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Kinematic analysis of vertical collapse on volcanoes using experimental models time series

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Volcanoes are often associated with vertical collapse, due to deeper magma withdrawal. Calderas are the most notable type of vertical collapse, on the summit of volcanoes, however, collapses have been observed and monitored only at Miyakejima (Japan; 2000) and Dolomieu (Reunion; 2007). These events highlighted our limited knowledge on the kinematic behaviour of caldera collapses. Here we use experimental models to investigate their kinematic evolution. We extract velocity and strain fields using the Particle Image Velocimetry (PIV) technique, generating time series. Vertical collapses undergoing constant subsidence velocity show three main kinematic behaviours in our models: a) continuous collapse, whose velocity is similar to the source subsidence velocity; b) incremental collapse, with episodic (stepwise) accelerations along pre-existing ring structures; c) sudden collapse, resulting from the upward migration of a cavity, only for T/D >2 (T and D are the depth and width of the magma chamber, respectively) and without ring structures. The velocity in the collapsing column may vary up to four orders of magnitude with regard to the source subsidence velocity. Comparison to nature suggests that: 1) there are close kinematic similarities with monitored collapse calderas, explaining their incremental subsidence after the development of ring structures; 2) sudden pit crater formation may be induced by the upward propagation of cavities, due to magma removal at depth and in absence of ring structures; 3) all these types of vertical collapses have a consistent mechanism of formation and kinematic behaviour, function of T/D and the presence/absence of ring structures.