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

*Georg F Zellmer[1], Jun-Ichi Kimura[2], Claudine Stirling[3], Gert Lube[1], Phil A Shane[4]

1. Volcanic Risk Solutions, Massey University, Tennent Drive, Palmerston North 4410, New Zealand, 2. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology [JAMSTEC], Natsushima-cho 2-15, Yokosuka 237-0061, Japan, 3. Department of Chemistry, University of Otago, Dunedin 9054, New Zealand, 4. School of Environment, University of Auckland, Auckland 1142, New Zealand

Mafic magmatism of the actively extending Taupo Volcanic Zone (TVZ) of the North Island, New Zealand, 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 cataclysmic caldera-forming eruptions. We have studied the major and trace element chemistry 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 (with the remaining 5 too sparsely phyric for mineral separation). Some minerals yield significant ^{234}U enrichments despite groundmass and whole rock close to ^{238}U-^{234}U secular 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 samples, 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 including mantle fertility, slab liquid flux, mantle volatile content, degree of melting, and P-T conditions of melt segregation. 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. For the first time, a direct link becomes apparent between the chemistry of recently erupted mafic magmas and the long-term activity and evolution of caldera volcanism in the TVZ.

Keywords: Arc Basalt Simulator, uranium isotopes, basaltic magmatism, rhyolitic magmatism, subduction zone processes