the hydrothermal fluid was low temperature even at deep part of the Unzen volcano, as shown by the well logging temperature less than 200 degrees around the conduit area beneath 1.4 km of the surface. On the other hand, faults, fractures and tuffisite veins have become good pathways for the relatively high temperature fluid.