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Evolution of deep collapse caldera: from structural to gravitational process

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We discuss the evolution of deep-subsiding caldera mainly controlled by gravitational process. Progress of caldera subsidence increases its subsidence/diameter ratio (S/D ratio). We investigate the surface features of calderas undergoing significant subsidence with regard to their diameter. First, we consider the evolution of the 2000 Miyake-jima caldera, from double-concentric ring faults at earlier collapsing stages, to a gravitational-erosion dominant stage at a mature stage. When the topographic S/D approaches 0.33, the topographic S/D (hereafter S/Dt) becomes significantly different from the structural S/D (hereafter S/Ds), owing to the gravitational erosion on the caldera wall and accumulation of the debris on the floor. As collapse progresses, the peripheral block bounded by the inner reverse fault and outer normal fault extends and tilts towards the caldera center; it finally collapses towards the caldera floor and the double-ring faults disappeares. Subsidence of the caldera floor induces the gravitational erosion of the wall. This process increases the topographic diameter and the filling of the floor decreases the topographic depth. Consequently, the S/Dt decreases, while the continuous caldera subsidence increases the S/Ds. This evolution finds close similarities with the caldera collapses of Krakatau (1883), Katmai (1912), Fernandina (1968), Tolbachik (1975-76), Pinatubo (1991) and Dolomieu (2007). Analogue experiments mimic the observed variation, evolving from a depression controlled by the activity of the double-ring faults to that controlled by the gravitational slumping of the wall and sedimentation at the floor. The transition occurs for S/Dt ∼0.34. These results show that the control on the shape of mature calderas (S/Ds>0.07) and approaching S/Dt=0.3 passes from a mainly structural to a mainly gravitational type. Both S/Dt and S/Ds are needed to describe the evolution of a collapse and the processes accompanying it. Evaluating the S/Dt and S/Ds allows a proper description of the precise evolutionary stage of a caldera and of the relative importance of the structural and erosional processes and allows making semi-quantitative comparisons between evolutionary stages of calderas.