Ba and Eu in the late-erupted parts of zoned felsic tuffs provide a smoking gun for cumulate melting

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Felsic pyroclastic deposits of overall low crystallinity erupted from caldera volcanoes frequently display internal gradients in composition and crystal content. The chemical gradients in the melt phase are consistent with mineral/melt element partitioning predicted from the observed phenocryst assemblage. The same units typically show crystal-scale evidence for generation of eruptible magma by thermal rejuvenation of initially static, high-crystallinity (>50%) mush. Deposit-scale zoning can be reconciled with system rejuvenation by a model in which a high-crystallinity cumulate mush beneath its cognate supernatant liquid is melted by mafic recharge to produce denser, remobilized magma of accumulative composition. In this model, zoning is a symptom of thermal rejuvenation, but requires a fusible cumulate, as provided by alkali feldspar ± qtz ± foids. We review existing data and present new whole-rock, glass and mineral compositions for several examples of zoned felsic units, across the spectrum of alumina- and silica-saturation. We show that whole rocks and glasses in the late-erupted, "least-evolved" parts of zoned eruption sequences are often strongly enriched in Ba, and exhibit positive Eu anomalies, providing unequivocal evidence for melting of alkali feldspar cumulate mush. Ba-Eu enrichment is modulated by the degree of equilibration and new crystal growth occurring between melting and eruption, and may be hard to detect in cases of very highly evolved magmas.