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Fundamental structures of collapse caldera and their variations

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Collapse caldera is a volcanic structure formed by the collapse of the roof rock into a decompressed magma chamber. Evacuation of magma from the chamber causes the drop of magmatic pressure inside the chamber and induces the collapse of roof rock into the chamber. Most of collapse calderas, particularly in silicic system, are formed by the eruption of magma to the surface. The calderas of Tambora 1815AD, Krakatau 1883AD, and Pinatubo 1991AD were formed by the large pyroclastic eruptions. In the case of mafic volcanoes, large lateral intrusion sometimes becomes a trigger of collapse (example Galapagos 1968AD, Miyakejima 2000AD and Piton de la Fournaise 2007AD).

We have rare chances to make direct observation of internal structure of natural collapse caldera and this prevents our further understanding about caldera forming process. Pyroclastic deposits produced during the caldera-forming eruption cover the caldera floor and hide the deformation structure on the caldera floor. In the case of calderas formed during the geological age, the original structure has been modified by the erosion, tectonic deformation and post-caldera volcanism.

During the last decade, the internal structure and collapse process of calderas are intensively discussed with analogue and numerical experiments. These results indicate that the development of caldera structure is controlled by the formation of ring faults propagate from the roof of magma chamber. In the shallow depth, the ring faults blanch to inner-reverse fault and outer normal fault and as result a double ring structure is formed. Developments of ring faults are controlled by the roof-aspect ratio. As increase the depth of magma chamber, deformation style sift from a coherent collapse to piecemeal. Some numerical simulations also show that the concentration of displacement to a specific faults with the progress of collapse and the block surrounded by the active ring fault(s) subside as a coherent block.

Comparison between the natural calderas and the experimental results indicates that the natural calderas without pyroclastic eruptions have very similar structures such as double ring faults and funnel-like cross section. This indicates that the fundamental structure of collapse caldera is a collapse of coherent or piecemealed block surrounded by ring faults. Existence of caldera-fill deposits produced during the ignimbrite eruptions and gravitational collapse of caldera wall modify the original collapse structure. Mechanical erosion by explosive activities also modifies the original caldera structure.

Keywords: volcano, eruption, magma, caldera, structure