

Explosion energy in Ontake 2014 eruption - estimation from thermodynamic properties of water-

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On 27 September 2014, eruption occurred near the summit of Mt. Ontake (3,067m above sea level) located in central Japan. This is a phreatic explosion caused by rapid expansion of gas-liquid mixed water. This study aims to estimate an energy balance to estimate how much of original thermodynamic energy was released as kinetic energy at the early stage of eruption. In the analysis we followed the method proposed by R.Tihery and L.Mercury (2009) to calculate total thermodynamic energy released by the water which was originally situated in magma or hydrothermal reservoir with high pressure and temperature. We also assumed that the thermodynamic process the water experienced was the decompression to an atmospheric pressure. Generally speaking, in the volcanic eruption, not all the thermodynamic energy of the water is converted into the kinetic energy leading to explosive event. In this study, we thus define an index ζ to represent a ratio of the kinetic energy versus the total thermodynamic energy of the original water at the reservoir with high pressure and temperature. Here we try to estimate ζ for Ontake, 2014 using all the available observation results reported about this eruption.

We started from the energy and mass conservation laws of water, ash, and rocks involved in the eruption. In the previous works done by R.Tihery and L.Mercury (2009) and Mastin (1995), the authors proposed methods to estimate theoretical maximum thermodynamic energy emitted by explosive process by assuming that all the ejecta derived from the deep hydrothermal reservoir. However, in actuality, rocks and mud which existed in the close proximity of the vent exit were also expelled by the erupting water, and acted as a conveyor of the kinetic energy. Therefore, in this study, we assumed that considerable amount of mud and rocks originally situating near the surface were also emitted from the vent with the same speed of the erupting water. Here we define another index η to represent the ratio of mass of the rocks conveyed from the reservoir versus the total ejecta emitted in the eruption. We substituted the observed numerical values of related parameters that appear in the equations of energy and mass conservations for the equation.

As a result, we came up with an equation which relates η to ζ . However, because of lack of constraints, we could not uniquely determine η and ζ , but were able to suggest upper and lower limits for those indexes. The estimated results for ζ and η were 0.2~1 and 0~0.5, respectively. To further narrow the range of η , we used the estimation for ζ (0.2~0.4) by Ohba et al. (2007) for Akita Yakeyama phreatic eruption in 1997 because we recognize the high similarity between the two eruptions and because it seemed to be reasonable to assume ζ would be similar. Thus we assume ζ is also 0.2~0.4 in the Mt. Ontake 2014 eruption, and we obtain η is 0~0.3. For this range of ζ , the calculated mechanical energy was estimated to be $10^3\sim 10^4$ GJ. This estimate means the total kinetic energy of the ejecta erupted during the early period of eruption, and hence this result is consistent with that of Taniguchi and Ueki (2014), which means discrete explosion energy causing formation of explosion craters.

Keywords: phreatic eruption, explosion energy, water, Ontake, thermodynamics