

A sequence of plinian eruption preceded by dome destruction at Kelud volcano, Indonesia, on February 13, 2014: insights from tephra fallout and pyroclastic density current deposits

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A plinian-style eruption with a radially spreading umbrella cloud occurred on February 13, 2014, at Kelud volcano, Indonesia. We present the sequence of this plinian event based on a geological study of the eruptive products, analysis of satellite images of the eruption plume, and surface features of the volcanic edifice before and after the eruption. The eruptive deposits were divided into four major depositional units (Units A, B, C, and D) and used to determine the sequence of events. The plinian phase was preceded by partial destruction of the existing lava dome and generation of high-energy pyroclastic density currents (PDCs) with a maximum runout distance of ~6.8 km mainly towards the NE. The PDCs produced a series of depositional subunits (Units A₀₋₂) and caused surface damage (blown-down trees and vegetation) over an area of 12 km² (stage 1). The main phase of the eruption was characterized by a strong eruption plume that produced widespread fallout tephra (Unit B) over East and Central Java (stage 2). The winds above the volcano significantly affected the tephra dispersal process. In stage 3, the plinian column collapsed, generating dense PDCs that flowed down the volcano valleys, producing pumiceous lobate deposits (Unit C). The declining phase of the eruption produced fine-rich fallout tephra layers (Unit D₁₋₂) from low-level eruption plumes and/or ash lofted from PDCs. The eruption sequence constructed from field observations is supported by geophysical observations, including remote seismic and infrasound signals, total electron content variation, lightning strokes, and satellite observations. The initial high-energy PDCs and fallout tephra contained juvenile pumice and dome-derived lithic clasts, and isolated crystals originated from the fragmentation of porphyritic magma. The deposit features and componentry suggest that newly ascended magma triggered the destruction of the lava dome and the generation of high-energy PDCs, and during the subsequent climactic phase the dome was completely destroyed. Thus, the pre-existing lava dome significantly affected the course of the eruption. This type of eruption sequence has not been previously documented in the historical records of Kelud volcano activity. The total volume of erupted material was estimated as 0.25–0.50 km³ (bulk deposit volume), corresponding to 0.14–0.28 km³ in DRE, and the mean eruption rate as $6.5 \pm 2.8 \times 10^7$ kg/s. The scale of the 2014 eruption had a VEI of 4, and was one of the largest eruptions at Kelud volcano over the past century. The eruption sequence and estimated physical parameters of the 2014 eruption will help assess future volcanic activity and potential hazards at Kelud volcano.

Keywords: Plinian, pyroclastic density current, blown-down tree, lava dome, Kelud