Changing the metaphor: from magma chamber to magma reservoir

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Two basic tenets of volcanology are: (1) volcanic eruptions are driven by exsolution of volatiles and (2) eruptions of near-liquidus (crystal-poor) melts require prior segregation/assembling of that melt into a single coherent body, or chamber. The first tenet derives from the prevalence of highly vesicular pyroclasts expelled by explosive eruptions coupled with clear evidence for syn-eruptive volatile loss during magma ascent and eruption coupled with the large volume change accompanying gas exsolution and decompression. The second is supported by the homogeneity of erupted magma compositions and physical properties erupted during single events, particularly during early phases of large eruptions. There is growing evidence, however, that both assumptions should be re-evaluated. First, not all explosively erupted pyroclasts are highly vesicular. Second, accumulation of very large volumes of crystal-poor melt is difficult to reconcile with (a) thermal models that suggest that large coherent volumes of eruptible magma should represent transients within the crust, (b) evidence that most magma is stored as crystal-rich mush, and (c) new data showing that erupted magma batches may be assembled shortly prior to eruption.

The inadequacy of conventional models is highlighted by mafic explosive caldera-forming eruptions, where storage of large melt volumes is thermally implausible and explosive ejection of large volumes of poorly vesicular magma is puzzling. To explain these eruptions, we suggest that melt is stored within, and erupted directly from, magma reservoirs, where we use the term reservoir in the sense used for water-, oil- and gas-bearing systems. This model extends the concept of eruptible melt assembled from a rigid sponge to the idea that the sponge itself may feed eruptions. Tapping an over-pressured network of melt pockets within a rigid crystal framework provides an attractive model for several reasons: (1) it does not require a large (thermally and physically unstable) body of molten magma to be assembled prior to an eruption, but instead allows erupted magma to be stored within a thermodynamically stable crystal mush; (2) it allows syn-eruption tapping of large melt volumes from within the reservoir through permeable networks established both prior to and during eruption; (3) decompression of an over-pressured reservoir provides a physical mechanism for magma ascent and eruption that does not rely on ascent-related gas exsolution as the only driving force; and (4) a reservoir model can link the timing of caldera collapse directly to the strength of the reservoir framework. We then examine the conditions under which this model may apply more generally to eruptions of crystal-poor melt.