Potential candidates to produce “Hunga-type” large shallow-marine phreatomagmatic eruptions in Japan

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The 2021-2022 eruption of Hunga Tonga-Hunga Ha’apai demonstrated that a large volcanic eruption in an oceanic setting can be extremely hazardous. Besides the typical hazards of a large volcanic eruption, it also prompts the risk of severe communication disruption through the damage to the ocean-bottom cables. In Japan which is a country surrounded by oceans and connected through them, only subaerial volcanoes are well monitored by world-class quality. Most of the oceanic volcanoes in Izu-Ogasawara, Ryukyu, and Kuril arcs have much less, sometimes minimal monitoring. The amount of knowledge about the volcanoes is also extremely limited, as their eruptive histories are usually not known. The number of Quaternary volcanoes that are not recognized is also considered to be very large. This state of knowledge, however, is the same as that of the subaerial volcanoes 100 years ago. The history of disaster mitigation proves that the steady process of knowledge accumulation substantially contributes to the reduction of hazards. It is therefore important that we continue to let them accumulate steadily and thoroughly.

The Hunga Tonga volcano is a 1600-m height shallow caldera in an oceanic setting. The diameter of the caldera is approximately 3 km, the depth of the caldera is 200 m, and the highest part of the caldera rim is approximately 100 m in height. While there are >50 volcanoes worldwide that have calderas in such a shallow depth, their potential genetic link has been never discussed. While there is no bathymetry data available after the eruption, the 2021-2022 eruption of Hunga Tonga most likely resulted in a further collapse of the original caldera, as it is indicated by the morphological shrinkage of the Hunga Tonga and Hunga Ha’apai islands. Hence such a shallow-marine caldera elsewhere can be the product of an eruption similar to the 2021-2022 eruption.

I analysed bathymetry data as well as past literature in order to find shallow-marine calderas which diameters are larger than the Hunga Tonga. Japan has 20 calderas and all of them are located in the 6 regions of Izu-Bonin arc and Ryukyu arc. Firstly in the northern part of the Izu arc, Toshima caldera and Niijima-Uranose caldera sits in proximity to Honshu at 25 and 50 km of distances respectively. Secondly, the middle of the Izu arc holds two small calderas: Kurose Hole and Kurose-Nishi Hole. Thirdly, the southern part of the Izu arc has the most number of calderas which are Higashi-Aogashima caldera, Myojin Knoll caldera, Myojin-sho caldera, Sumisu caldera, Daisan-Sumisu caldera, Torishima caldera. They are moderate-sized as many of their longer diameters exceed 10 km. Fourthly, the Bonin arc also has calderas at its southern end, which are Higashi-Kaitoku caldera, Kita-Iwoto caldera, and Kita-Fukutoku caldera. The last Kita-Fukutoku caldera has 17 km of diameter in its longer axis and is the largest in the Izu-Bonin arc. Fifthly, the northern Ryukyu arc has the well-studied gigantic calderas of Aira caldera, Ata caldera, and Kikai caldera. Their sizes which are around 20 km in their diameter are exceptionally largest in the shallow-marine calderas worldwide. Lastly, the middle of Ryukyu arc has relatively small Izena Hole and Kume Hole. Only 3 out of 20 calderas have the ages of their caldera formations. My assessment suggests that these calderas require relatively prioritized research as well as the attention from the public in terms of future disaster reduction.

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