Time variations in the chemical and isotopic composition of fumarolic gases at Hakone volcano, Honshu Island Japan over the earthquake swarm and eruption in 2015, interpreted by magma sealing model

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Definite increases in the components ratios of CO_2/H_2O, CO_2/H_2S, CO_2/CH_4 and He/CH_4 were observed at the fumarolic gases from Owakudani geothermal area located at the center of Hakone volcanic caldera (Honshu Island, Japan), synchronized with the earthquake swarm in 2015 (Fig.1). Such variations were due to the dominance of a magmatic component over a hydrothermal component, suggesting the earthquake swarm was produced by the injection of magmatic gases into the hydrothermal system. The CO_2/H_2O ratio of magmatic gas was estimated to be 0.0045 before the earthquake swarm, which increased up to 0.013 during the earthquake swarm, likely produced by the pressurization of magma as a result of magma sealing where the pressure increment of magma was estimated to be 3 % to the lithostatic pressure (Fig.2). The H_2O and CO_2 concentration in magma were estimated to be 6.3 wt % and 20 wt ppm, respectively, assuming a temperature 900ºC and a rhyolitic composition. In May 2015, a few months prior to the earthquake swarm in May 2015, a sharp increase of the Ar/CO_2 and N_2/He ratios and a decrease in the isotopic ratio of H_2O were observed at the fumarolic gas. The invasion of air into the hydrothermal system increased the Ar/CO_2 and N_2/He ratios. The decrease in the isotopic ratio of H_2O was induced by partial condensation of H_2O vapor.

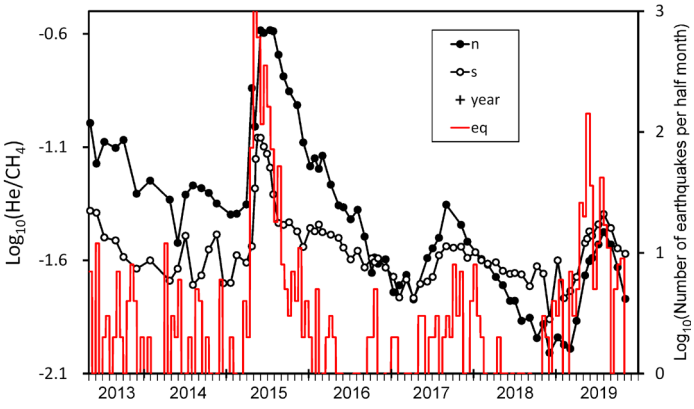

Fig.1. He/CH_4 variation of two fumarolic gases at Owakudani geothermal area with the number of earthquakes observed by Meteorological Agency Japan.

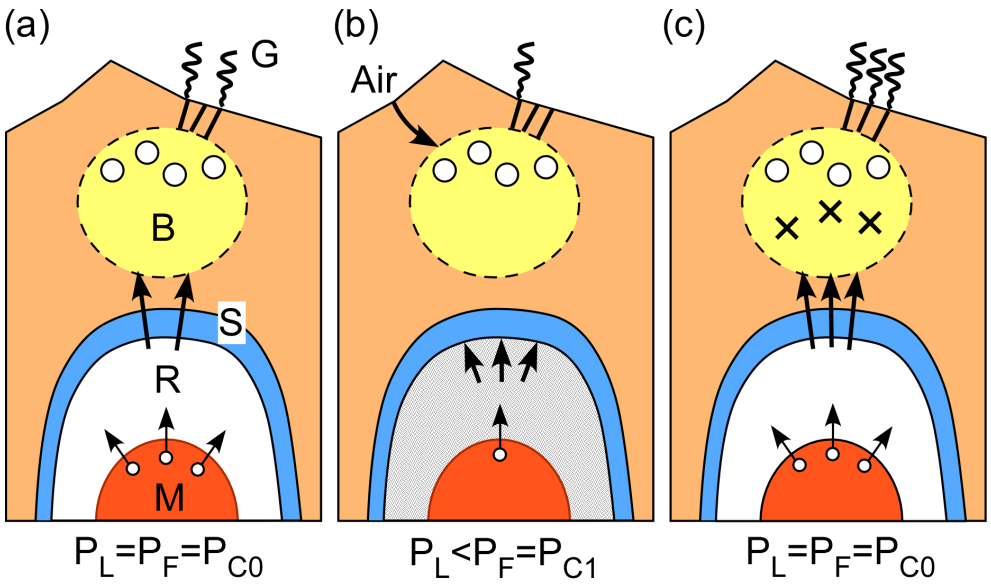

Fig.2. Sequence at Hakone volcano before and after the earthquake swarm in May 2015. (a) Normal situation represented by the period in 2014. M: degassing magma, R: magmatic gas reservoir, S: sealing zone, B: hydrothermal system made of brittle crust, G: fumarolic gas, PL: lithostatic pressure, PF: magmatic gas pressure, P_{C0}: gas pressure equilibrated with the degassed magma, P_{C1}: gas pressure equilibrated with un-degassed magma. (b) Sealing zone is restricting the magmatic gas transport to hydrothermal system, corresponding to the period in few months prior to May 2015. Air invasion was allowed into hydrothermal system. (c) Break of sealing zone in May 2015. A large number of earthquakes (cross-marks) happened in hydrothermal system

Reference

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