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What factors control the size of an eruption?

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For human society, eruption sizes (eruptive volumes or masses) are of the greatest concern. In particular, the largest eruptions, producing volumes of the order of hundreds or thousands of cubic kilometres, provide, together with meteoritic impacts, the greatest natural threats to mankind. Eruptive volumes tend to follow power laws so that most eruptions are comparatively small whereas a few are very large. It follows that a while during most ruptures of the source chambers a small fraction of the magma leaves the chamber, in some ruptures a very large fraction of the magma leaves the chamber.
Most explosive eruptions larger than about 25 km3 are associated with caldera collapse. In the standard 'under-pressure' ('lack of magmatic support') model, however, the collapse is the consequence, not the cause, of the large eruption. For poroelastic models, typically less than 4% of the magma in a felsic chamber and less than 0.1% of the magma in a mafic chamber leaves the chamber during rupture (and eventual eruption). In some caldera models, however, 20-70% of the magma is supposed to leave the chamber before the ring-fault forms and the caldera block begins to subside. In these models any amount of magma can flow out of the chamber following its rupture and there is apparently no way to forecast either the volume of magma injected from the chamber (hence the potential size of an eventual eruption) or the conditions for caldera collapse.
An alternative model is proposed here. In this model normal (small) eruptions are controlled by standard poroelastity behaviour of the chamber, whereas large eruptions are controlled by chamber-volume reduction or shrinkage primarily through caldera/graben block subsidence into the chamber. Volcanotectonic stresses are then a major cause of ring-fault/graben boundary-fault formation. When large slips occur on these faults, the subsiding crustal block reduces the volume of the underlying chamber/reservoir, thereby maintaining its excess pressure so as to drive out magma for a much longer time during an eruption than is otherwise possible. As a consequence a much higher proportion of the magma in the chamber is driven or squeezed out during an eruption associated with caldera or graben subsidence than is possible during an ordinary poroelastic chamber behaviour. It follows that the volume of eruptive materials may approach the total volume of the chamber resulting in a large eruption. Here a large eruption is thus the consequence—not the cause—of the subsidence of the caldera/graben block. Thus, once the factors controlling large-scale subsidence of a caldera/graben block are established during a particular unrest/rifting episode, primarily using geodetic and seismic data, the probability of a large eruption can be assessed and used for reliable forecasting.

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