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Caldera Formation in Pull-Apart Systems: Preliminary Experimental Results

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Caldera volcanoes are large volcano-tectonic depressions that form through catastrophic collapse of a magma chamber roof into the underlying magma chamber. Many calderas are associated with pull-apart systems along regional-scale strike-slip structures. The role of such regional-tectonic systems in caldera development is poorly understood, however. Structural relationships at young calderas are usually obscured by drift, vegetation, and infilling sedimentary and volcanic rocks. Although potentially better exposed through deeper erosion, structural relationships at ancient caldera structures are commonly masked by post-collapse intrusions and regional deformation. Furthermore, it may be difficult to link the lower structural levels exposed at ancient calderas to the upper topographic levels seen at young, active calderas elsewhere.

We therefore used analogue models of caldera formation in a pull-apart regional tectonic regime to better understand structural controls of pull-apart systems on the volcano-tectonic evolution of caldera volcanoes. We used a sand/gypsum mix and cream honey as analogue materials for the Earth's brittle crust and granitic magma respectively. A pull apart system was created in a sand/gypsum pile by incorporating a releasing bend onto the edge of an underlying mobile base plate. Different experimental sets simulated: a) pull apart formation without magmatic influence; b) pull apart formation with synchronous magma chamber intrusion; and c) pull apart formation, magma chamber intrusion, and subsequent caldera collapse.

The results of our experiments suggest that geometry of a pull apart is strongly influenced by releasing bend length, orientation of the bend with respect to the master strike-slip system, and by depth of the brittle crust (sand/gypsum pile). The geometry of the pull-apart in turn strongly influences the shape of a magma chamber formed

with in it, and subsequently the caldera geometry. In particular, the ‘side-wall’ faults of the pull-apart exert a strong control on the geometry of syn-tectonic intrusions, and are therefore usually reactivated to form the bounding faults to the collapse caldera. Through comparison of our models with the Indonesian calderas of Tondano, Ranau, and Suwoh, we highlight the important morphological control of these pull-apart related ‘side-wall’ faults on younger calderas. From our experiments, we may infer a strong structural influence of these ‘side-wall’ faults throughout such young calderas’ evolutions, particularly at deeper unexposed levels.