Thermal conditions of storage of dacitic magmas

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Developing constraints on the conditions of magma storage within the crust and time scales of assembly of erupted bodies of magma is important in understanding the evolution of crustal magma systems as well as for volcanic hazards assessment. Magma temperature is one of the main variables controlling crystallinity, which in turn exerts a major influence on bulk viscosity and therefore mobility. A long-standing debate centers on the thermal conditions of magma storage in the crust. Some data suggest storage over tens to hundreds of kyr at temperatures where the magma is melt-dominated ("warm storage"), whereas other data suggest that magmas are stored largely in a crystal-dominated state and remobilized in the decades to centuries prior to eruption ("cold storage").

We present U-series ages of plagioclase combined with durations of intracrystalline diffusion of Sr in plagioclase from the same crystal populations from dacitic eruptions ranging in size from <1 km^3 to >10 km^3, including Lassen Volcanic Center, Mount Hood, Mount St Helens, Volcán Quizapu, Chile, Mount Pinatubo and Huaynaputina, Chile. Pre-eruptive crystal residence ages for plagioclase in each of these eruptions are 10^3-10^4 y. In contrast, modeled diffusion durations at 750°C are decades to centuries (up to a few millenia for Lassen samples). In all cases, these modeled diffusion durations are a factor of 10-100 shorter than the crystal residence times, indicating that crystals in this suite of eruptions were derived from regions of the magma reservoirs that were stored cold (i.e, <750°C) for >90% of their history. These storage temperatures imply a crystal-dominated mush rather than a liquid-dominated magma like those erupted. Although mobilization of magma is complex and can occur at a range of crystallinities, this pattern suggests that the conditions of storage and the time scales of assembly of erupted dacitic magma bodies are similar across a broad range in eruptive volumes typical of arc systems. Very large eruptions (>100 km^3) and/or eruptions of different composition may show different behavior.