

## The 2015 Hakone eruption: rupture of shallow vapor pocket triggered by magma replenishment?

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Previous studies have indicated that the volcanic unrests of Hakone volcano were preceded by inflation of deep source (~10 km deep) accompanying deep low frequency earthquakes (DLFE) (~20 km deep)<sup>1,2</sup>. The volcanic unrests, which include various phenomena such as earthquake swarms, inflation in shallow and blow out of steam wells, seem to be induced by increase of pore fluid pressure within the hydrothermal system of the volcano (~5 km)<sup>2</sup>. Approximately two months before the 2015 eruption of the volcano, when earthquake swarm and blow out of a steam well started, very localized uplift (~ 200 m of diameter) in the future eruption center was observed by satellite InSAR and its inflation sources was estimated to be at around 150 m deep<sup>3,4</sup>. At this location and depth, we found resistive body by our CSAMT survey<sup>5</sup>. The resistive body located within a smectite-rich conductive layer, which is interpreted as the cap rock structure of the volcano<sup>6</sup>. Since the location of resistive body coincident with the inflation source of before the eruption, it was interpreted as the vapor pocket. In the vapor pocket, pores and cracks within the cap rock structure was filled with vapor and inflated due to increase of vapor flux during the volcanic unrest. The 2015 eruption was apparently triggered by a hydrothermal crack intrusion on the morning of June 29<sup>3,7</sup>. The uppermost tip of the hydrothermal crack may have been reached to the vapor pocket; however, the

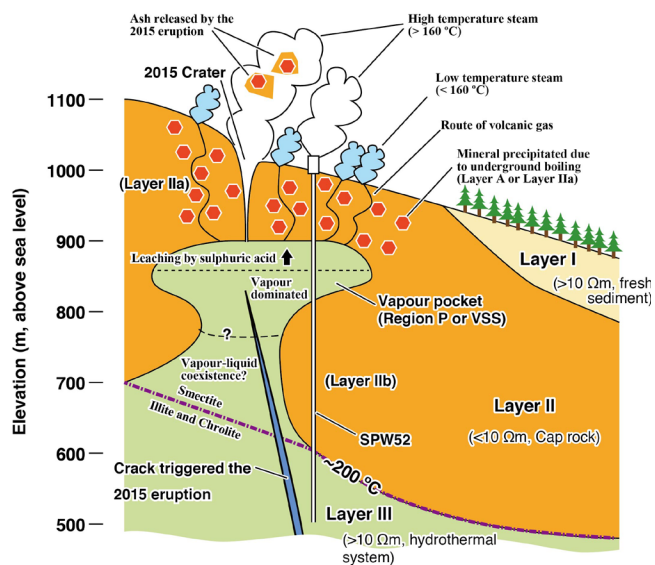


Fig. 1 Schematic model of the 2015 eruption center and adjacent area. Beneath the eruption center area, a vapor pocket is formed and the steam migrates from the pocket to the surface through the cap rock. The open crack formed at 7:32 of 29 June 2015 triggered the eruption, but the uppermost tip seems not to have reached the surface.

water and solid particles originated from deeper than the vapor pocket were not recognized during the eruption and the eruption seems to have been caused by the rupture of the vapor pocket. Because the volume of the hydrothermal crack of the 2015 eruption ( $0.16 \times 10^6 \text{ m}^3$ )<sup>3,7</sup> was comparable to that of the 2014 Ontake eruption ( $0.38 \times 10^6 \text{ m}^3$ )<sup>8</sup>, the crack intrusion had a potential to cause much larger and lethal eruption. The factor of controlling eruption volume will be the next challenge to decipher the process of phreatic eruption.

After the 2015 eruption, a few volcanic unrests have been observed in Hakone volcano. Such volcanic unrests accompanied change in ratios of volcanic gases, inflation of deep source, and DLFE; however, very local uplift has never been observed and number of shallow earthquakes beneath the 2015 eruption center is limited. These observations imply that the 2015 eruption breached cap rock of the volcano and its hydrothermal system is no longer able to be pressurized by the magma replenishment.

#### Main References

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