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Petrology and Geochemistry of the Recent Eruption History at Rabaul Caldera, Papua New Guinea: implications for magmatic processes and recurring volcanic activity.

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**A THESIS SUBMITTED FOR THE DEGREE OF MASTER OF PHILOSOPHY OF
THE AUSTRALIAN NATIONAL UNIVERSITY**

July, 2004



STATEMENT

All the results and conclusions presented in this thesis are the author's own, except where otherwise indicated. All sources used have been acknowledged in this thesis.

I certify that this thesis contains no material that has been accepted for the award of any other degree or qualification at any other university or institution.

A handwritten signature in black ink, appearing to read 'Herman Patia', with a stylized flourish extending from the end.

Herman Patia

ACKNOWLEDGEMENTS

This research was conducted at the Department of Geology, Australian National University, Canberra, Australia between July 2001 to July 2003. Financial support was provided by the Australian overseas Aid Agency (AusAID), in the form of an AusAID Scholarship Award.

I wish to thank Dr. Steve Eggins for his understanding, encouragement, guidance and advice during the course of this study. Professor Richard Arculus for his support, discussions and for allowing me to participate in the 16th Australian Geological Convention held in Adelaide during July 2002.

I also thank Chris McKee for his assistance and guidance during the fieldwork and for collaboration during this study. Without his experience and knowledge of the Rabaul Volcanic Complex this study would not have achieved its goal. RVO staff for their assistance during the fieldwork.

I also wish to thank Wally Johnson and Shane Nancarrow of Geoscience Australia for their assistance and collaboration while in Canberra. Wally Johnson provided some of the images and collected most of the samples erupted during Phase 1.

I thank Frank Brink and Cheng Huang from the Electron Microprobe Unit at the Research School of Biological Sciences (RSBS), and Nick Ware from the Research School of Earth Sciences (RSES) for their help and patience during the time required to collect the large quantity of electron microprobe analyses obtained for this study. I would also like to thank Charlotte Allen and Mike Shelly at RSES for their assistance in collecting trace element data with the LA-ICP-MS

I also wish to thank Patricia Wallace for her help and assistance in collecting some of the data and for collaboration with her work on the pre-1400 BP eruptives at Rabaul during this study.

I would like to thank Peter Wood of the Institute of Geological & Nuclear Science in Taupo, New Zealand, for providing major and trace element data for the Rabaul 'main series' and for Tavui caldera.

The ACT branch of the Geological Society for funding my participation at the 16th Australian Geological Convention held in Adelaide in July 2002.

I would also like to acknowledge the kind and generous manner in which the technical and general staff help me at the Geology Department during my M. Phil, and whose unrewarded efforts have made my life easier. In particular John Vickers (thin section Lab), Tony Phimphisane (Geochemistry Lab), Brian Harold (IT), Sarah O'Callaghan and Maree Goldrick (Secretary).

AusAID Liaison Officer Lynne Toohey and her colleagues Maree Millar and Sheryl Murray for advice and assistance during the course of my M. Phil program.

The Director of Human Resource Division in conjunction with the Director of the Geological Survey of Papua New Guinea and the Assistant Director of the Rabaul Volcanological Observatory, Department of Mining, for granting me study leave to undertake this study. I also would like to acknowledge the Department of Mining for paying for air tickets and allowance for my family.

Family friends here in Canberra, Joe Demas & family of Woden, Sam Wuvuai & family of Queanbeyan, J & K. Dickson & family of Lyneham and John Yamin & family of Nicholls.

My family (Bertha and our children) who without them I would have not achieved this study.

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ABSTRACT

The initial phase (Phase 1 – 19 September 1994 to 16 April 1995) of the current (1994-2003) eruption at Rabaul Caldera occurred with synchronous vulcanian and vulcanian-plinian eruptions from Taurvur and Vulcan, respectively, on opposing sides of the caldera. A second phase of activity (Phase 2), beginning on 28 November 1995 and continuing until the present (2003), is characterised by intermittent vulcanian and strombolian eruptions that are restricted to Taurvur, on the northeastern side of Rabaul Caldera.

Whole-rock geochemical data and phenocryst mineral chemistry indicate the eruption of similar dacite magmas from both Vulcan and Taurvur, and provide evidence for tapping of the same magma reservoir by both vents. Hybridised andesitic magmas, which have strongly bimodal phenocryst assemblages and form linear compositional arrays that extend from end-member dacite toward mafic basalt compositions, have been erupted only from Taurvur.

The moderately large volume SO₂ flux observed in the Taurvur volcanic plume (and absence in the Vulcan plume; Roggensack et al., 1996), combined with high dissolved S contents in the basaltic melt inclusions trapped in olivine, indicates the injected basaltic magma was confined to the eastern/northeastern sector (Taurvur-side) of a shallow, dacite-filled caldera reservoir. The H₂O-CO₂ volatile contents of melt inclusions (Roggensack et al., 1996) combined with the extent of the low-velocity zone defined by the recent RELACS seismic tomographic experiment (Finlayson et al., 2003), permit the estimation of a dacitic magma reservoir below the caldera. The volume of magma in the reservoir is ~10 km³ at a depth of ~3 km and within the approximate 30 km² boundary formed by the seismically active caldera ring-fault (Jones and Stewart, 1997).

The results of this study suggest the 1994-2003 eruption was triggered by a mafic magma injection event that took place at or immediately prior to the onset of the eruption and during Phase 2. This event was most likely the latest of a sequence of similar events that took place in the 23 years prior to 1994, based on observed seismicity and changes in ground deformation and mass beneath the Rabaul Caldera since 1971.

Comparison with dacite magma compositions erupted in 1937-1943, 1878, and during the recent prehistoric era and the presence of plagioclase phenocrysts reflecting

older basalt-dacite magma interaction events (i.e., anorthite cores overgrown with thick andesine rims). The petrologic and geochemical observations made in this study indicate the shallow magma system at Rabaul Caldera has been subject to repeated mafic magma injection since, and also during, the latest caldera-forming eruption about 1400 years BP. The frequency and repeated occurrence of these injections may maintain a near steady-state system that is characterized by the persistent eruption of similar, crystal-poor dacite compositions over the last 1400 years, and the presence at shallow level of a large volume of dacite magma beneath Rabaul Caldera (Finlayson et., 2003; Mori et al., 1989).