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Magmatic evolution of Whakaari volcano, New Zealand: Insights from marine cores

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Nearshore island volcanoes often have incomplete preservation of eruptive histories and are overlooked for their eruptive hazards, yet they can pose considerable risk to coastal communities. Whakaari (White Island), which lies 50 km offshore, is New Zealand's most historically active volcano, yet the evolution, drivers, and longer-term cyclicity of its magmatic system remain poorly constrained. Exposed subaerial stratigraphy has been partially destroyed by hydrothermal alteration, lacks a robust temporal framework, and is biased towards effusive eruptions, limiting our ability to contextualise historic and future activity. We present geochemical and petrological data from 10 radiocarbon-dated tephra deposits preserved in marine sediment cores collected around the island, to provide insights into Whakaari's magmatic evolution over the last ~9000 years and establish a temporal framework for prehistoric explosive eruptions. We measured major element compositions of minerals and glass, as well as trace element and Sr/Pb isotopic compositions of glass separates. The dominant mineral assemblage is plagioclase, orthopyroxene, and clinopyroxene with trace olivine in selected units. Groundmass glass is mostly dacitic and texturally bimodal, with microlite-rich and microlite-poor endmembers, and is less radiogenic than subaerial whole rock samples. Distinct changes in glass chemistry are observed through time with systematic changes in mineral zonation patterns and corresponding core and rim compositions. Our results highlight the temporal variability of Whakaari's magmatic system in response to the gradual evolution of the shallow magma reservoir and fluctuating input and mixing of mafic magma from depth. Two possible modes of mafic recharge into the shallow reservoir are identified that include: (1) elevated recharge associated with a high-Mg andesite eruption with $Fo_{\sim 90}$ olivine and unmixed melt compositions (56 – 75 wt.% SiO_2) that exhibit elevated Cr and Ni, and (2) comparatively low but steady state recharge with well mixed melt (62 – 66 wt.% SiO_2) and low Cr and Ni. Both modes may be succeeded by up to 1000 years of continued but decelerating mafic recharge, before resumption of more evolved (65 – 70 wt.% SiO_2), infrequent dacitic eruptions. Given recent high-Mg andesite eruptions from Whakaari between 1976 and 2000, this work has implications for future recharge driven eruptive activity.