Fine-scale temporal reconstruction and evolution of the post-supereruption magma system at Taupo volcano, New Zealand

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The processes that follow supereruptions are less fully documented than those which lead to such large events. In particular, how and over what time scales the overall magma system moves into a post-caldera mode of recovery provides important clues to the dynamics of such systems. The 530 km^3 Oruanui eruption (Taupo, New Zealand), is the world's youngest (25.4 ka) supereruption. Following this event, and after only ~5 kyr of quiescence, Taupo erupted three small volume (~0.1 km^3) dacitic pyroclastic units, followed by another ~5 kyr year time break, and then eruption of the modern sequence of 25 rhyolitic units starting at 12 ka. Taupo's young eruptive units are stratigraphically constrained over short time intervals, providing fine-scale temporal snapshots of the post-supereruption magma system. Here we present major and trace element bulk rock, glass and mineral chemistry, along with U/Th model-age dating of zircons from pumices from the post-Oruanui dacites and rhyolites to investigate how Taupo's magma system re-established and evolved. Immediately after the Oruanui eruption, Taupo's magma system underwent significant heating. Dacite units show wide variations in melt inclusion compositions and strongly zoned minerals consistent with sources involving less-evolved mafic magmas, forming at a depth of >8 km, overlapping with the base of the Oruanui magma system. The scarcity of Oruanui or pre-Oruanui aged zircons in the first erupted rhyolites imply that Taupo's magmatic system was thermally and chemically reset. The first rhyolites formed through fractionation and cooling of a source similar in composition to the dacites, with overlapping melt inclusion and crystal core compositions. For the younger rhyolite units, fine scale changes in melt chemistry and mineralogy occur over time, which are closely liked to the development, stabilisation and maturation of a new, unitary rhyolite mush system. This mush system is closely linked with underlying mafic melts, which provide the thermal and chemical driving force for magmatism. For the most recent eruptive units, the magmatic system underwent widespread destabilisation and heating from underlying mafic roots, resulting in rapid melt extraction and an increase in eruption volume to generate one of the largest and most energetic Holocene eruptions on Earth.