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Crustal conditioning leading to caldera-forming eruptions in the long-lived Jemez Mountains volcanic field

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The Jemez Mountains volcanic field (JMVF) hosts two cataclysmic caldera-forming eruptions at 1.60 and 1.25 Ma that produced the rhyolitic Otowi Member (383 cubic kilometers) and Tshirege Member (∼400 cubic kilometers) of the Bandelier Tuff, respectively. These eruptive events postdate a long history (∼10 m.y.) of volcanism dominated by intermediate to silicic compositions. Here we use plagioclase and amphibole chemistry and zircon geochronology to refine pre-caldera magma evolution processes leading to development of the Bandelier magmatic system. In pre-caldera eruptive units, sieved or patchy textures in plagioclase reflect dissolution and regrowth indicating disequilibrium conditions in almost all magmatic systems. Plagioclase crystals with sieved rims and commonly An-poor cores with An-rich rims are almost ubiquitous in late dacite-dominated magmatism (Tschicoma Formation), reflecting widespread heating. Existence of two plagioclase populations is coupled with two distinct co-crystalized amphibole groups: a low-Al, low-temperature, high-fO_2 group, and a high-Al, high-temperature, low-fO_2 group. Back-calculation of melt Sr, Ba, La, and Ce concentrations from plagioclase core and rim compositions suggests that chemical variations in plagioclase are largely produced by magma mixing. A shallow silicic crustal mush is inferred as the silicic end-member involved in the late dacite-dominant magmatic systems and source of the late low-temperature rhyolite (Bearhead Rhyolite). Recharging of the silicic mush by mafic melts explains the diversity in both mineral disequilibrium textures and chemistries in the late dacitic magmas. Amphibole thermometry and oxybarometry, as well as Ti-in-zircon thermometry, suggest the pre-caldera JMVF magmatic system evolved towards cooler and more oxidized conditions with time, indicating gradual thermal maturation of local crust, building up to a transcrustal magmatic system and culminating in voluminous silicic volcanism. Lack of zircon inherence implies pre-caldera magmatic systems were developed as discrete batches without significant interactions. The Otowi Member of the Bandelier Tuff was derived from wholesale melting of pre-caldera plutons and country rocks, as evidenced by large proportions of inherited zircon. In contrast, different magmatic processes occurred in the younger Tshirege Member, which lacks inherited older zircon, and shows a greater complexity of zircon trace element and isotopic compositions. This study underlines the importance of precursor intermediate and silicic magmas for driving thermal maturation of the upper crust and contributing material to create caldera-forming silicic magmatic systems. Pre-conditioning for the first JMVF caldera-forming eruption lasted for at least ∼10 m.y., however, generation and storage of the magma producing the Otowi Member was orders of magnitude shorter (zircon age span of 140±60 kyr). Priming for the second caldera-forming eruption occurred within a 350 kyr repose time, comparable to the magma residence time (zircon age span of 180±140 kyr) for the younger Tshirege Member.