Magma Storage and Triggering of Volcanic Eruptions

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We test possible triggering mechanisms of Cascade volcanic eruptions using pre-eruption temperature and diffusion time scale estimates. Temperatures within mafic enclaves, the putative record of mafic recharge, record 250 °C of pre-eruptive cooling at the Lassen Volcanic Center (LVC) and other Cascade volcanoes. We infer that this large cooling interval requires protracted timescales, too long for recharge to represent a proximate eruption trigger. Instead, since mafic enclaves are mostly vesiculated, we surmise that vapor saturation is the proximate or immediate cause. To determine time-scales of pre-eruptive, post-mixing cooling we measured olivine (Ol) diffusion profiles.

Olivine profiles derive from four different domes from the ca. 1100 yr Chaos Crags eruptions at the LVC. All Ol grains exhibit nearly constant composition cores (Fo80), showing only slight normal zoning (to Fo77), ending abruptly in steep composition profiles at their rims, at least where a distinct rim is observed. Diffusion-based timescales modeled following Costa et al. (2008) indicate very rapid quenching of Ol crystals (on the order of seconds), effectively freezing-in the high temperatures at which recharge magmas entered a shallow staging area. Mineral compositions indicate recharge magmas intruded at 1.5-2.0 kbar, saturated with Ol ± Pl ± Cpx, at 1050-1100°C, where they interact with resident felsic magmas that are 750-800°C (or cooler). Upon contact, Ol, and probably also Cpx, are mostly, but not always instantly quenched. Lower-T Cpx then preciptiates, and Pl continues to crystallize, until the resulting mixed/fractionated magmas reach Amp saturation at 900°C or lower. The pre-eruptive T interval after mixing is at least 100-160°C, but may reach 250°C for some enclaves. We surmise that Pl and Amp may provide more useful records of crsytallization time-scales.