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Deciphering between highly-explosive surges and block-and-ash flows from decompression experiments: example of Mt. Pelée (Martinique, F.W.I)

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Surges and block-and-ash flows (BAF) are two eruptive styles generated from destruction of silicic lava domes. Yet, the highly energetic nature of the surges contrasts with the mildly-explosive valley-channelled emplacement of the BAFs. The occurrence of one or the other eruptive styles, and the associated differences in risk assessment, is well illustrated at Mt Pelée (e.g. the devastating surge of 8 May 1902). This rises questioning about the generation of dome explosivity.
Decompression-induced crystallization experiments have been conducted to simulate magma ascent in the volcanic conduit, in order to infer magma ascent conditions and rates that may lead to either explosive of effusive eruptions. The starting material is Mt Pelée rhyolitic interstitial melt (76-77 wt. % SiO_2) and the experiments consisted in three consecutive steps: melt hydration (850°C, 200 MPa, H_2O saturation and undersaturation), isothermal decompression (Pf of 5-10 MPa; rate from 0.003 to 25 MPa/min), and annealing at Pf (up to 15 days). Two samples were cooled by 25°C and 50°C at Pf. The experiments generated three types of crystals: pre-, syn-, and post-decompression crystals.
The textures and compositions of the experimental plagioclases have been compared to Mt Pelée's plagioclase microlites to infer eruption dynamics. The results suggest that dome and BAF magmas ascend within more than 4-5 days, giving time for syn-decompression crystallization around pre-existent microlites. In contrast, surge magmas ascended within less than ~4 days, without significantly crystallizing in the volcanic conduit. Microlite crystallization massively occurs at dome depth, forcing gas pressurization and subsequent magma fragmentation. The extent and violence of dome destruction may depend on the size/age of the dome, with large/old domes favouring mildly-explosive BAFs, whereas small/young protodomes may generate highly-explosive surges.