Temporal and spatial evolution of volcanic and magmatic activity at Rabaul (Papua New Guinea)

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The last caldera-forming eruption at Rabaul (Papua New Guinea) occurred 1400 y BP, and produced ~10 km^3 of crystal-poor, two-pyroxene dacite. Since then, five eruptive episodes have occurred from vents along the caldera rim. This is an ideal setting to investigate the temporal evolution of a magmatic system after a cataclysmic event. The most recent period of eruptive activity started in 1994 with the simultaneous eruption of Vulcan and Tavurvur on opposite sides of the caldera, and was preceded by decade-long unrest (since 1971). This provides a great opportunity to investigate the temporal and spatial evolution of the magmatic system prior to eruption. Most eruptive products are andesitic in composition and show clear signs of mixing/mingling between a basalt and a high-K_2O dacite. The hybridization is in the form of banded pumices, quenched mafic enclaves, and hybrid bulk rock compositions. Tavurvur 1994 eruptive products are slightly more mafic (61-63 wt% SiO_2) and clearly more heterogeneous than those of Vulcan 1994 (63 wt% SiO_2). They also preserve clear signs of the basaltic (An_{90-94} plagioclase, olivine phenocrysts) and dacitic (An_{50} plagioclase, clinopyroxene Mg#<72) magmas they formed from, whereas Vulcan samples are more hybridized (max An_{85-90}, sieve textures, no olivine). Storage depths and temperatures estimated from volatile contents, mineral-melt equilibria and rock densities suggest that basalts ascended from ~20 km (~600 MPa) to ~7 km (200 MPa) and cooled from ~1150-1100°C before intruding the dacitic magma reservoir at ~950°C. All of these observations are in agreement with geophysical studies (seismic tomography, GPS and seismicity). Basaltic magmas are injected into the main reservoir from the east near Tavurvur and mix as they progress westwards toward Vulcan. Time scales of hybridization were constrained from Fo and Mn zoning in olivine and Mg and Sr zoning in plagioclase and coincide with the duration of unrest.