

Volcanological timeline of the Hunga Tonga-Hunga Ha'apai eruption in mid-January 2022

*Setsuya Nakada¹, Mie Ichihara², Fukashi Maeno², Takao Ohminato², Taaniela Kula³, Marco Brenna⁴, Shane J. Cronin⁵

1. National Research Institute for Earth Science and Disaster Resilience, 2. Earthquake Research Institute, the University of Tokyo, 3. Tonga Geological Services, Kingdom of Tonga, 4. The University of Otago, New Zealand, 5. The University of Auckland, New Zealand

The submarine eruption at Hunga Tonga-Hunga Ha'apai volcano caused strong explosions, an extremely high rate of eruption plume growth and was accompanied by strong airwaves. Constructing a detailed timeline of the eruption progression is important to understand the source volcanic processes. We are preparing this through meetings of JICA's humanitarian support for Kingdom of Tonga since February 2022. The summary so far and questions arising for future research are presented here.

Hunga Tonga-Hunga Ha'apai consisted of islets connected by pyroclastic cones that developed in the northern rim of the submarine caldera of Hunga volcano. The last eruption of Hunga volcano began with phreatomagmatic explosions on 20 December 2021 and continued until 5 January 2022 according to local observations. A series of eruption events (precursory phase) resumed from the afternoon of 13 January and continued for about 20 hours to the afternoon of 14 January 2022 (all times in UTC). This was followed by intermittent explosions in the evening of 14 January. The major part of pyroclastic cone between the two islets was destroyed during the event on the 14th, before the onset of the climactic eruption on 15 January. The climactic phase started around 4:01-02 of 15 January, according to precise analysis on the correlation of airwaves and seismic waves in a Fiji observation site (~750 km distant). The rising eruption plume was first captured by Himawari-8 around 4:07. The airwaves and seismic waves increased their magnitude with time, strong seismic bursts including a M5.8 earthquake at 4:15 and another 200 s later taking place. The strong very-low-frequency airwaves, travelling around the globe several times, had a peak pressure at 4:28. The eruption plume grew steadily and rapidly, reaching about 58 km asl at 4:40, and continued lateral expanding, according to satellite image analysis. The main eruption phase lasted ~2 hours, but intermittent and declining activity continued until around 15:00, with the largest post-climatic event peaking at 8:30. Analysis of helicopter images show that 75% of Hunga Ha'apai and 91% of Hunga Tong have collapsed inward into the caldera. The strong explosive eruption and the finely fragmented ash particles show that magma-water interaction was an important component to the eruption.

The first tsunami arrived at Nuku'alofa, Tongatapu island at 4:27, and the largest wave of the series hit at 4:46. Considering the travel time of the first wave from the source, a volume change should have occurred around 4:07. However, simple volcanic tsunami models cannot well explain the observed data. Submarine cables from Tongatapu to Fiji and other islands were cut at 4:30 and 5:37, respectively. Those breakages may be due to gravity currents from the volcano, although the generating processes and travel paths for these remain unclear. Lapilli and coarse ash pumice started falling on Tongatapu island at 4:40 after the edge of the plume umbrella covered the island at 4:26. Magma of the climactic eruption is andesite a little poorer in SiO₂ than the 2014-15 eruptions (~56-57 wt%). Following the lapilli, gentle fine-medium ash grade material fell across Tongatapu island at times blown with a strong NW wind. The ash has low vesicularity and < 8% phenocrysts, is highly angular, and microlite-free, suggesting quenching in a submarine eruption. The scale of the eruption is estimated 1 to a few km³ by several methods, however, there is a real lack of quantitative base data on fall deposits.

Keywords: Hunga volcano, magma-water interaction, correlation of airwaves and seismic waves, volcanic tsunami, gray pumice