Genesis of recent mafic magmatism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of caldera-forming systems?

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Mafic magmatism of the actively extending Taupo Volcanic Zone (TVZ) is volumetrically minor, but thought to tap the material that provides the heat source for voluminous rhyolite production through partial melting of the crust, which ultimately results in caldera-forming eruptions. We have studied the major and trace element chemistry of 14 mafic samples from across the entire TVZ, and the uranium isotopic composition of whole rocks, groundmasses and separates of mafic mineral phases from a selection of 9 samples. Some minerals yield significant ^{234}U enrichments despite groundmass and whole rock close to ^{238}U-^{234}U equilibrium, pointing to uptake of variably hydrothermally altered antecrystic minerals prior to the eruption of originally sparsely pyric to aphyric mafic magmas. However, incompatible trace element pattern indicate that there are three chemically distinct groups of rocks, and that all but one sample may be used to derive primary melt compositions. We employ the latest version of the Arc Basalt Simulator (ABS5) to forward model these compositions, deriving mantle source parameters. We show that mafic rocks erupted in areas of old, now inactive calderas constitute low-degree, deep melts, while those in areas of active caldera-volcanism are high-degree partial melts segregated from a less depleted source at an intermediate depth. Finally high-Mg basaltic andesites erupted in the southwest and the northeast of the TVZ point to a fertile, shallow mantle source. Our data are consistent with a petrogenetic model where mantle melting is dominated by decompression, rather than fluid fluxing, and progresses from shallow to deeper levels with time. Melt volumes initially increase to a tipping point, at which large scale crustal melting and caldera volcanism become prominent, and then decrease due to progressive depletion of the mantle wedge by melting, resulting in the dearth of heat provided and eventual cessation of rhyolitic cataclysim.