



Tracking reservoir dynamics across a complete caldera cycle at Rabaul, Papua New Guinea

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Caldera-forming eruptions are some of the most devastating events on Earth; however, the volcanoes that produce these eruptions frequently have much more minor activity. Knowing if a restless caldera is currently primed for a large eruption, therefore, has important implications for hazard assessment and risk management. Many calderas, including Rabaul in Papua New Guinea, show cycles of activity with multiple caldera-forming eruptions interspersed with more minor activity. We present data that spans an entire cycle, from one caldera-forming eruption to the next and estimate the storage conditions for each eruption. The last complete caldera cycle of Rabaul started at ~10.5 ka, with the eruption of the dacitic Vunabugbug Ignimbrite. Following the Vunabugbug, little volcanic activity was preserved until ~4.4 ka, suggesting either a period quiescence or destruction and burial during the subsequent caldera-forming eruptions of the region. From 4.4 ka, there is an increase in the volume and SiO₂ contents of volcanic deposits that are preserved, which culminated in the eruption of the dacitic Memorial Ignimbrite at ~4.1 ka. The Memorial Ignimbrite was smaller than the Vunabugbug Ignimbrite and Rabaul Pyroclastics and may not have formed a caldera; however, it does appear to have altered the plumbing system and allowed deeper, hotter basalts to reach the surface. Following the eruption of these basalts, the system gradually evolves towards more silicic magmas, until the eruption of the dacitic Rabaul Pyroclastics at ~1.4 ka. After the Rabaul Pyroclastics hotter, more mafic magmas can again reach the surface, both as more mafic lava flows and as hybrid andesites that contain crystal cargos transported from deeper in the system.

Two-pyroxene, clinopyroxene–liquid and plagioclase–liquid thermobarometers suggest that the dacites, including those erupted during the caldera-forming eruptions, were stored at pressures of ~1 kbar (~4 km depth) and at temperatures of ~930 °C. There is a tight relationship between the temperature and the SiO₂ content of the magmas, with the basalts erupted after the large ignimbrites recording temperatures of up to 1100 °C. Some of the more mafic magmas also record deeper storage, at pressures of 3–4 kbar (11–15 km). Plagioclase–liquid pairs suggest melt H₂O contents of ~2.8 wt.% for the dacites, although some of the more mafic magmas have slightly higher melt H₂O contents (3.2–4.0 wt.%)—this may be because the basalts were saturated and

stored at greater pressures. Magnetite–liquid pairs record relatively constant oxygen fugacities of ~ 1.2 log units above the FMQ buffer.

At Rabaul it would take on the order of a few millennia to differentiate or accumulate enough dacitic magma to produce a large explosive eruption. The eruption of highly evolved, crystal-poor, cold, hydrous magmas geochemically similar to those erupted prior to the Memorial Ignimbrite and Rabaul Pyroclastics may provide a warning of an impending large explosive eruption.