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Explosive eruptions with little warning: Experimental petrology and geodetic observations from the 2014 eruption of Kelud, Indonesia

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Explosive eruptions that occur with little or no precursory unrest pose the greatest hazards from volcanoes to nearby populations. Here we focus on the pre-eruptive conditions for these explosive events, their triggers and how these eruptions evolve. An example of such an event is the 2014 explosive eruption of Kelud volcano, where we have conducted a set of petrological experiments to understand pre-eruptive storage conditions for several recent eruptions. For the 2014 event, we combine this with an analysis of InSAR measured deformation. Our data suggest that both explosive and effusive eruptions at Kelud are sourced from a magma storage system at 2-3 km. However, explosive eruptions are fed by magma stored under relatively cool ($\sim$1000° C) and water-saturated conditions, whereas effusive eruptions are fed by slightly hotter ($\sim$1050° C), water-undersaturated magmas. We propose that the initial phase of the 2014 eruption was triggered by volatile overpressure, which then fostered a top-down decompression consistent with InSAR observations of co-eruptive subsidence at depths >2 km. By compiling a global dataset of monitoring signatures of explosive eruptions, we show that the onset of unrest rarely indicates shallow ascent of magma, as ascent mostly occurs in a matter of hours or minutes. We relate the timescale of pre-eruptive unrest to eruption triggering mechanisms, with yearly/decadal periods of unrest relating to magma injection events (which may or may not precede a magmatic eruption), whereas internal triggering (e.g. volatile overpressure) of an already present, cooling magma body leads to explosive eruptions with little warning.