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Viscosity controlled magma-carbonate interaction: a comparison of Mt. Vesuvius (Italy) and Mt. Merapi (Indonesia).

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Magma-carbonate interaction is increasingly seen as a viable and extremely important cause of magma contamination, and the generation of a crustally sourced CO_2 phase (Goff et al., 2001; Freda et al., 2010). Even though the process is well recognized at certain volcanoes e.g. Popocatépetl, (Mexico); Merapi, (Indonesia); and Colli Albani, (Italy) (Goff et al., 2001; Deegan et al., 2010; Freda et al., 2010), neither the kinetics of carbonate assimilation nor its consequences for controlling the explosivity of eruptions have been constrained. Here we show the results of magma-carbonate interaction experiments conducted at 1200 °C and 0.5 GPa for varying durations (0 s, 60 s, 90 s and 300 s) for the Mt. Merapi (Indonesia) and Mt. Vesuvius (Italy) volcanic systems. We performed experiments using glassy starting materials specific to each volcano (shoshonite for Mt. Vesuvius, basaltic-andesite for Mt. Merapi) with different degrees of hydration (anhydrous vs hydration with $\sim$ 2 wt % water) and using carbonate fragments of local origin; see Deegan et al., (2010) and Jolis et al., (2011).

Experimental products include a gas phase (CO_2-rich) and two melt phases, one pristine (Ca-normal) and one contaminated (Ca-rich) separated by a ‘contamination front’ which propagates outwards from the carbonate clast. Vesicles appear to nucleate in the contaminated glass and then migrate into the pristine one. Both contamination front propagation and bubble migration away from the carbonate are slower in anhydrous basaltic-andesite (Merapi anhydrous series) than in hydrated basaltic-andesite and shoshonite (Merapi and Vesuvius hydrated series), suggesting that assimilation speed is strongly controlled by the degree of hydration and the SiO_2 content, both of which influence melt viscosity and hence diffusivity. As the carbonate dissolution proceeds in our experiments, initially dissolved and eventually exsolved CO_2 builds up in the contaminated Ca-rich melt phase. Once melt volatile oversaturation is achieved, the reaction can only progress further if vesicles are efficiently removed from the contaminated melt phase. Viscosity, which controls the vesicle migration efficiency, thus ultimately determines the progression and rate of the contamination reaction.

Our results show that characteristics of magma-carbonate interaction at different volcanic systems are likely to differ as a result of a volcanos’ individual magma properties, especially viscosity, which determines the speed at which gaseous reaction products (i.e. CO_2) can be removed from the reaction site.

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