Modeling carbonate assimilation into crustal magmas: Quantifying overpressure and eruption triggers

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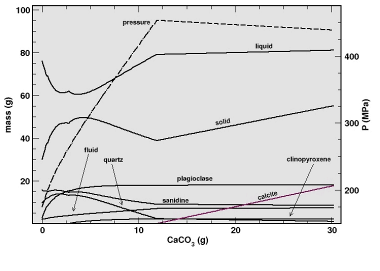
The H_2O-CO_2-mixed-fluid saturation model of Ghiorso and Gualda [1] has been incoporated into MELTS [2], resulting in the ability to model phase relations in magmatic systems containing carbon-bearing minerals, fluids, and melts. This combined thermodynamic modeling tool is used to explore the process of carbonate assimilation into crustal magmas. Model outcomes reproduce experimental studies by Iacono-Marziano et al. [3] on limestone assimilation into hydrated alakli-basaltic magma and verify the plausibility of the Daly [4] hypothesus. Magma-carbonate assimilation scenarios are investigated for three systems: (1) a high-silica rhyolitic magma, (2) the parental magmas of the Colli Albani in the Roman Magmatic Province [5], and (3) the late-stage interaction between crustal limestones and the magmatic system at Merapi volcano, Indonesia [6]. Simulations are constructed to examine carbonate titration under constraints of (1) constant temperature and pressure, (2) constant heat content with temperature variation between assimilant and magma, and (3) constant volume during the assimilation process. The last constraint scenario permits a quantitative examination of maximum overpressure associated with liberation of fluid in the reacting magma system. As illustrated for the case of high-silica rhyolite, assimilation at constant volume generates over-pressures of several hundred MPa for modest addition of carbonate, due mainly to the insolubility of CO_2 in the melt phase.



Similar results for Colli Albani and Merapi demonstrate that carbonate assimilation has the potential to trigger explosive activity if rates of assimilation are rapid in comparison to rates of deformation or fluid loss.

[1] Ghiorso & Gualda (2015) *Contr Mineral Pet* **169**, 53. [2] Gualda et al. (2012) *J Petrol* **53**, 875-890; melts.ofm-research.org. [3] Iacono-Marziano et al. (2008) *Contrib Mineral Petrol* **155**, 719-738. [4] Daly (1910) *Geol Soc Am Bull* **21**, 87-118. [5] Cross et al. (2014) *Lithos* **190-191**, 137-153. [6] Deegan et al. (2010) *J Petrol* **51**, 1027-1051.