Classification of Suijoki-hunka (steam eruption)

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The Japanese word "Suijoki hunka" and its English equivalents are usually defined by the phenomena including transformation from groundwater into steam, whereas the actual eruption is determined as Suijoki hunka based on absence of juvenile material from volcanic ash. The inequality sometimes hinders understanding of the eruption mechanism and prediction of subsequent volcanic activity. This paper represents a new classification of non-juvenile eruptions based on the reviews on three literatures: Sterns and MacDonald (1944), Mastin (1995), and Browne and Lawless (2001). Subaerial eruptions are classified according to relevance to phase transition of external water. Eruptions unrelated to phase change of external H_2O consist of magmatic eruption and gas eruption that is a kind of non-juvenile eruptions. Gas eruption is an explosive eruption derived from pressurized volcanic gas accumulated underground. Eruptions relevant to the phase change (hydro-eruptions or hydro-explosion) are further subdivided into five types: phreatic, phreatomagmatic, hydrothermal, magmatic-hydrothermal, and mixing eruptions. Phreatic eruption occurs when a cold aquifer is heated by newly injected hot magma to explode, and if the explosion involves the hot magma, the eruption is phreatomagmatic. Hydrothermal eruptions and magmatic-hydrothermal eruptions occur in geothermal fields and volcanoes underlain by underground hydrothermal systems. Hot hydrothermal fluid can explode itself by sudden phase change from water to steam without external heat influx (hydrothermal eruption). When the hot hydrothermal fluid is injected by hot magma that supplies additional thermal energy for explosion, the eruption is magmatic-hydrothermal. Mixing between groundwater and hot rock such as solidified new lava results in an explosive eruption that is a mixing eruption. As thermal regimes within volcanic edifices determine the eruption types, three types of regimes are assumed here. A volcano with a low temperature regime (type P hereinafter) contains a cold aquifer that can be the source of phreatic and phreatomagmatic eruptions when a batch of new magma injects. In a volcano with a high temperature regime (type G), hydro-eruption hardly occurs because liquid water can not exist in the heated volcanic edifice. Magmatic and gas eruptions are common to type G volcanoes. A volcano with an intermediate thermal regime (type H) includes a sub-volcanic hydrothermal system containing hot water (often boiling water and steam). The hydrothermal fluid in the type H volcano is the source of hydrothermal and magmatic-hydrothermal eruptions. It is noteworthy that hydrothermal eruption can occur without injection of or heating by new magma as the hot hydrothermal fluid can explode itself by releasing thermal energy of the fluid when it is decompressed. These thermal regimes can easily change each other in response to change of magmatic activity; types H and P change into type G when magmatic activity intensifies. To evaluate subsequent volcanic activity when a non-juvenile eruption occurs, it is crucial to realize the internal thermal condition of the volcano beforehand by means of geophysical, geochemical, and geological investigations.

Keywords: Gas eruption, Phreatic eruption, Phreatomagmatic eruption, Mixing eruption, Hydrothermal eruption, Magmatic-hydrothermal eruption

