Caldera formation associated with the growth of a basaltic volcano: A model for gravitational collapse

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Basaltic volcanoes above the oceanic crust or island-arc crust develop calderas. Caldera width, its depth, and [caldera horizontal width (CR) / volcano size (VR)] depend on the physical properties of the oceanic crust. The 1968 caldera collapse of Fernandina volcano, Galapagos, the 1924 caldera collapse of Kilauea volcano, Hawaii, and the 2000 caldera collapse of Miyakejima volcano are compared. Caldera collapse is inevitable with an increases in gravitational instability of magma plumbing system, and in a view of the long-term growth of the magma plumbing system in the crust.

Basaltic volcanoes above the oceanic crust or island-arc crust develop calderas. At the formation of this caldera, collapsed volume is far larger than erupted volume. Caldera width, its depth, and [caldera horizontal width (CR) / volcano size (VR)] depend on the physical properties of the oceanic crust. [CR/VR] decreases away from the ridge. At Fernandina volcano, Galapagos, a caldera was formed in 1968 during the phase dominated by circumferential fissure eruptions after the phase dominated by radial fissure eruptions. At Kilauea volcano, Hawaii, during the phase dominated by central eruptions, several drain backs of lava lake had occurred since 1800, and, finally, a caldera was collapsed in 1924. Caldera collapse is inevitable because accumulated crystals and solidified magma under a volcano increases gravitational instability. According to the gravitational collapse model proposed in this paper, it is difficult to evaluate when, how wide, and how deep caldera collapse will occur. The magma plumbing system expands horizontally and vertically in the long-term growth. Caldera collapse contributes to the vertical growth. The horizontal growth and vertical growth are governed by the physical properties of the crust beneath the volcano; the former process is dominant in Hawaii, and the latter one is dominant in Galapagos. In the case of Miyakejima volcano, the caldera collapse may be triggered by a dike intrusion into the region of low probability of intrusions or by an increase in magma supply beneath the magma chamber. At Miyakejima 2000 eruption, a caldera was formed in the shallow crust; in the deep crust, ductile mass or dense magma with crystal mush may have moved downward or northwestward.