A physical model for the phreatic explosion on July 15, 1888 at Bandai volcano, northeastern Japan

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The 1888 eruption at Bandai volcano, Japan, has been well known as one of the most gigantic historical phreatic explosions. The precise nature of the explosion mechanism, however, has not been quantitatively clarified until now. It is due to the statements and interpretations in the leading article of Sekiya and Kikuchi (1890) were mainly based on the various circumstantial evidences that were collected by seeing of authors' selves and local habitants. They inferred that the hydrothermal fluid triggering the explosion and rock avalanche might have been located beneath the exploded peak called Kobandai-san and that the depths of the earthquakes immediately preceding the eruption might be very shallow in the volcano. These naive inferences have been left without any quantitative examination for more than one century. We re-examined their ambiguous inferences about the explosion source and the earthquakes preceding the eruption. We analyzed primarily the following two observational data: The one is the shallow bulge structure beneath the old crater that is recently deduced from the seismic tomography and the other is the isoseismal map drawn from questionnaire by Sekiya and Kikuchi. The map showed that the perceptible area of the biggest preceding earthquake had a shape of an ellipsoid elongated in the direction of N25E and its intensity at the boundary was assigned to 1 on the JMA scale which was equivalent to ca. 2 gal. The characteristics of the observed isoseismal were compared with those calculated as a function of source depth and directivity under several reasonable assumptions. Referring to the observed 3D bulge structure beneath the old crater, an explosion source was modeled by a pressurized spherical cavity with a radius of 0.5 km located at a depth of 1.0 km. The numerical analysis revealed that the fluid pressure would escape from the cavity through two tensile fractures oriented in different directions; one is oriented upward from the apex of the cavity and the other is at an oblique angle of 30 degrees with the ground surface at a horizontal distance of about 1.8 km from the apex. We concluded that the explosion source with a radius of 0.5 km was located beneath Numanotaira (the old crater) at a shallow depth of 1.0 km but not beneath Kobandai-san (the collapsed mountain) and that two tensile fractures in directions of N20W and N100E were simultaneously opened due to an excess pressure, resulting the dynamic collapse with large rock avalanche into the north and the steam-jet burst with mud flow into the south-east. The seismic moment and magnitude of the biggest earthquake immediately preceding the explosion were estimated to be 10**16 Nm and M4.6, respectively. These results provided a counter-evidence for the traditional inference by Sekiya and Kikuchi.