



Eruptive products from hydrothermal systems beneath active volcanoes

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Hydrothermal and magmatic-hydrothermal eruptions are common phenomena at volcanoes in subduction settings. These eruptions produce volcanic ash that abundantly contains hydrothermally altered lithic fragments. The explosive eruptions derive the altered lithic fragments from the hydrothermal system developed under the crater or old altered basement rocks. We have carried out petrological observations on the altered lithic fragments as well as co-occurring juvenile fragments in ash samples from some volcanoes in Japan. Most samples are characterized by acid alteration (silicification and advanced argillic alteration) that typically develops at shallow (< 1 km) under active volcanic craters, implying on-going hydrothermal alteration. Because the explosiveness of these eruptions is caused by expansion of steam derived from hydrothermal systems, the alteration is intimately related to the fluid chemistry of the hydrothermal system under the volcano. Besides the acidic alteration, some samples contain other types of alteration. The volcanic ash from the 2014 eruption at Ontake shows a wide variation including silicification, advanced argillic alteration, sericitic alteration, and potassic alteration, indicating the volcanic ash were derived from a zoned hydrothermal system which is similar to porphyry copper systems. At Tokachidake, observed alteration types are only silicification and limited types of advanced argillic alteration involving precipitation of kaolinite and alunite. Most of the ash particles from Tokachi are incompletely altered preserving unaltered glass and minerals, although altered parts indicate intense leaching of cations. This implies that highly acidic fluid influenced by volcanic gas interacts with young volcanic rocks before an eruption. The difference between Ontake and Tokachi is related to frequencies of magmatic injections. Magmatic eruptions are frequent at Tokachi, once in several decades, whereas magmatic injection is less active at Ontake, where an average of intervals of magmatic eruptions is several thousand years. Volcanic gas from sporadically intruding magma is the source of acidic fluid that alters the shallow volcanic rocks of Tokachi. On the other hand, a stable porphyry-system-like hydrothermal system is developed under Ontake volcano. We observed the temporal variation of alteration types in hydrothermal/magmatic-hydrothermal eruption deposits at Kurikoma volcano. Throughout Holocene, a series of hydrothermal and magmatic-hydrothermal eruptions occurred, and clayey volcanic ash was spewed from the craters. The alteration type varied with time, and the alteration mineral assemblage may be influenced by a magmatic event at 5 ka. However, correlations among the alteration type, time, and magmatic event are not obvious. Crater locations and depth of explosions may be the additional factors that determine the alteration type.