Geochemistry, Geophysics, Geosystems

RESEARCH ARTICLE

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Key Points:

- Bathymetric and real-time hydroacoustic monitoring took place during the 2011–2012 El Hierro submarine eruption and the seafloor was later imaged and sampled in situ by remote operated vehicle ROV
- A new submarine volcano named Tagoro was built over two main episodes intercalated with collapse events, with eruptive activity ranging from effusive to explosive with a wide range of eruption styles and associated products, even over short time intervals
- Products include volcaniclastic aprons, glassy ash and lapilli, lava balloons, lava ponds, bulbous pillow lavas, scoria, and hydrothermal hornitos

Supporting Information:

- Supporting Information S1
- Table S1
- Table S2

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Evolution of submarine eruptive activity during the 2011–2012 El Hierro event as documented by hydroacoustic images and remotely operated vehicle observations

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Abstract Submarine volcanic eruptions are frequent and important events, yet they are rarely observed. Here we relate bathymetric and hydroacoustic images from the 2011 to 2012 El Hierro eruption with surface observations and deposits imaged and sampled by ROV. As a result of the shallow submarine eruption, a new volcano named Tagoro grew from 375 to 89 m depth. The eruption consisted of two main phases of edifice construction intercalated with collapse events. Hydroacoustic images show that the eruptions ranged from explosive to effusive with variable plume types and resulting deposits, even over short time intervals. At the base of the edifice, ROV observations show large accumulations of lava balloons changing in size and type downslope, coinciding with the area where floating lava balloon fallout was observed. Peaks in eruption intensity during explosive phases generated vigorous bubbling at the surface, extensive ash, vesicular lapilli and formed high-density currents, which together with periods of edifice gravitational collapse, produced extensive deep volcaniclastic aprons. Secondary cones developed in the last stages and show evidence for effusive activity with lava ponds and lava flows that cover deposits of stacked lava balloons. Chaotic masses of heterometric boulders around the summit of the principal cone are related to progressive sealing of the vent with decreasing or variable magma supply. Hornitos represent the final eruptive activity with hydrothermal alteration and bacterial mats at the summit. Our study documents the distinct evolution of a submarine volcano and highlights the range of deposit types that may form and be rapidly destroyed in such eruptions.

Plain Language Summary Today and through most of geological history, the greatest number and volume of volcanic eruptions on Earth have occurred underwater. However, in comparison to subaerial eruption, little is known about submarine eruptive processes as they are dangerous to cruise it over, especially during explosive phases. This work shows the results of a study carried out during the eruption of the submarine volcano occurred during 2011–2012 1 km offshore El Hierro Island, Canary Islands, Spain. The submarine volcano emitted periodically large bubbles of gas, ashes, and giant steamed lava balloons that floated in the sea surface before sinking. These products identified later after the eruption using a submersible vehicle forming huge accumulations of lava balloons on the seafloor. More quiet periods erupted toothpaste lava from secondary cones which formed stalactite-like formations. Massive accumulation of blocks on the summit evidence intermittent violent explosions occurred when the cooling of lava progressively close the vent accumulating gas that finally exploded. The final stage of this submarine eruption consisted in the formation of chimneys by liquid-like lavas mixed with hydrothermal fluids forming 5-10 m tall "hornitos" structures at the summit of the volcano at 89 m depth but without emerging as it was expected.

1. Introduction

Today and through most of geological history, the greatest number and volume of volcanic eruptions on Earth have occurred underwater along mid-ocean ridges, near subduction zones, on oceanic plateaus, and on thousands of intraplate seamounts [*Rubin et al.*, 2012]. However, in comparison to their subaerial equivalents, little